



WashU McKelvey Engineering

McKelvey School of Engineering Graduate Programs

2026–27

Bulletin

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About This Bulletin

The graduate and professional *Bulletins* are the catalogs of programs, degree requirements, courses that may be offered and course descriptions, pertinent university policies, and faculty of the following schools of Washington University in St. Louis: Architecture & Urban Design; Art; Arts & Sciences; Business; Engineering; Law; Medicine; Public Health; and Social Work & Social Policy.

The *WashU Continuing & Professional Studies Bulletin* is the catalog for WashU Continuing & Professional Studies (CAPS), the professional and continuing education division at Washington University in St. Louis. The catalog includes programs, degree requirements, course descriptions, and pertinent university policies for students earning a degree or taking courses through CAPS.

The 2026-27 *Bulletin* is entirely online but may be downloaded in PDF format for printing. Individual pages as well as information from individual tabs may be downloaded in PDF format using the PDF icon in the top right corner of each page. To download the full PDF, please choose from the following:

- Architecture & Urban Design Bulletin (PDF) (*to come*)
- Art Bulletin (PDF) (*to come*)
- Arts & Sciences Bulletin (PDF) (*to come*)
- Business Bulletin (PDF) (*to come*)
- Engineering Bulletin (PDF) (*to come*)
- Law Bulletin (PDF) (*to come*)
- Medicine Bulletin (PDF) (*to come*)
- Public Health Bulletin (PDF) (*to come*)
- Social Work & Social Policy Bulletin (PDF) (*to come*)
- School of Continuing & Professional Studies Bulletin (undergraduate & graduate) (PDF) (*to come*)

The degree requirements and policies listed in the 2026-27 *Bulletin* apply to students entering Washington University during the 2026-27 academic year. For more information, please visit the Catalog Editions (p. 9) page.

Every effort is made to ensure that the information, applicable key policies, and other materials presented in the *Bulletin* are accurate and correct as of the date of publication (July 1, 2026). To view a list of changes that have taken place after that date, visit the Program & Policy Updates page. Please note that the *Bulletin* highlights key university policies applicable to its students. Not all applicable university and departmental policies are included here.

Washington University reserves the right to make changes at any time without prior notice to the *Bulletin* and to university policies. Therefore, the electronic version of the *Bulletin* as published online is considered the official, governing document, and it may change from time to time without notice.

The next edition of the *Bulletin* will be published on July 1, 2027. Midyear changes to current courses (titles, descriptions, and credit units) are not reflected in this *Bulletin*. For more information about determining the appropriate edition of the *Bulletin* to consult, please visit the Catalog Editions page (p. 9) in the About This Bulletin section.

For the most current information about registration, visit the Plan for Next Semester Overview page of the Workday@WashU website. To view current semester course listings, consult the Class Schedule Search on the Office of the University Registrar website.

Degree progress is monitored in Workday based on program requirements as published in the *Bulletin* in the year of the student's matriculation. Students are responsible for reviewing their academic progress for accuracy and remaining credential requirements. Questions about degree requirements and course applicability should be directed to advisors.

Please email the Bulletin editor (bulletin@wustl.edu), Jennifer Etling Gann, with any questions concerning the *Bulletin*.

Bulletin Policies

Policies related to this catalog include the following:

Changes to the Bulletin

Every effort is made to ensure that the information, policies and other materials presented in the *Bulletin* are accurate and correct as of the date of publication. For more information about the content review process for the *Bulletin*, please visit the Catalog Editions page (p. 9).

The *Bulletin* for the upcoming academic year is published annually on July 1, and certain post-publication changes may be made until October 1. To view a list of changes that have taken place after the July 1 publication date, please visit the Program & Policy Updates page.

Washington University reserves the right to make changes at any time without prior notice. Therefore, the electronic version of the *Bulletin* and the policies set forth therein may change from time to time without notice. The governing document at any given time is the then-current version of the *Bulletin*, as published online, and then-currently applicable policies and information are those contained in that *Bulletin*.

Discontinued Programs

Students enrolled in programs that discontinue admitting new students during their tenure are expected to meet degree requirements published in the *Bulletin* and in place during their year of matriculation. If a program's requirements change, a student may request to change to a subsequent version effective during their enrollment, which is subject to approval by their school. Students who leave the university may not be allowed to return to a discontinued program depending on the time frame the university has established that the program will teach out remaining students.

Students are held to other policies in effect and as published for the current academic year.

For more information, please visit the Prior Bulletins page (p. 9).

Year of Matriculation

Students are expected to meet degree requirements published in the *Bulletin* and in place during their year of matriculation. If a program's requirements change, a student may request to change to a subsequent version effective during their enrollment, which is subject to approval by their school.

For more information, please visit the Catalog Editions page (p. 9).

Course Numbering

Washington University adopted a new course labeling structure in Fall 2025. The first part is the subject code indicating the area of study: for example, ANTHRO for Anthropology or MEMS for Mechanical Engineering and Materials Science. The second part is a four-digit course number. Course numbers demonstrate a progression of difficulty and/or depth in coursework.

- 1000 to 1999 indicates an introductory undergraduate course, usually without prerequisites.
- 2000 to 2999 indicates an introductory or intermediate undergraduate course, sometimes with prerequisites.
- 3000 to 3999 indicates an upper-level undergraduate course, often with a prerequisite of a prior course or class standing (e.g., junior standing).
- 4000 to 4999 indicates an undergraduate course or seminar with advanced content, in which a graduate student may be eligible to register.
- 5000 to 9999 indicates a graduate course, in which advanced undergraduates may request to register.

The presence of a course in this *Bulletin* signifies that it is part of the curriculum currently offered and may be scheduled for registration.

Curriculum Designators

The subject codes shown below are used in Washington University's course records and are listed here alphabetically.

A

Code	Name
AAS	Asian American Studies
ACCT	Accounting
AFAS	African & African American Studies
AHBR	Applied Health Behavior Research
AMCS	American Culture Studies
ANESTH	Anesthesiology
ANTHRO	Anthropology
APL	Applied Linguistics
ARAB	Arabic
ARC	Archaeology
ARCH	Architecture
ART	Art
ARTARCH	Art History & Archaeology
ASGS	Arts & Sciences Graduate Studies

B

Code	Name
BBS	Biology & Biomedical Sciences
BDSAI	Biomedical Data Science and AI
BEYOND	Beyond Boundaries
BIOCHEM	Biochemistry & Molecular Biophysics
BIOL	Biology & Biomedical Sciences
BME	Biomedical Engineering
BMI	Biomedical Informatics
BSDC	Brown School Doctoral

C

Code	Name
CAPS-AFAS	CAPS - African & African American Studies
CAPS-AMCS	CAPS - American Culture Studies
CAPS-ANTHRO	CAPS - Anthropology
CAPS-ARAB	CAPS - Arabic
CAPS-ART	CAPS - Art
CAPS-ARTARCH	CAPS - Art History & Archaeology
CAPS-BIO	CAPS - Biology
CAPS-BUS	CAPS - Business
CAPS-CHEM	CAPS - Chemistry
CAPS-CHINESE	CAPS - Chinese
CAPS-CIM	CAPS - Computers & Information Management



CAPS-CLASSICS	CAPS - Classics
CAPS-COMM	CAPS - Communications
CAPS-COMPLIT	CAPS - Comparative Literature
CAPS-CRM	CAPS - Clinical Research Management
CAPS-CS	CAPS - Computer Science
CAPS-DANCE	CAPS - Dance & Somatic Movement Studies
CAPS-DATASTUDIES	CAPS - Data Studies
CAPS-DRAMA	CAPS - Drama
CAPS-EASIA	CAPS - East Asian Studies
CAPS-ECOMP	CAPS - English Composition
CAPS-ECON	CAPS - Economics
CAPS-EDUC	CAPS - Education
CAPS-ELIT	CAPS - English & American Literature
CAPS-ELP	CAPS - English Language Programs
CAPS-EPSC	CAPS - Earth & Planetary Sciences
CAPS-FILM	CAPS - Film & Media Studies
CAPS-FR	CAPS - French
CAPS-GERMAN	CAPS - Germanic Languages & Literatures
CAPS-GIS	CAPS - Geographic Information Systems
CAPS-GS	CAPS - General Studies
CAPS-HCARE	CAPS - Health Care
CAPS-HEBR	CAPS - Hebrew
CAPS-HINDI	CAPS - Hindi
CAPS-HIST	CAPS - History
CAPS-HRM	CAPS - Human Resources Management
CAPS-IA	CAPS - International Affairs
CAPS-IRISH	CAPS - Irish Studies
CAPS-IS	CAPS - International Studies
CAPS-ISLA	CAPS - Integrated Studies in Liberal Arts
CAPS-ITAL	CAPS - Italian
CAPS-JAPAN	CAPS - Japanese
CAPS-JME	CAPS - Jewish, Islamic, & Middle East Studies
CAPS-JRN	CAPS - Journalism
CAPS-KOREAN	CAPS - Korean
CAPS-LAS	CAPS - Latin American Studies
CAPS-LING	CAPS - Linguistics
CAPS-MATH	CAPS - Mathematics & Statistics
CAPS-MUS	CAPS - Music
CAPS-NPM	CAPS - Nonprofit Management
CAPS-PHIL	CAPS - Philosophy
CAPS-PHYS	CAPS - Physics
CAPS-POLSCI	CAPS - Political Science
CAPS-PORT	CAPS - Portuguese

CAPS-PSYCH	CAPS - Psychological & Brain Science (Psychology)
CAPS-RELST	CAPS - Religious Studies
CAPS-RUSS	CAPS - Russian
CAPS-SCAN	CAPS - Scandinavian
CAPS-SCI	CAPS - Science
CAPS-SOC	CAPS - Sociology
CAPS-SPAN	CAPS - Spanish
CAPS-SPCH	CAPS - Speech
CAPS-SUST	CAPS - Sustainability
CAPS-WGSS	CAPS - Women, Gender, & Sexuality Studies
CFH	Center for the Humanities
CHEM	Chemistry
CHINA	Chinese
CHST	Children's Studies
CLASSICS	Classics
CLNV	Clinical Investigation
CNST	Construction Management
COMPLITHT	Comparative Literature & Thought
CSE	Computer Science & Engineering
CWP	College Writing Program
CYBER	Cybersecurity Management

D

Code	Name
DANCE	Dance
DAT	Data Analytics
DCDS	Division of Computational & Data Sciences
DESIGN	Design
DRAMA	Drama

E

Code	Name
EALC	East Asian Languages & Cultures
ECON	Economics
EDUC	Education
EECE	Energy, Environmental, & Chemical Engineering
EEPS	Earth, Environmental, & Planetary Sciences
EGS	Engineering Graduate Studies
ELIT	English Literature
EMED	Emergency Medicine
EMGT	Engineering Management
ENGR	General Engineering
ENST	Environmental Studies
ESE	Electrical & Systems Engineering
ETEM	Engineering Management



F

Code	Name
FASHION	Fashion Design
FILM	Film & Media Studies
FIN	Finance
FRENCH	French

G

Code	Name
GENETICS	Genetics
GENST	General Studies
GERMAN	Germanic Languages & Literatures
GLOBAL	Global Studies
GNOUN	Genetic Counseling
GREEK	Greek

H

Code	Name
HBRW	Hebrew
HCO	Health Care Operations
HINDI	Hindi
HISTORY	History

I

Code	Name
IMSE	Institute of Materials Science & Engineering
INFO	Information Management
INTERD	Interdisciplinary Studies
INTL	International Studies
IPMS	Movement Science
ITAL	Italian

J

Code	Name
JAPAN	Japanese
JCE	Joint Civil Engineering
JCHE	Joint Chemical Engineering
JCS	Joint Intro to Computing
JEC	Joint Engineering Communications
JEE	Joint Electrical Engineer
JEMT	Joint Engineering Math
JIMES	Jewish, Islamic, & Middle East Studies
JME	Joint Mechanical Engineering

K

Code	Name
KOREA	Korean

L

Code	Name
LANDARCH	Landscape Architecture
LATAM	Latin American Studies
LATIN	Latin
LAW	Law
LAWO	Law Online
LING	Linguistics
LWST	Legal Studies

M

Code	Name
MAIR	Military Aerospace Science
MARM	Military Science
MATH	Mathematics & Statistics
MBIO	Molecular Biology
MBIOPHARM	Molecular Biology & Pharmacology
MEC	Managerial Economics
MEDH	Medical Humanities
MEDICINE	Internal Medicine
MEDINTER	Medicine Interdisciplinary
MEDPHASE1	Medicine Phase 1
MEDPHASE2	Medicine Phase 2
MEDPHASE3	Medicine Phase 3
MEDPHYS	Medical Physics
MEDRSRCH	Medicine Research
MEMS	Mechanical Engineering & Materials Science
MGS	Medicine Graduate Studies
MGT	Management
MKT	Marketing
MSB	Biostatistics & Genetic Epidemiology
MUSIC	Music

N

Code	Name
NEUROL	Neurology
NEUROSCI	Neuroscience
NEUROSUR	Neurological Surgery
NRSSI	Nursing Science



O

Code	Name
OB	Organizational Behavior
OBGYN	Obstetrics & Gynecology
OPHTH	Ophthalmology & Visual Sciences
ORTHO	Orthopedic Surgery
OSP	Overseas Programs
OT	Occupational Therapy
OTO	Otolaryngology

P

Code	Name
PACS	Audiology & Communication Sciences
PATH	Pathology
PBPMSTUDY	Biological & Physical Sciences for PBPM
PE	Physical Education
PEDS	Pediatrics
PHCC	Public Health Concentration Courses
PHDC	Public Health Doctoral
PHEL	Public Health Electives
PHFN	Public Health Foundation
PHIL	Philosophy
PHPC	Public Health Practicum
PHRS	Public Health Research
PHS	Population Health Sciences
PHSL	Public Health Skill Lab
PHTPS	Public Health Transdisciplinary Problem Solving
PHYSICS	Physics
PHYSTHER	Physical Therapy Program - Grad
PNP	Philosophy-Neuroscience-Psychology
POLSCI	Political Science
PORTUG	Portuguese
PRJM	Project Management
PSY	Psychiatry
PSYCH	Psychological & Brain Sciences
PUBLTHSOC	Public Health & Society

R

Code	Name
RADIOL	Radiology
RADONC	Radiation Oncology
RELPOL	Religion & Politics
REPRSCI	Reproductive Science
RESEARCH	Research
REST	Religious Studies
RUSS	Russian

S

Code	Name
SCOT	Supply Chain, Operations, & Technology
SDS	Statistics & Data Science
SLU	Saint Louis University
SOC	Sociology
SPAN	Spanish
SPCN	Social Policy Concentration
SPFN	Social Policy Foundation
SPGN	Social Policy General
SPHR	Speech & Hearing
SURGERY	Surgery
SWCP	Social Work Concentration Practicum
SWDT	Social Work Doctoral
SWEL	Social Work Electives
SWEV	Social Work Evaluation
SWFN	Social Work Foundation
SWHS	Social Work History & Professional Theme
SWLM	Social Work Leadership & Management
SWPM	Social Work Practice Methods
SWSL	Social Work Skill Lab
SWSP	Social Policy
SWTH	Social Work Theory

T

Code	Name
TIPM	Industrial Management

U

Code	Name
UMSL	University of Missouri-St. Louis
URBDES	Urban Design
URST	Urban Studies



W

Code	Name
WGSS	Women, Gender, & Sexuality Studies
WRITING	Writing

Catalog Editions

The courses and policies listed in this *Bulletin* are subject to change at any time through normal approval channels within Washington University. New courses, changes to existing coursework, and new policies are initiated by the appropriate institutional departments, committees, or administrators. Academic policy revisions are generally implemented in the next academic year following notification thereof. Washington University publishes a new edition of the *Bulletin* each July, and its contents apply to the subsequent fall, spring, and summer terms. Occasionally a policy or requirement must be changed and implemented during the same academic year (e.g., in the case of relevant external requirements, such as state regulations). All changes must be approved by college or school personnel who oversee academic curriculum and policies.

Washington University students are expected to meet degree requirements published in the *Bulletin* and in place during their year of matriculation. Undergraduates who initially enroll in a summer term to pursue a special program follow requirements for the subsequent fall term. Students will need to check their school's processes to potentially change applicable catalog years or alter their degree requirements.

Students should review specific Washington University and individual school policies related to transfer credit, changing programs, leaves of absence, and military service.

Prior Bulletins

To find program details, course descriptions, and relevant policies, choose the year of enrollment below to find the available *Bulletins*.

If the required year is not shown or the school's *Bulletin* is not available, please email the Office of the University Registrar (registrar@wustl.edu) with specifics of what information is needed.

2025-2026

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Business Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)
- Law Bulletin (HTML) (PDF)
- Medicine Bulletin (HTML) (PDF)
- Public Health Bulletin (HTML) (PDF)

- Social Work & Social Policy Bulletin (HTML) (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- School of Continuing & Professional Studies Bulletin (HTML: Undergraduate, Graduate) (PDF)

2024-2025

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Business Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)
- Law Bulletin (HTML) (PDF)
- Medicine Bulletin (HTML) (PDF)
- Social Work & Public Health Bulletin (HTML) (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- School of Continuing & Professional Studies Bulletin (HTML: Undergraduate, Graduate) (PDF)

2023-2024

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Business Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)
- Law Bulletin (HTML) (PDF)
- Medicine Bulletin (HTML) (PDF)
- Social Work & Public Health Bulletin (HTML) (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- School of Continuing & Professional Studies Bulletin (HTML: Undergraduate, Graduate) (PDF)

2022-2023

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Business Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)
- Law Bulletin (HTML) (PDF)
- Medicine Bulletin (HTML) (PDF)
- Social Work & Public Health Bulletin (HTML) (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- University College Bulletin (HTML: Undergraduate, Graduate) (PDF)

2021-2022

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Business Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)
- Law Bulletin (HTML) (PDF)
- Medicine Bulletin (HTML) (PDF)
- Social Work & Public Health Bulletin (HTML) (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- University College Bulletin (HTML: Undergraduate, Graduate) (PDF)

2020-2021

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Business Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)
- Law Bulletin (HTML) (PDF)
- Medicine Bulletin (HTML) (PDF)
- Social Work & Public Health Bulletin (HTML) (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- University College Bulletin (HTML: Undergraduate, Graduate) (PDF)

2019-2020

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Business Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)
- Law Bulletin (HTML) (PDF)
- Medicine Bulletin (HTML) (PDF)
- Social Work & Public Health Bulletin (HTML) (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- University College Bulletin (HTML: Undergraduate, Graduate) (PDF)

2018-2019

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)

- Law Bulletin (HTML) (PDF)
- Medicine Bulletin (HTML) (PDF)
- Social Work & Public Health Bulletin (HTML) (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- University College Bulletin (HTML: Undergraduate, Graduate) (PDF)

2017-2018

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)
- Law Bulletin (HTML) (PDF)
- Medicine Bulletin (HTML) (PDF)
- Social Work & Public Health Bulletin (HTML) (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- University College Bulletin (HTML: Undergraduate, Graduate) (PDF)

2016-2017

- Graduate Architecture & Urban Design Bulletin (HTML) (PDF)
- Graduate Art Bulletin (HTML) (PDF)
- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Graduate Engineering Bulletin (HTML) (PDF)
- Medicine Bulletin (PDF)
- Undergraduate Bulletin (HTML) (PDF)
- University College Bulletin (HTML: Undergraduate, Graduate) (PDF)

2015-2016

- Graduate Arts & Sciences Bulletin (HTML) (PDF)
- Medicine Bulletin (PDF)
- Undergraduate Bulletin (HTML) (PDF)

2014-2016

- University College Bulletin (undergraduate & graduate) (PDF)

2014-2015

- Medicine Bulletin (PDF)
- Undergraduate Bulletin (HTML) (PDF)

2013-2014

- Medicine Bulletin (PDF)
- Undergraduate Bulletin (HTML) (PDF)

2012-2015

- Graduate Arts & Sciences Bulletin (PDF)

2012-2014

- University College Bulletin (undergraduate & graduate) (PDF)

2012-2013

- Medicine Bulletin (PDF)
- Undergraduate Bulletin (HTML) (PDF)

2011-2012

- Medicine Bulletin (PDF)
- Undergraduate Bulletin (HTML) (PDF)

2010-2011

- Medicine Bulletin (PDF)
- Undergraduate Bulletin (PDF)

2009-2012

- Graduate Arts & Sciences Bulletin (PDF)

2009-2010

- Medicine Bulletin (PDF)

2008-2010

- Undergraduate Bulletin (PDF)

2008-2009

- Medicine Bulletin (PDF)

2006-2009

- Graduate Arts & Sciences Bulletin (PDF)
and accompanying 2008 Update (PDF)

2006-2008

- Undergraduate Bulletin (PDF)

About Washington University in St. Louis

Who We Are Today

Washington University in St. Louis — a medium-sized, independent university — is dedicated to challenging its faculty and students alike to seek new knowledge and greater understanding of an ever-changing, multicultural world. The university is counted among the world's leaders in teaching and research, and it draws students from all 50 states, the District of Columbia, Guam, Puerto Rico, and the Virgin Islands. Students and faculty come from more than 100 countries around the world.

The university offers more than 250 programs and 5,500 courses leading to associate, bachelor's, master's, and doctoral degrees in a broad spectrum of traditional and interdisciplinary fields, with additional opportunities for minor concentrations and individualized programs. For more information about the university, please visit the About WashU page of our website.

Enrollment by School

For enrollment information, please visit the University Facts page of our website.

Our Mission Statement

The mission of Washington University in St. Louis is to act in service of truth through the formation of leaders, the discovery of knowledge, and the treatment of patients for the betterment of our region, our nation, and our world.

At WashU, we generate, disseminate, and apply knowledge. We foster freedom of inquiry and expression of ideas in our research, teaching, and learning.

We aim to create an environment that encourages and supports wide-ranging exploration at the frontier of discovery by embracing diverse perspectives from individuals of all identities and backgrounds. We promote higher education and rigorous research as a fundamental component of an open, vibrant society. We strive to enhance the lives and livelihoods not only of our students, patients, and employees but also of the people of the greater St. Louis community and beyond. We do so by addressing scientific, social, economic, medical, and other challenges in the local, national, and international realms.

Our goals are:

- to foster excellence and creativity in our teaching, research, scholarship, patient care, and service
- to welcome students, faculty, and staff from all backgrounds to create an inclusive, equitable community that is nurturing and intellectually rigorous

- to cultivate in students habits of lifelong learning and critical and ethical thinking, thereby enabling them to be productive members and leaders of a global society
- to contribute positively to our home community of St. Louis, and to effect meaningful, constructive change in our world

To this end we intend:

- to hold ourselves to the highest standards of excellence
- to educate aspiring leaders of great ability from diverse backgrounds
- to encourage faculty and students to be innovative, bold, independent, critical thinkers
- to build an inclusive, equitable, respectful, ethically-principled environment for living, teaching, learning, and working for the present and future generations
- to focus on meaningful and measurable outcomes for all of our endeavors

Mission statement endorsed by the Faculty Senate Council in April 2021 and approved by the Board of Trustees on October 1, 2021.

Trustees & Administration

Board of Trustees

Washington University's Board of Trustees is the chief governing body of Washington University in St. Louis. Current members of the board include the following:

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Chair

Andrew E. Newman
Vice Chair

Penny Pennington
Vice Chair

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Chris Boerner

Blackford F. Brauer

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Lori Coulter

Arnold W. Donald

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Gaurav Garg

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Anthony W. Ryan

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Mary Danforth Stillman

Kurt A. Summers

Barbara Schaps Thomas

Lawrence E. Thomas

David A. Ulevitch

Eric B. Upin

Henry D. Warshaw

Joseph F. Wayland

Dean Yamamoto

Nicholas S. Zeppos

Please visit the Board of Trustees website for more information.

University Administration

In 1871, Washington University co-founder and then-Chancellor William Greenleaf Eliot sought a gift from Hudson E. Bridge, a charter member of the university's Board of Directors, to endow the chancellorship. Soon after this endowment was received, the position was renamed the "Hudson E. Bridge Chancellorship."

The officers of the university administration are currently led by Chancellor Andrew D. Martin. University leadership is detailed on the Washington University website.

Andrew D. Martin

Chancellor

Mark D. West

Provost

Academic Calendar

The academic calendar of Washington University in St. Louis is designed to provide an optimal amount of classroom instruction and examination within a manageable time frame, facilitating our educational mission to promote learning among both students and faculty. The dates listed here are the outline of the standard semester calendar, applicable to traditional undergraduate and many graduate programs. Certain schools or programs may have varying calendars due to the nature of particular fields of study. Please refer to the Academic Calendar page of the Office of the University Registrar's website for more information.

Fall Semester 2026

Date	Day	Description
August 24	Monday	First day of classes
September 7	Monday	Labor Day holiday (no classes)
October 3-6	Saturday-Tuesday	Fall Break (no classes)
November 25- November 29	Wednesday-Sunday	Thanksgiving Break (no classes)
December 7	Monday	Last day of classes
December 8-9	Tuesday-Wednesday	Reading days
December 10-16	Thursday-Wednesday	Final exams

Spring Semester 2027

Date	Day	Description
January 18	Monday	Martin Luther King, Jr. holiday (no classes)
January 19	Tuesday	First day of classes
March 14-21	Sunday-Sunday	Spring Break (no classes)
May 3	Monday	Last day of classes
May 4-5	Tuesday-Wednesday	Reading days
May 6-12	Thursday-Wednesday	Final exams

Commencement

Date	Day	Description
May 21	Friday	Class of 2027 Commencement

Summer Semester 2027

Date	Day	Description
May 24	Monday	First Summer Session begins
May 31	Monday	Memorial Day holiday (no classes)
July 5	Monday	Independence Day holiday observed (no classes)
August 19	Thursday	Last Summer Session ends

Religious Holiday Class Absence Policy

As home to students, faculty, and staff of all the world's major religions and as a non-sectarian institution, Washington University in St. Louis values the rich diversity of spiritual expression and practice found on campus. It is therefore the policy of the university that students who miss class, assignments, or exams to observe a religious holiday should be accommodated as follows:

1. Absences should be counted as excused in any course in which attendance is a measure of academic performance;
2. Reasonable extensions of time should be given, without academic penalty, for missed assignments; and
3. Exams should be reasonably rescheduled without academic penalty.

To ensure that accommodations may be made, students who plan to miss class for a religious holiday must inform their instructors in writing *before the end of the third week of class* or as soon as possible if the holiday occurs during the first three weeks of the semester. Instructors should inform students on their syllabus and/or at the start of the class how they would like students to notify them of any accommodation needs related to religious observance.

Absence for religious reasons does not lessen students' responsibility for coursework or material covered during their absence. It is incumbent on the student who misses a class to catch up on any material discussed and assignments given during that class period. If a student believes that they have not received a reasonable accommodation despite engaging with their instructor on the topic, they should follow the course grievance process outlined by their school.

The Office for Religious, Spiritual & Ethical Life provides a list of Religious & Spiritual Holidays that fall within the academic year. This list is not a designation of religious holidays recognized by the university, and it is not meant to be comprehensive; it is simply a guide to help students and instructors plan their courses and assignments.

For Faculty

Every effort should be made to avoid scheduling exams on religious holidays, particularly those with work restrictions as noted on the holiday calendar.

Faculty should be supported in establishing a teaching schedule that allows them to avoid conflict with their observance of religious holidays. Where this is not possible, faculty should make up any missed class(es) in the method most appropriate to student learning in their course (e.g., rescheduling for an alternate time, providing asynchronous material, engaging a guest lecturer). Appropriate advance notice should be provided to students.

Any instructor with concerns regarding either a given holiday or the academic implications of a particular student's religious observance of holidays may seek guidance from the chair of their department, the dean of their school, or the Director for Religious, Spiritual & Ethical Life.

Campus Resources

Student Support Services

The Learning Center

The Learning Center, located on the lower level of the Mallinckrodt Center and housed within the Center for Teaching and Learning, is the hub of academic support at Washington University in St. Louis. The Learning Center's programs are designed to support students in their course work by helping them develop the lifelong skill of "learning how to learn" and by stimulating their independent thinking. All services are free (with the exception of MCAT prep), and each year more than 1,800 students participate in one or more of our programs.

The Learning Center offers support for foundational courses through Peer-Led Team Learning and our drop-in mentoring programs (Residential Peer Mentoring and Drop-In Academic Mentoring). Individual peer-led coaching is available for academic skills such as time management, study strategies, note-taking, accessing resources, and managing test anxiety. Other services offered include small group mentoring for eligible students and an MCAT preparation program.

For more information, visit the Learning Center website or call 314-935-2066.

Disability Resources

Disability Resources supports students with disabilities by fostering and facilitating an equal access environment for the Washington University community of learners. Disability Resources partners with faculty and staff to facilitate academic and housing accommodations for students with disabilities on the Danforth Campus. Students enrolled in the School of Medicine should contact their program's director. Please visit the Disability Resources website or call 314-935-5970 for more information.

TRIO: Student Support Services

TRIO is a federally funded program that provides customized services for undergraduate students who are low income, who are the first in their family to go to college, and/or who have a documented disability. Services include academic coaching, academic peer mentoring, cultural and leadership programs, summer internship assistance and post-graduation advising. First-year and transfer students are

considered for selection during the summer before they enter their first semester. Eligible students are encouraged to apply when they are notified, because space in this program is limited. For more information, visit the TRIO Program website.

Medical Student Support Services

For information about Medical Student Support Services, please visit the School of Medicine website.

Office for International Students and Scholars

The Office for International Students and Scholars (OISS) is dedicated to fostering an inclusive environment that celebrates our international students' and scholars' diverse experiences, cultures, and aspirations. OISS plays a pivotal role in cultivating a vibrant, intercultural atmosphere on our campus, extending support to international students, scholars, faculty, and staff through immigration sponsorship. OISS commits to ensuring a seamless integration process for those who are admitted, appointed, or employed by Washington University. Grounded in the belief that education can shape global perspectives, the OISS mission is to empower the Washington University international community with the knowledge and resources needed to navigate U.S. immigration compliance while guiding them with care and compassion at every step.

OISS has locations on both the Danforth Campus and the Medical Campus. For information about OISS locations, office hours, staff, and services, visit the Office for International Students and Scholars website, email oiss@wustl.edu, or call 314-935-5910.

Office of Military and Veteran Services

This office serves as the university's focal point for military and veteran matters, including transitioning military-connected students into higher education, providing and connecting students with programs and services, and partnering across campus and in the community. Services include advising current and prospective students on how to navigate the university and maximize Department of Defense and Veterans Affairs (VA) educational benefits, transition support, Veteran Ally training for faculty and staff, veteran-unique programming, and connecting students to campus and community resources. Military-connected students include veterans, military service members, spouses, dependent children, caregivers, survivors and Reserve Officer Training Corp cadets. There are two university policies that apply to students who still serve in the Armed Forces and students who use VA educational benefits:

- The Policy on Military Absences, Refunds and Readmissions applies to students serving in the U.S. Armed Forces and their family members when military service forces them to be absent or withdraw from a course of study.

- The Policy on Protections for VA Educational Benefit Users applies to students using VA education benefits when payments to the institution and the individual are delayed through no fault of the student.

The Office of Military and Veteran Services is located in Umrath Hall on the Danforth Campus. Please visit the Military and Veteran Services website or send an email to veterans@wustl.edu for more information.

Relationship and Sexual Violence Prevention (RSVP) Center

The RSVP Center offers free and confidential services including 24/7 crisis intervention, counseling services, resources, support and prevention education for all students on the Danforth Campus. The RSVP Center operates from a public health model and uses trauma-informed practices to address the prevalent issues of relationship and sexual violence. By providing support for affected students, it is our goal to foster post-traumatic growth and resilience and to help ensure academic retention and success. Our prevention efforts call for community engagement to engender an intolerance of violence and an active stance toward challenging cultural injustices that perpetuate such issues. Learn more at the RSVP Center website.

WashU Cares

WashU Cares assists the university with handling situations involving the safety and well-being of Danforth Campus students. WashU Cares is committed to fostering student success and campus safety through a proactive, collaborative and systematic approach to the identification of, intervention with and support of students of concern while empowering all university community members to create a culture of caring. If there is a concern about the physical or mental well-being of a student, please visit the WashU Cares website to file a report.

The Writing Center & Speaking Studio

The Writing Center & Speaking Studio — a free service — offers writing and public speaking support to all Washington University undergraduate and graduate students. Tutors will read and discuss any kind of work in progress, including student papers, senior theses, application materials, dissertations and oral presentations. The Writing Center staff is trained to work with students at any stage of the writing process, including brainstorming, developing and clarifying an argument, organizing evidence, and improving style. Rather than editing or proofreading, tutors will emphasize the process of revision and teach students how to edit their own work.

The Writing Center is located in Mallinckrodt Center on the lower level. Appointments are preferred and can be made online, but walk-ins will be accepted if tutors are available. Dedicated Undergraduate Walk-in Hours are held in the second half of each semester (after fall break and spring break) on Tuesday and Wednesday afternoons. Questions? Email writing@wustl.edu.

Student Health and Well-Being Services, Danforth Campus

The Student Health Center – Danforth Campus provides medical, psychiatric, and health promotion services for undergraduate and graduate students on the Danforth Campus. Please visit the Student Health Center – Danforth Campus website for more information about Health Center services and staff members.

Hours:

Monday, Tuesday, Thursday, and Friday: 8 a.m. - 5 p.m.

Wednesday: 10 a.m. - 5 p.m.

Saturday, Sunday, and university holidays: Closed

For after-hours care, students should access TimelyCare.

Medical Services

Medical Services staff members provide care for the evaluation and treatment of an illness or injury, preventive health care and health education, immunizations, nutrition counseling, sports medicine, travel medicine, and sexual health services. Student Psychiatry Services staff provide ongoing medication management for students to address their mental health concerns. Student Health Center providers are participating members of the Washington University in St. Louis Physician's Network. Any condition requiring specialized medical services will be referred to an appropriate specialist. The Health Center accepts health insurance plans that have met waiver criteria for the Student Health Insurance Plan and will be able to bill the plan according to plan benefits. The Student Health Insurance Plan requires a referral for medical care any time care is not provided at Student Health (except in an emergency). Call 314-935-6666 or visit the Student Health Center – Danforth Campus website to schedule an appointment.

Appointments are also available for the assessment and referral of students struggling with substance use.

The Student Health Center lab provides full laboratory services. Some tests can be performed in house. The remainder of all testing that is ordered by Student Health is completed by LabCorp. LabCorp serves as Student Health's reference lab, and it is a preferred provider on the student health insurance plan. This lab can perform any test ordered by Student Health Center providers or outside providers.

All incoming students must provide proof of immunization for measles, mumps, and rubella (i.e., two vaccinations after the age of one year old; a titer may be provided in lieu of the immunizations). Proof of receiving a meningococcal vaccine on or after the age of 16 is

required for all incoming undergraduate students. A TB test in the past six months is required for students entering the university who screen positive on the TB questionnaire found on the student portal. It is also recommended that before beginning their studies at WashU, all students will have received the tetanus diphtheria pertussis immunization, the hepatitis A vaccine series, the hepatitis B vaccine series, the HPV vaccine series, the meningitis B vaccine, and the varicella vaccine. Failure to complete the required forms will delay a student's registration and prevent their entrance into housing assignments. Please visit the Student Health Center website for complete information about immunization requirements and deadlines.

Health Promotion Services

Health Promotion Services staff and Peer Health Educators provide free programs and risk reduction information related to mental health, sexual health, alcohol/other drugs, and community care. For more information, visit the Zenker Wellness Suite in Sumers Recreation Center, consult the Health and Wellbeing Digital Library, follow us on Instagram (@washu_healthpromotion), and/or email wellness@wustl.edu. In 2018, this department launched the WashU Recovery Community to provide an opportunity for students in recovery from substance use to connect with other students with similar experiences.

Center for Counseling and Psychological Services (CCPS)

Hours:

Monday, Tuesday, Thursday, and Friday: 8 a.m. - 5 p.m.

Wednesday: 10 a.m. - 5 p.m.

Saturday, Sunday, and university holidays: Closed

For after-hours mental health support, students should access the TimelyCare app and request a "Talk Now" visit.

Located in the Student Health Center-Danforth Campus, CCPS is staffed by licensed professional staff members who work with students to resolve personal and interpersonal difficulties. These may include conflicts with or worry about friends or family, concerns about eating or drinking patterns, and feelings of anxiety and depression. Services include individual, group, and couples counseling; crisis counseling; and referral for off-campus counseling when students' needs can be better met outside of CCPS. All full-time students who pay the university health and wellness fee as part of their tuition are eligible for services. Visit the CCPS website or call 314-935-6695 to schedule an appointment during business hours. For additional information, visit the CCPS website or send an email to ccpscoordinator@wustl.edu.

Important Information About Health Insurance and Fees for Danforth Campus Students

All full-time, degree-seeking WashU students are automatically enrolled in the Student Health Insurance Plan upon completion of registration. Students may opt out of this coverage and receive a refund of the health insurance fee if they provide proof of existing comprehensive insurance coverage that meets all university requirements. Information concerning opting out of the student health insurance plan can be found online after June 1 of each year. All students must request to opt out by September 5 of *every year* in which they wish to be removed from the Student Health Insurance Plan. The Student Health Center provides billing services to many of the major insurance companies in the United States. Specific fees and copays apply to students using Medical Services and Student Psychiatric Services; these fees are billable to the students' insurance plans. More information is available on the Student Health Center – Danforth Campus website.

In addition, WashU has a health and wellness fee designed to improve the health and well-being of the campus community. It is assessed by the university, and it is entirely separate from health insurance. This fee helps support membership to the Summers Recreation Center, health education/prevention efforts, the Center for Counseling and Psychological Services, and TimelyCare.

Student Health Services, Medical Campus

For information about student health services on the Medical Campus, please visit the Student & Occupational Health Services page of the School of Medicine website.

Campus Security

The Washington University campus is among the most attractive in the nation, and it enjoys a safe and relaxed atmosphere. Personal safety and the security of personal property while on campus is a shared responsibility. Washington University has made safety and security a priority through our commitment to a full-time professional police department, the use of closed-circuit television, card access, extensive lighting initiatives based on Crime Prevention Through Environmental Design (CPTED) practices, shuttle services, emergency telephones, and ongoing educational safety awareness programs. The vast majority of crimes that occur on college campuses are crimes of opportunity, which can be prevented.

The best protection against crime is an informed and alert campus community. Washington University has developed several programs to help make everyone's experiences here safe and secure. An extensive network of emergency telephones — including more than 200 "blue light" telephones — is connected directly to the University Police

Department and can alert the police to a person's exact location. In addition to the regular shuttle service, an evening student walking/mobile escort service known as "Bear Patrol" and a mobile Campus Circulator shuttle are available on the Danforth Campus.

The Campus2Home shuttle will provide a safe ride home for those living in four designated areas off campus — Skinker-DeBaliviere, Loop South, north of the Loop, and just south of the campus — within these boundaries:

- North – Olive Blvd
- South – Clayton Road
- East – Union Blvd
- West – Hanley Road

Shuttles will run from 7:00 p.m. to 4:00 a.m. seven days a week during academic sessions. Rides should be requested via the TripShot app. Pickup locations to choose from are the Mallinckrodt Center, the Summers Welcome Center, and the Knight Center. The shuttle takes passengers directly to the front doors of their buildings. Shuttle drivers will then wait and watch to make sure passengers get into their buildings safely.

The University Police Department is a full-service organization staffed by certified police officers who patrol the campus 24 hours a day throughout the entire year. The department offers a variety of crime prevention programs, including a high-security bicycle lock program, computer security tags, personal safety classes, and security surveys. Community members are encouraged to download and install the WashU Safe personal safety app on their phones; this app allows users to call for help during emergencies, to use Friend Walk to track their walks on and off campus, and to access many additional safety features. For more information about these programs, visit the Washington University Police Department website.

WashU PD also has comfort dogs — Bear, Brookie, Misty, and Archie — on campus to support our students, faculty, and staff. In addition, there is a decompression/comfort room inside the police station at 6615 Shepley Drive on the South 40. This room offers a supportive, stress-free, and welcoming environment designed to promote wellness and connection with the officers and the comfort dogs. Students are welcome to walk in at any time, or they can schedule a visit by emailing wupddogs@wustl.edu to secure a dedicated time with the dogs.

In compliance with the Campus Crime Awareness and Security Act of 1990, Washington University publishes an annual report entitled *Safety & Security: Guide for Students, Faculty, and Staff — Annual Campus Security and Fire Safety Reports and Drug & Alcohol Abuse Prevention Program*. This report is available to all current and prospective students on the Danforth Campus and to university employees on the Danforth, North and West campuses. To request a hard copy, contact the Washington University Police Department, 6615 Shepley Drive, Clayton, MO 63105, 314-935-5555.

For information regarding protective services at the School of Medicine, please visit the Campus Safety page of the Washington University Operations & Facilities Management Department.

Student Complaints

WashU provides students with different processes to handle complaints depending on the nature of the complaint. The Student Feedback & Complaint Form provides information on the different avenues available, as well as a web-form for submitting complaints. Complaints submitted through the form are reviewed by the Office of the Vice Chancellor for Student Affairs and forwarded to the University office or department that would be responsible for addressing the complaint. Complaints may be made anonymously, but students have the option of providing contact information to receive a response regarding steps taken to resolve the complaint. The University's Whistleblower Protection Policy applies to students making good-faith complaints regarding violations of policy or unethical acts.

If a student has a complaint related to distance education, as a participant in the National Council for State Authorization Reciprocity Agreements (NC-SARA), WashU follows the SARA policy that provides for the resolution of complaints resulting from distance education courses, activities, and operations delivered by WashU to students who participate in such courses outside of the state of Missouri (including the District of Columbia, Puerto Rico, and the US Virgin Islands, but excepting California, which is not a member of NC-SARA). Under NC-SARA Policy Section 4.5 (Process for Resolving Complaints), students are asked to seek resolution of complaints first through WashU, as described above. If the complaint is not resolved, distance education students should contact the Missouri State Portal Entity:

Joshua Fischer, Program Specialist
Email: joshuafischer@dhewd.mo.gov
Phone: 573-751-2361
Missouri Department of Higher Education and Workforce Development
PO Box 1469
Jefferson City, MO 65102-1469

Students who participate in distance education courses and who reside in California may contact the Bureau for Private Postsecondary Education.

University Policies

Washington University has various policies and procedures that govern our faculty, staff and students. Highlighted below are several key policies of the university. Web links to key policies and procedures are available on the Office of the University Registrar website and on the University Policies page. Please note that the policies identified on these websites and in this *Bulletin* do not represent an entire repository of university policies, as schools, offices, and departments may implement policies that are not listed. In addition, policies may be amended throughout the year.

Application to Graduate

Students are required to apply for program completion in Workday, by the deadline relevant to the semester in which they intend to graduate, in order to be eligible for degree conferral. Additional information is available from the Office of the University Registrar.

Compliance with Section 103 of the Veterans Benefits and Transition Act of 2018

It is WashU's policy to not impose penalties on individuals using Veteran Education Benefits, including the assessment of late fees, the denial of access to classes, libraries or other institutional facilities, or the requirement to borrow additional funds to cover the student's inability to meet his or her financial obligations to the institution due to the delayed disbursement of a payment by the VA. This applies to individuals who submit their Certificate of Eligibility for entitlement to educational assistance to their VA School Certifying Official (SCO).

1. Students should submit a Certificate of Eligibility not later than the first day of a course for which the student wishes to use the entitlement for educational assistance. The SCO will advise the student to provide additional Documentation and information necessary for the proper certification of enrollment.
2. If a student does not receive their Certificate of Eligibility from the VA by the start of the academic term, the student should notify their SCO of their intent to use Veteran Education Benefits and should submit additional Documentation and forms as requested.
3. In cases where a student is unable to meet a financial obligation to the university because the amount of a disbursement from the VA is less than anticipated, the university will require additional payment from the student and will provide the student with a timeline for payment before assessing late fees. Students should contact their SCO for assistance.
4. Students may request certification for previous academic terms if they were eligible for benefits at the time for which they want to be certified. In cases where Veteran Education Benefits are used to certify previous academic terms, students are responsible for any late fees incurred prior to the date of the certification request. This excludes Yellow Ribbon benefits, which are not retroactive for previous fiscal years.

Courses and Credit

Academic Calendar

Washington University in St. Louis primarily follows a standard semester-based academic calendar: a fall and spring semester, each spanning 16 calendar weeks, including sessions of half-semester lengths and intersessions beginning before the term start date, and

a summer term of 13 weeks, including sessions of half-term length, an intersession beginning before the term start date, and 3-, 5- and 8-week lengths. The Doctor of Medicine program follows a yearlong calendar supporting modular curriculum delivery.

Credit Measure

Credit hours for undergraduate and graduate programs are awarded as “units” based on the University Statement on Credit, which is in alignment with the Federal definition found in 34 CFR 600.2.

Email Communication

Email is the mechanism for official communication with students at Washington University. Students are expected to read email communications from the university in a timely fashion.

All students will be individually assigned a University email address, which will be maintained in the University email directory. Official University communications will be sent to the student's University email address in order to ensure such communications reach the intended recipient.

With the exception of School of Medicine students, a student may have email forwarded from their assigned University email address to another email address of the student's choice. School of Medicine students are prohibited from forwarding their University-assigned email address to an email address external to the University other than @bjc.org and @va.gov email domains. Students who choose to have email forwarded to another email address do so at their own risk. The University is not responsible for email forwarded to any other email address. A student's failure to read official University communications sent to the student's University email address does not absolve the student of responsibility for awareness of and compliance with the content of the official communication. Faculty and administrators should use a student's University email address when communicating via email with the student. This policy will ensure that all students will be able to comply with course and other requirements communicated to them by email from course instructors and administrators.

Graduate Student Academic Integrity

Authority of Schools Over Graduate and Graduate Professional Students

1. Each school at the university may establish an academic integrity officer and/or a panel to hear and decide cases of alleged academic or professional misconduct by its graduate or graduate professional students. Schools that so choose are required to create procedures to govern the process of investigating and adjudicating the complaints filed.

- a. The school dean, or a designee, determines the composition of such a panel and the scope of the panel's authority, which will not exceed the parameters set out immediately below.
 - b. The panel has authority to impose or recommend appropriate sanctions to the school dean, including suspension or expulsion, if academic or professional misconduct is determined.
 - c. Appeals of decisions made by an academic and professional integrity panel of a school may be made to the school dean, whose decision is final. This includes decisions of a school's academic and professional integrity panel, where the panel is vested with such authority, and the panel's decision is to impose the sanctions of suspension or expulsion. Schools are permitted, but not required, to establish an intermediate level of appeal that must be completed before a final appeal to the dean.
 - d. Except for cases falling within the immediately preceding sub-bullet, any appeal from a decision of a dean of a school to suspend or expel a student will be made in accordance with the provisions of Section VI of the Code.
2. If a school does not establish an academic integrity officer or panel or if an established officer or panel fails to function, complaints of academic or professional misconduct against graduate or graduate professional students may be heard by Academic Integrity in the Office of the Provost, the Academic Integrity Board, or the Student Conduct Board.

Source: Washington University Student Conduct Code IVA.6

International Travel

WashU is concerned with the health, safety, and security of all members of our community while they are traveling outside of the United States of America.

The WashU International Travel Policy has been adopted to ensure a consistent set of travel standards to be followed by all units of the university. The policy applies to all international travel that is sponsored by, that is funded in any part by, or that involves registered academic experiences at Washington University in St. Louis.

The full text of the International Travel Policy is available on the WashU Global website.

Involuntary Leave

Policy Statement

The primary goals of this Involuntary Leave Policy (“policy”) are to protect the well-being and safety of Washington University students and the university community and to preserve the integrity of the university's academic, residential and administrative functions.

An involuntary leave under this policy will not be invoked unless the student's behavior is of such a serious nature that the continued presence of the student at the university is judged to threaten the safety, well-being or health of that student and/or others in the WashU community, or the ability of that student or others to engage in customary functions and activities at the university.

Examples of circumstances where this policy may be invoked include: suicidal threats; self-starvation or purging behavior; substance abuse or addiction; threats of harm to self or others; or disturbing, disruptive or destructive behavior.

This policy is not intended to replace disciplinary actions taken in response to violations of other university policies, including the university Student Conduct Code (SCC). A student who commits a violation of any university policy before taking voluntary leave or being placed on involuntary leave may be required to defend such charges before being considered for re-admission. Temporary suspension may also be issued in accordance with the SCC and this policy.

Policy Procedures

The vice chancellor for student affairs, the dean of any school or the designees of any of the aforementioned (referred to herein as "administrator") may be alerted to a student's concerning behavior from a variety of sources on campus including the student's advisor, a college dean, residential life staff, student affairs staff, health care providers or other faculty members. If the administrator deems it appropriate, the following procedures may be initiated.

1. **Notification:** Whenever possible, the administrator will notify the student that involuntary leave is under consideration and attempt to meet with the student to discuss his or her behavior. The administrator will provide the student with a copy of this policy. During the meeting, the administrator may choose to encourage the student to take a voluntary leave of absence, thereby eliminating the need to complete the procedures for involuntary leave. If the administrator believes that the student's well-being may be in imminent danger, he or she may proceed with a case conference without notifying and/or meeting with the student.
2. **Assembly of Case Conference Committee:** If the student is unable or chooses not to meet with the administrator, or if the student chooses not to take a voluntary leave of absence and the administrator still believes that involuntary leave may be appropriate, the administrator will convene a Case Conference Committee ("committee") of appropriate individuals or their designates to conduct a case conference regarding the need for an involuntary leave of absence. The committee may include the following:
 - The dean of the student's college or school
 - The assistant/associate vice chancellors for student affairs
 - Student conduct administrator
 - Director of the Student Health Center, Danforth Campus
 - Director of Counseling and Psychological Services
 - Assistant director of sorority and fraternity life
 - Executive director of Campus Life

- Chief of police
- Residential Life staff
- Director of the Office of International Students & Scholars
- Office of the General Counsel
- The student's advisor(s) or academic dean
- Professors, instructors, or staff who have observed the student's behavior of concern

3. **Committee Consideration:** The administrator should convene a Case Conference as soon as possible. During this conference, the committee should address whether and to what extent the student engages in, or is judged to be likely to engage in, behavior described in this policy. Where deemed necessary by the committee to facilitate a more informed recommendation, the committee may consult with other university administrators, faculty or staff familiar with the student. The committee may seek additional information from the student or enlist the assistance of other university faculty or staff members familiar with the student to consult with the student on behalf of the committee. If contacted, the student may refuse to provide information, but such refusal shall not limit the right of the committee to make a recommendation under this policy, nor limit the right of the university to mandate an involuntary leave.
4. **Committee Recommendation:** Following the Case Conference and the review of relevant information, the committee will make a written recommendation to the administrator. In lieu of recommending involuntary leave, the committee may make recommendations as to other conditions and/or requirements under which the student may remain at the university.
5. **Decision:** After review of the committee's recommendation, the administrator will decide whether to mandate an involuntary leave of absence, to mandate other requirements if the student remains at the university, or to permit the student to remain at the university with no additional requirements. The administrator will give the student written notice of this decision. This notice will provide (1) a brief summary of the reasons for decision, (2) the duration of the leave or a description of the requirements for the student to remain on campus, and (3) the steps that the student must take to request readmission if involuntary leave is invoked. The administrator may notify a parent or guardian, in accordance with the Family Educational Rights & Privacy Act ("FERPA"). Pursuant to FERPA, the administrator may also notify a spouse or partner upon obtaining the student's consent. Where an involuntary leave is mandated, the student must leave campus within the time frame established in the notice. In that event, the student's parent(s), guardian(s) or other persons may be asked to make arrangements for the safe removal of the student from the university community.

Option of Voluntary Leave

At any time prior to the administrator's decision, the student may choose to take voluntary leave. The university expects students to notify family members when they voluntarily withdraw from the university. However, when permitted by FERPA, the university retains the discretion to notify parents, guardians, spouses or partners if the student chooses to leave.

Records and Tuition

Leave may affect academic grades, credits and access to university housing or other facilities. Tuition, financial aid, and housing costs will be refunded in accordance with university policy. Regardless of whether leave is voluntary or involuntary, the student's status at the university will be updated in student systems to reflect a leave of absence, which includes a notation on the transcript indicating: "Leave of Absence" and the start date. When involuntary leave is not mandated, but a student is required to fulfill certain requirements to remain on campus, the student's in-progress status is unchanged and no notation will be made on the transcript.

Safety and Security

In cases involving serious and imminent threat to the safety, well being or health of the student or other members of the campus community, or to the ability of others in the university community to conduct their customary university functions and activities, the administrator may take immediate action to remove the student from the university community. In such event, the administrator may immediately notify the student's parent, guardian, spouse, partner, or other relevant individuals in accordance with FERPA. The parent, guardian or other person may be asked to make arrangements for the safe removal of the student from the university community pending a decision on involuntary leave.

Request for Re-Enrollment

When a student is placed on involuntary leave or accepts voluntary leave, a letter from the administrator to the student will outline the conditions for re-enrollment. Conditions for re-enrollment are at the discretion of the administrator. If the leave was for health or medical reasons, the administrator will work with the director of health services or his/her designate to formulate appropriate conditions of return, which may include requirements and/or guidance regarding treatment. A copy of this letter will be forwarded to the academic dean of the student's college or school and, where health-related, to the director of the Student Health Center.

When a student's voluntary or involuntary leave is not health-related, the procedures to request re-enrollment will be outlined in the administrator's letter.

The following process will guide re-enrollment for all students taking involuntary or voluntary leave of absence for a health-related reason:

1. The student must contact in writing both the academic dean and the director of the Student Health Center to request re-enrollment between June 1 and July 1 for the upcoming fall semester or November 1 and December 1 for the spring semester.
2. The student's health status must be reviewed by the director of the Student Health Center or his/her designate. As part of the review, the student may be asked to present written evidence that the student has been evaluated and completed follow-up measures recommended by the student's treating health care professional. This evidence may include a recitation of the health care professional's credentials, a description of their contact with the student, the evaluation method, the diagnosis, the recommended follow-up measures and the student's efforts to complete them. The student's efforts to complete those follow-up measures will be evaluated to determine whether the student used the time away from the university to address the issues that led to the separation and to acquire skills to facilitate a successful return to the university.
3. A recommendation regarding medical eligibility for re-enrollment will be made by the director of the Student Health Center or his/her designate and forwarded to the student's academic dean and the administrator. The academic dean, in consultation with the administrator, will determine academic eligibility for re-enrollment and will communicate in writing the final decision and any conditions to the student.

Appeal of Administrator Decisions

A student may submit, within 24 hours of receiving the written decision from the administrator, a written appeal to the provost who will review the written record only. A decision to affirm or reverse the administrator's decision will be rendered within 48 hours. The decision of the administrator will be affirmed if supported by substantial information appearing in the record of the case. The decision of the provost is final.

Confidentiality

The university will strive to protect, to the greatest extent possible, the confidentiality of students involved in matters of voluntary or involuntary leave. Because the university has an obligation to preserve the security of its community, the university cannot guarantee complete confidentiality where it would conflict with the university's obligation to investigate meaningfully matters which may threaten a student's health or safety or the safety and security of the university community. When some disclosure of the university's information or sources is necessary, that disclosure will be limited to the extent possible. Medical records of a student will be protected in accordance with the WashU Student Health Center Notice of Privacy Practices. The university will, to the extent permitted by law, keep confidential all records of committee reviews. The records maintained by the Case Conference Committee will be available only to the administrator.

and other university officials in accordance with FERPA. All records will be destroyed after a period of ten (10) years from the date of final decision on involuntary leave or the student's decision to take voluntary leave.

Nondiscrimination Statement

Washington University encourages and gives full consideration to all applicants for admission, financial aid, and employment. The university does not discriminate in access to, treatment during, or employment in its programs and activities on the basis of race, color, national origin (including shared ancestry or ethnic characteristics), citizenship (where prohibited by federal law), age, religion, sex, sexual orientation, gender identity or expression, veteran status, disability, or genetic information.

Policy on Discrimination and Harassment

Washington University is committed to having a positive learning and working environment for its students, faculty, and staff. University policy prohibits discrimination on the basis of race, color, age, religion, sex, sexual orientation, gender identity or expression, national origin (including shared ancestry or ethnic characteristics), citizenship (where prohibited by federal law), veteran status, disability, or genetic information. Harassment based on any of these classifications is a form of discrimination; it violates university policy and will not be tolerated. In some circumstances, such discriminatory harassment may also violate federal, state, or local law. A copy of the Discrimination and Harassment Policy is available on the Human Resources website.

Conduct Prohibited by Title VI

Title VI of the Civil Rights Act of 1964 prohibits discrimination based on race, color, or national origin in programs that receive federal financial assistance. Discrimination on the basis of race, color, or national origin includes discrimination or harassment based on a person's actual or perceived 1) shared ancestry or ethnic characteristics; or 2) citizenship or residency in a country with a dominant religion or distinct religious identity (such as individuals who are Hindu, Jewish, Muslim, Buddhist, or Sikh). Such conduct is prohibited by the Discrimination and Harassment Policy.

Sexual Harassment

Sexual harassment is a form of discrimination that violates university policy and will not be tolerated. It is also illegal under state and federal law. Title IX of the Education Amendments of 1972 prohibits discrimination based on sex (including sexual harassment and sexual violence) in the university's educational programs and activities. Title IX also prohibits retaliation for asserting claims of sex discrimination. The university has designated the Title IX Coordinator identified below to coordinate its compliance with and response to inquiries concerning Title IX.

For more information or to report a violation under the Policy on Discrimination and Harassment, please contact the following individuals:

Discrimination and Harassment Response Coordinators

Apryle Gladney, Vice Chancellor and Chief Human Resources Officer

Phone: 314-935-1252

apryle.gladney@wustl.edu

Gillian Lawson, Director of Investigations, Office of Institutional Equity

Phone: 314-935-1139

oie-investigations@wustl.edu; gillian.boscan@wustl.edu

Office: The Link in the Loop

Address: 621 N. Skinker Blvd., Suite 300, St. Louis, MO 63130

WashU University Reporting Hotline

Title IX Coordinator

Jessica Kennedy, Director & Title IX Coordinator, Office of the Provost

Phone: 314-935-3118

jwkennedy@wustl.edu

Office: Umrath Hall, Room 001

Address: One Brookings Drive, MSC 1175-0153-0B, St. Louis, MO 63130

Inquiries or complaints regarding civil rights may also be submitted to the United States Department of Education's Office of Civil Rights at 400 Maryland Avenue, SW, Washington, DC 20202-1100; by visiting the U.S. Department of Education website; or by calling 800-421-3481.

Student Academic Records and Transcripts

Under the Family Educational Rights and Privacy Act of 1974 (FERPA) — Title 20 of the United States Code, Section 1232g, as amended — current and former students of the university have certain rights with regard to their educational records. Washington University's FERPA policy is available via the Office of the University Registrar's website.

All current and former students may request official Washington University transcripts of their academic records from the Office of the University Registrar. Current students may print unofficial transcripts for their personal use from Workday. Instructions and additional information are available on the Office of the University Registrar's website.

Washington University does not release nor certify copies of transcripts or other academic documents received from other schools or institutions. This includes test score reports and transcripts submitted to Washington University for purposes of admission or evaluation of transfer credit.

Academic records may not be altered after degree conferral, at which time records are considered closed or sealed.

Student Conduct

The Washington University in St. Louis Student Conduct Code (“the Code”) sets forth community standards and expectations for university students. These community standards and expectations are intended to foster an environment conducive to working, learning, and inquiry. Each student is held to the expectations outlined in the Code.

Freedom of thought and expression as well as respect for different points of view are essential to the university’s academic mission. Nothing in the Code should be construed to limit the lawful, free, and open exchange of ideas and viewpoints, even if that exchange proves to be offensive, distasteful, or disturbing to some. However, such speech must conform to university policies.

The Code also describes general procedures that may be used to ensure that these standards and expectations are upheld by all students. The university is committed to ensuring that students adhere to university policies, take responsibility for their actions, and recognize how their choices may affect others.

Complaints against students that include allegations of sex-based discrimination — including sexual harassment, sexual assault, dating violence, domestic violence and stalking — in violation of the Student Conduct Code are governed by the procedures found on the Gender Equity and Title IX Compliance Office website. These procedures are also available in hard copy from the Title IX Coordinator or the director of the Office of Student Conduct and Community Standards.

Students may be accountable to both governmental authorities and to the university for acts that constitute violations of law and the Student Conduct Code.

For a complete copy of the Student Conduct Code, visit the Student Affairs website.

For more information, visit the Student Conduct and Community Standards website.

Student Financial Responsibility

Communication

Washington University in St. Louis uses University-assigned email accounts and University-supported systems for communication with students and authorized users. Washington University will also contact students via personal email addresses, cellular phone numbers, or wireless devices from time to time regarding the Student Account or other general information. Students are responsible for reading University communications in a timely manner.

Promise to Pay

When students register for any course at or receive any service from Washington University in St. Louis, they accept full responsibility to pay all tuition, fees, and other associated charges assessed as a result of registration and/or receipt of services such as housing, dining, and other University-provided items that exceed financial support provided by the University, the University payment plan, and/or third parties by the scheduled due dates shown on the WebSTAC student account. Failure to attend class or receive a bill does not absolve students of financial responsibility as described above.

Failure to Pay

University policies regarding Student Accounts (including payment options, late fees, holds, and refunds) are published on the University’s Financial Services website. If a student fails to pay the Student Account balance by the scheduled due dates, the University will place a financial hold preventing the student from registering for future courses and could assess a late fee on the past due portion until the past due amount is paid in full. Failure to pay will result in a Delinquent Student Receivable Account. Delinquent Student Accounts will be referred to University’s Collection Services department. Collection Services may report the Delinquent Student Account to one or more national credit bureaus, refer the Delinquent Student Account to a third-party collection agency, and pursue all legal and equitable remedies to collect the monies owed to the University.

Student Health

Drug and Alcohol Policy

Washington University is committed to maintaining a safe and healthy environment for members of the university community by promoting a drug-free environment as well as one free of the abuse of alcohol. Violations of the Washington University Drug and Alcohol Policy will be handled according to existing policies and procedures concerning the conduct of faculty, staff, and students. This policy is adopted in accordance with the Drug-Free Workplace Act and the Drug-Free Schools and Communities Act.

Tobacco-Free Policy

Washington University is committed to providing a healthy, comfortable and productive work and learning environment for all students, faculty, and staff. Research shows that tobacco use in general, including smoking and breathing secondhand smoke, constitutes a significant health hazard. The university strictly prohibits all smoking and other uses of tobacco products within all university buildings and on university property, at all times. A copy of our complete Tobacco-Free and Smoke-Free Policy is available on the Washington University Human Resources website.

Medical Information

Entering students in Danforth Campus programs must provide medical information to the Student Health Center – Danforth Campus. This will include the completion of a health history and a record of all current immunizations.

If students fail to comply with these requirements prior to registration, they must obtain the required vaccinations and tests at the Student Health Center – Danforth Campus or in the community. Students will be assessed the costs of the vaccinations and/or tests. Students will be unable to complete registration for classes until all health requirements have been satisfied.

Noncompliant students may be barred from classes and from all university facilities, including housing units, if in the judgment of the university their continued presence would pose a health risk to themselves or to the university community.

Medical and immunization information is to be given via the student health portal on the Student Health Center – Danforth Campus website. All students who have completed the registration process should access the student health portal on the website. Students should fill out the form and follow the instructions for transmitting it to the Student Health Center – Danforth Campus. Student information is treated securely and confidentially.

Entering students in Medical Campus programs must follow the requirements as outlined on the WashU Medicine Student Health Services website.

Student Status: Expulsion and Dismissal

The terms *expulsion* and *dismissal* are used to indicate distinct types of involuntary separation of a student from the university or from their program of study.

- *Expulsion* refers to a permanent removal from the university. A student who is expelled is not eligible to return to a prior program of study nor to enter a new program of study.
- *Dismissal* refers to a permanent separation from a specific program of study or school. A student may apply to begin a different program of study and may or may not be admitted according to the standards and practices of that program or school.

Time Away and Reinstatement

Degree-seeking students may be eligible to request a leave of absence for health or other personal reasons (e.g., family, military service, professional obligations, religious mission). The mechanism and process are described on the Office of the University Registrar's website. Such leaves may exceed no more than two years from the effective date of the leave; individual programs' policies may limit

students to shorter leaves. Students must verify their school and program policies and any other relevant requirements related to immigration or financial aid/support policies. Students who have not requested and received approval for reinstatement after two years will have their records withdrawn.

Required enrollment reporting to the federal government will reflect a leave of absence for 180 days after it is enacted; any longer duration of institutional leave is recorded in their systems as a withdrawal.

Students on approved leave of absence will retain access to their Washington University email addresses, and to Workday to review their records. Access to other University privileges such as recreation facilities and libraries as well as participation in activities are paused during a leave of absence.

Students are expected to request reinstatement to in-progress status to resume studies via the process outlined on the Office of the University Registrar's website. Depending on the nature of their leave, additional steps or documentation may be required and must be provided to appropriately consider the request. Students whose records have been withdrawn as a result of two years of inactivity may be allowed, depending on program-specific policies regarding the maximum time allowed to complete the program of study, to request to re-enter their programs. In these cases, additional items may be required of the student depending on the circumstances, the length of time away, and whether their program of study has undergone curricular revisions since their enrollment.

Undergraduate Student Academic Integrity

Effective learning, teaching, and research all depend upon the ability of members of the academic community to trust one another and to trust the integrity of work that is submitted for academic credit or conducted in the wider arena of scholarly research.

Such an atmosphere of mutual trust fosters the free exchange of ideas and enables all members of the community to achieve their highest potential.

In all academic work, the ideas and contributions of others must be appropriately acknowledged, and the work of a student that is presented as original must be, in fact, original. Faculty, students, and administrative staff all share the responsibility of ensuring the honesty and fairness of the intellectual environment at Washington University in St. Louis.

Scope and Purpose

This statement on academic integrity applies to all undergraduate students at Washington University. Graduate students may be governed by policies in each graduate school or division. To the extent a graduate school or program has not adopted its own academic integrity policy, the provisions of this policy will apply. All students are expected to adhere to the highest standards of behavior.

The purpose of the statement is twofold:



1. To clarify the university's expectations with regard to undergraduate students' academic behavior; and
2. To provide specific examples of academic misconduct (the examples are only illustrative, *not* exhaustive).

This policy and statement were endorsed by the Faculty Senate Council. Any changes to the policy are to be reviewed by the Faculty Senate Council, as described in the Faculty Senate Council bylaws.

Violations of This Policy Include but Are Not Limited to the Following:

1. Plagiarism

Plagiarism consists of taking someone else's ideas, words or other types of work product, and presenting them as one's own. To avoid plagiarism, students are expected to be attentive to proper methods of documentation and acknowledgement. To avoid even the suspicion of plagiarism, a student must always:

- Enclose every quotation in quotation marks and acknowledge its source.
- Cite the source of every summary, paraphrase, abstraction or adaptation of material originally prepared by another person and any factual data that is not considered common knowledge. Include the name of author, title of work, publication information and page reference.
- Acknowledge material obtained from lectures, interviews or other oral communication by citing the source (name of the speaker, the occasion, the place and the date).
- Cite material from the internet or material generated by an artificial intelligence as if it were from a traditionally published source. Follow the citation style or requirements of the instructor for whom the work is produced.

2. Cheating on an Examination

A student must not receive or provide any unauthorized assistance on an examination. During an examination, a student may use only materials authorized by the faculty.

3. Copying or Collaborating on Assignments Without Permission

When a student submits work with their name on it, this is a written statement that credit for the work belongs to that student alone. If the work was a product of collaboration, each student is expected to clearly acknowledge in writing all persons or artificial intelligences who contributed to its completion.

Unless the instructor explicitly states otherwise, it is dishonest to collaborate with others when completing any assignment or test, performing laboratory experiments, writing and/or documenting computer programs, writing papers or reports, and completing problem sets.

If the instructor allows group work in some circumstances but not others, it is the student's responsibility to understand the degree of acceptable collaboration for each assignment and to ask for clarification if necessary.

To avoid cheating or unauthorized collaboration, a student should never:

- Use, copy, or paraphrase the results of another person's work or material generated by an artificial intelligence and represent that work as their own, regardless of the circumstances.
- Refer to, study from, or copy archival files (e.g., old tests, homework, solutions manuals, or backfiles) that were not approved by the instructor.
- Copy another's work or to permit another student to copy their work.
- Submit work as a collaborative effort if they did not contribute a fair share of the effort.

4. Fabrication or Falsification of Data or Records

It is dishonest to fabricate or falsify data in laboratory experiments, research papers, reports or in any other circumstances; to fabricate source material in a bibliography or "works cited" list; or to provide false information on a résumé or other document in connection with academic efforts. It is also dishonest to take data developed by someone else and present them as one's own.

Examples of falsification include:

- Altering information on any exam, problem set, or class assignment being submitted for a re-grade.
- Altering, omitting, or inventing laboratory data to submit as one's own findings. This includes copying laboratory data from another student to present as one's own; modifying data in a write-up; and providing data to another student to submit as their own.

5. Other Forms of Deceit, Dishonesty, or Inappropriate Conduct

Under no circumstances is it acceptable for a student to:

- Submit the same work, or essentially the same work, for more than one course without explicitly obtaining permission from all instructors. A student must disclose when a paper or project builds on work completed earlier in their academic career.
- Request an academic benefit based on false information or deception. This includes requesting an extension of time, a better grade or a recommendation from an instructor.
- Make any changes (including adding material or erasing material) on any test paper, problem set or class assignment being submitted for a re-grade.
- Willfully damage the efforts or work of other students.
- Steal, deface, or damage academic facilities or materials.
- Collaborate with other students planning or engaging in any form of academic misconduct.

- Submit any academic work under someone else's name other than their own. This includes but is not limited to sitting for another person's exam; both parties will be held responsible.
- Violate any rules or conditions of test-taking or other course assessment (e.g., bringing materials or devices into an exam room when disallowed).
- Engage in any other form of academic misconduct not covered here.

This list is not intended to be exhaustive. To seek clarification, students should ask the professor or teaching assistant for guidance.

Reporting Misconduct

Faculty Responsibility

Faculty and instructors are strongly encouraged to report incidents of student academic misconduct to the academic integrity coordinators in the Office of the Provost in a timely manner (normally within five business days of discovery) so that the incident may be handled fairly and consistently across schools and departments. Teaching assistants and assistants in instruction are expected to report instances of student misconduct to their supervising instructors. Faculty members are expected to respond to student concerns about academic integrity violations in their courses.

Student Responsibility

If a student observes others violating this policy, they are strongly encouraged to report the misconduct to the instructor, to seek advice from the academic integrity coordinator in the Office of the Provost, or to address the student(s) directly.

Exam Proctor Responsibility

Exam proctors are expected to report incidents of suspected student misconduct to the course instructor and/or the Disability Resources staff, if applicable.

Procedure

Jurisdiction

This policy covers all undergraduate students, regardless of their college of enrollment, as well as graduate and professional students whose schools and programs do not have a separate policy and procedure. Cases will be heard by a panel drawn from an Academic Integrity Board made up of faculty and students representing the undergraduate schools and participating graduate programs.

Student Rights and Responsibilities in a Hearing

A student accused of an academic integrity violation, whether by a professor, teaching/graduate assistant, academic integrity coordinator or student is entitled to:

- A presumption of non-responsibility unless and until a panel determines that, based upon the evidence, it is more likely than not that the student engaged in a violation of academic integrity under this policy.
- Request a mediation/facilitation session prior to a hearing.
- Review the written evidence in support of the charge.
- Ask relevant questions.
- Offer an explanation as to what occurred.
- Present relevant material that would cast doubt on the correctness of the charge.
- Determination of the validity of the charge by an unbiased and objective panel and generally without reference to any past record of misconduct.

When responding to a charge of an academic integrity violation, a student may:

- Deny the charges and request a hearing in front of an Academic Integrity Board panel.
- Admit the charges and request a hearing to determine recommended sanction(s).
- Admit the charges and accept the imposition of sanctions by the academic integrity coordinator without a committee hearing.
- Request a leave of absence from the university. The academic integrity matter must be resolved prior to re-enrollment. A notation will be placed on the student's transcript indicating there is an unresolved academic integrity matter pending.
- Request to withdraw permanently from the university with a transcript notation that there is an unresolved academic integrity matter pending.

A student has the following responsibilities in resolving the charge of academic misconduct:

- Admit or deny the charge. This will determine the course of action to be pursued.
- Provide truthful information regarding the charges. It is a student code violation to provide false information to the university or anyone acting on its behalf.

Sanctions

If Found *Not* in Violation of the Academic Integrity Policy

If the charges of academic misconduct are not proven, no record of the allegation will appear on the student's transcript.

If Found in Violation of the Academic Integrity Policy

If, after a hearing, a student is found responsible for violation of the academic integrity policy or if a student has admitted to the charges prior to a hearing, the academic integrity coordinator may impose sanctions, including but not limited to the following:

- Issue a formal written reprimand.
- Impose educational sanctions, such as completing a workshop on plagiarism or academic ethics.
- Recommend to the instructor that the student fail the assignment. (A grade is ultimately the prerogative of the instructor.)
- Recommend to the instructor that the student fail the course.
- Recommend to the instructor that the student receive a course grade penalty less severe than failure of the course.
- Place the student on disciplinary probation for a specified period of time or until defined conditions are met. The probation will be noted on the student's transcript and internal record while it is in force.
- Impose suspension or expulsion.

Additional educational sanctions may be imposed. This list is not intended to be exhaustive.

A hearing panel may also elect to refer their recommended sanctions to the SCB Chairperson for determination if, for example, the recommendation departs from their standard recommendations.

Withdrawing from the course will not prevent the academic integrity coordinator or hearing panel from adjudicating the case, imposing sanctions, or recommending grade penalties, including a failing grade in the course.

A copy of the sanction letter will be placed in the student's academic file and may be reported in accordance with the Policy on Reporting of Student Conduct Violations.

Appeals

If a student believes the panel did not conduct a fair hearing or if a student believes the sanction imposed is excessive (i.e., suspension or expulsion), they may seek an appeal within 14 days of the original decision. For cases in which the decision resulted in suspension or expulsion, the appellate officer will be the Vice Provost of Educational Initiatives or the Vice Provost for Graduate Education. For all other cases, the appellate officer will be the Chair of the Student Conduct Board. Appeals are governed by Section VI of the university Student Conduct Code.

Administrative Record-Keeping Responsibilities

It is the responsibility of the academic integrity coordinators to keep accurate, confidential records concerning academic integrity violations. When a student has been found responsible for an academic integrity violation, a letter summarizing the allegation, the outcome, and the sanction will be placed in the student's official conduct file and may be reported out in accordance with the Policy on Reporting of Student Conduct Violations.

In addition, a report of the outcome of every formal accusation of student academic misconduct will be shared with the director of university student conduct programs, who shall maintain a record of each incident.

Multiple Offenses

When a student is formally accused of academic misconduct and a hearing is to be held, the academic integrity coordinator shall query the Office of Student Conduct and Community Standards (OSCCS) about the student(s) accused of misconduct. OSCCS shall provide any information in the OSCCS records concerning prior code violations of that student to the integrity coordinator. Such information will be used in determining sanctions if the student is found responsible for an academic integrity violation in the present case. Evidence of past misconduct generally may not be used to resolve the issue of whether a student has committed a violation in a subsequent case unless the hearing chair deems it relevant.

Reports to Faculty and Student Body

Periodic (at least annual) reports will be made to the students and faculty of their school concerning accusations of academic misconduct and the outcomes, without disclosing specific information that would allow identification of the student(s) involved.

*Endorsed by the Faculty Senate Council on March 16, 2010
Effective July 1, 2010
Updated December 4, 2014*

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Updated April 18, 2024*

University Affiliations

The accrediting organizations and memberships of the different areas of Washington University are listed below.

Additional information about professional and specialized accreditation can be found on the Office of the Provost website.

Washington University in St. Louis

Accreditation

- Higher Learning Commission

Memberships

- American Academy of Arts & Sciences
- American Association of Colleges & Universities
- American Council of Learned Societies
- American Council on Education
- Association of American Universities
- Hispanic Association of Colleges and Universities
- Independent Colleges and Universities of Missouri
- National Association of Independent Colleges and Universities
- National Council for State Authorization Reciprocity Agreements
- Universities Research Association

College of Arts & Sciences

Memberships

- American Academy of Physician Associates
- American Camp Association
- Association for Pre-College Program Directors
- Association of University Summer Sessions
- Diversity Abroad
- Forum on Education Abroad
- Higher Education Protection Network
- International Center for Academic Integrity
- International Educational Exchange
- Midwest Association of Pre-Law Advisors
- National Academic Advising Association
- National Association of Advisors for the Health Professions
- National Association of Fellowships Advisors
- North American Association of Summer Sessions
- Professional and Organizational Development Network

Office of Graduate Studies, Arts & Sciences

Accreditation — Office of Graduate Studies

- American Psychological Association Commission on Accreditation
- Psychological Clinical Science Accreditation System

Memberships

- American Academy of Physician Associates
- Association of Graduate Schools
(Founding member)
- Council of Graduate Schools
(Founding member)
- Midwest Association of Pre-Law Advisors
- Pod Network
- Student Affairs Administrators in Higher Education
- The Council of Independent Colleges

Sam Fox School of Design & Visual Arts

Accreditation — College of Art

- National Association of Schools of Art & Design
(Founding member)

Accreditation — College of Architecture

- Master of Architecture: National Architectural Accrediting Board
- Master of Landscape Architecture: Landscape Architectural Accreditation Board

Membership — College of Architecture

- Association of Collegiate Schools of Architecture

Accreditation — Mildred Lane Kemper Art Museum

- American Alliance of Museums

Membership — Mildred Lane Kemper Art Museum

- Association of Academic Museums and Galleries
- Association of Art Museum Directors
- College Art Association

Olin Business School

Accreditation

- Association to Advance Collegiate Schools of Business International
(Charter member since 1921)

McKelvey School of Engineering

Accreditation

- In the McKelvey School of Engineering, many of the undergraduate degree programs are accredited by the Engineering Accreditation Commission of ABET.

Membership

- American Society for Engineering Education

School of Law

Accreditation

- American Bar Association

Memberships

- American Association of Law Libraries
- American Society of Comparative Law
- American Society of International Law
- Association of Academic Support Educators
- Association of American Law Schools
- Central States Law Schools Association
- Clinical Legal Education Association
- Equal Justice Works
- Mid-America Association of Law Libraries
- Mid-America Law Library Consortium

- National Association for Law Placement
- National Association of Law Student Affairs Professionals
- Southeastern Association of Law Schools

School of Medicine

Accreditation

- American Speech-Language-Hearing Association, Council on Academic Accreditation in Audiology and Speech-Language Pathology (ASHA CAA)
- Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC)
- Liaison Committee on Medical Education
- Council on Education of the Deaf (CED)
- Missouri Department of Elementary and Secondary Education (DESE)
- American Occupational Therapy Association, Accreditation Council for Occupational Therapy Education (ACOTE)
- American Physical Therapy Association, Commission on Accreditation in Physical Therapy Education (CAPTE)
- Accreditation Council for Genetic Counseling (ACGC)
- Accreditation Council for Continuing Medical Education (ACCME)
- Accreditation Council for Pharmacy Education (ACPE)
- American Nurses Credentialing Center (ANCC)
- Association of Regulatory Boards of Optometry's Council on Optometric Practitioner Education (ARBO/COPE)
- Joint Accreditation for Interprofessional Continuing Education
- Accreditation Council for Graduate Medical Education (ACGME)

Membership

- Association of American Medical Colleges

School of Public Health

Accreditation

- Council on Education for Public Health

Affiliation

- Association of Schools and Programs of Public Health

Brown School

Accreditation

- Council on Social Work Education



School of Continuing & Professional Studies

Memberships

- American Association of Collegiate Registrars and Admissions Officers
- Council for Adult and Experiential Learning
- International Center for Academic Integrity
- National Academic Advising Association
- National Association of Student Personnel Administrators
- University Professional and Continuing Education Association

Note: Business-related programs in the School of Continuing & Professional Studies are not accredited by the Association to Advance Collegiate Schools of Business International.

University Libraries

Membership

- Association of Research Libraries



Graduate Policies

Please expand the sections below for more information about WashU's graduate policies and guidelines.

Academic Load Status for Financial Aid, Immigration, and Enrollment Verification

Graduate (Fall, Spring)

Status	Enrolled Units of Credit
Full time	9+ units
Half time	4.5-8.99 units
Less than half time	Fewer than 4.5 units

Graduate (Summer)

Status	Enrolled Units of Credit
Full time	6+ units
Half time	3-5.99 units
Less than half time	Fewer than 3 units

Certain courses may, due to appropriate curriculum and monitoring circumstances, be encoded to carry a load value higher than the actual academic credit awarded. Examples include certain engineering co-op experiences, doctoral research study and select clinical or practicum courses.

Registration in Courses

Registration dates are published in advance on the Office of the University Registrar's website. Late registration after the term begins is permitted only until the "add/drop" deadline relevant to a student's program. Students will not earn credit for courses in which they are not duly registered. Students may not register in courses that have conflicting meeting times.

Students may drop a course by the published deadline found on the Office of the University Registrar's website; dropped courses do not appear on the permanent academic record, and no grade is recorded. Students may withdraw from a course after the drop deadline and until the published withdrawal deadline. A withdrawal will result in a W notation associated with the course on the permanent record, including the transcript. Students who wish to drop or withdraw from a course are expected to follow steps to do so by the appropriate deadline. Failure to drop a course or withdraw by the published deadline may result in a failure of the course, and the transcript will reflect the failing grade.

Transfer Credit

Transfer credit is recorded on a student's permanent record. Courses transferred from other institutions of higher education do not have grades or grade points awarded and therefore do not apply toward a student's GPA.

Institutionally, Washington University participates in the Inter-University Exchange Program. Courses taken at Saint Louis University and the University of Missouri–St. Louis, according to the parameters documented, are approved to transfer to Washington University. The School of Law has a specific agreement in place with Saint Louis University for JD students only and under certain circumstances. Other transfer credit policies vary by school and program. Details may be found in the relevant academic sections of this *Bulletin*.

Tuition and Cost of Attendance

The cost of a Washington University education varies by school and, in some cases, by program. Tuition rates and fees are available through the Office of Financial Planning and Budget and are typically listed in greater detail (including fees and financial support options and procedures) on school websites.

Withdrawals and Refunds

If a student withdraws from Washington University after classes have begun, they must promptly file a request to withdraw in order to have appropriate registration and refund policies apply. These timelines vary by school and, in some cases, by program. Students should refer to the appropriate sections of this *Bulletin* for details.

University PhD Policies & Requirements

Academic PhD Programs

The following university-wide policies and practices apply to all PhD students regardless of school affiliation. They are specific to PhD program administration and PhD student experience. Schools/divisions may set stricter standards for students within their ambit, but they may not set standards that fall below university-wide policies. This page *does not* include those policies and practices that apply to the student community as a whole (e.g., the University Student Conduct Code).

Academic and Professional Integrity for PhD Students

The Academic and Professional Integrity Policy for PhD Students (PDF) continues to apply to all PhD students on the Danforth and Medical campuses, including dual-degree students when one of the degree programs is a PhD program.

Involuntary Leave of Absence

The Involuntary Leave of Absence Policy that applies to undergraduates was adopted to apply to all PhD students in 2014.

PhD Student Support Policies and Resources

New Child Leave

Full-time PhD students may request a New Child Leave to assume care for a new child. They should maintain their full-time student status. Students on New Child Leave are not expected to participate in mentored teaching or research experience for up to 60 consecutive calendar days (8 weeks) and will receive their current stipend support during this 60-day period. Students may request additional time off via a leave of absence without receiving a stipend (for up to a full semester) if approved by the student's department/program.

New Child Leave does not affect the student's full-time status and will not appear on the student's official transcript. New Child Leave must be taken within the first year after the child's date of birth or adoption. Students should contact their department/program to request a New Child Leave. Students who receive support from external agencies should consult the policies and guidelines of the sponsor as well as their Vice Dean or designee before requesting a New Child Leave.

Child Daycare Subsidy

The Child Daycare Subsidy is sponsored by WashU, and its purpose is to help PhD students with children under their care (who meet the requisite eligibility criteria) to meet the costs of child daycare while they pursue their studies.

The amount of the Child Daycare Subsidy awarded to eligible applicants is based on their financial need, the number of children they have enrolled in child daycare facilities, their child daycare expenses, and available funding. Eligible PhD students can expect the following:

- For one child, the maximum award is \$3,550 per Fall/Spring semester.
- For two children, the maximum award is \$4,550 per Fall/Spring semester.
- For three or more children, the maximum award is \$5,550 per Fall/Spring semester.

The subsidy amount cannot exceed the cost of the daycare facility.

The application is available on the Office of the Provost website.

Financial Policies

PhD Student Minimum Financial Award

The education of PhD students represents a significant commitment on the part of both WashU and the students admitted/enrolled. WashU typically funds most full-time PhD students for a minimum of five years (with the exception of post-professional PhD programs in the School of Medicine). Funding typically consists of full tuition scholarship and financial support to defray living expenses. Financial support may also be referred to as stipends or fellowships. Such financial support may be sourced internally from university-wide fellowships such as the Olin Chancellor's Fellowship (OCF), the McDonnell International Scholars Academy (p. 210), or school/program/department funds or from external sources (e.g., external research contracts and grants, external fellowships such as NSF GRFP).

The minimum PhD financial support rate for the 2026-27 academic year is \$37,853 annually, dispersed on a monthly basis while the student is enrolled full time. The rate applies to all PhD programs with the exception of post-professional specialty programs in the School of Medicine. Departments, schools, cross-school interdisciplinary programs, and other fellowship programs may choose to offer a rate higher than the established minimum, but they must do so for all students in their cohort. The eligibility criteria for PhD students receiving such financial support are outlined in the PhD Student Funding section below.

Students admitted to a part-time PhD program or on a part-time basis are not eligible for this minimum financial award.

PhD Student Funding

Financial support at or above the university-wide PhD minimum stipend rate allows PhD students to focus on their programmatic requirements, enabling them to make expeditious progress toward degree completion. This section predominantly pertains to PhD students, but it may apply to other graduate and professional students receiving financial support from the university.

Eligibility and Status

Students receiving university financial support must do the following:

- Enroll and maintain full-time student status in a graduate or professional program during the academic year;
- Make satisfactory academic progress in accordance with their degree program requirements; and
- Report to their degree program and university fellowship program (if applicable) any additional financial award(s) they receive or employment they engage in as outlined in this policy.

Because graduate students sometimes receive funding from multiple sources, it is the responsibility of the student, the student's department/degree program, and the Principal Investigator (if applicable) to understand and abide by the terms and conditions of each funding source.

Funding From Multiple Sources

Eligible students are encouraged to seek additional fellowships from external agencies. In addition to the funding amount, which can be more generous than that of a university financial award, these external fellowships are prestigious; they provide valuable training, experiences, and resources, and they enhance future career opportunities. In addition, securing external funding to support training and research is often an important component of the professional development of graduate students.

PhD students receiving university financial support who also receive an external fellowship or stipendiary award *may not* combine or "stack" the external award with the university financial support.* Students receiving an external fellowship or stipendiary award have two options.

Option 1: Supplementation of an External Fellowship or Stipendiary Award

If the sum of all external fellowship or stipendiary awards is less than the university financial support, the university funds may supplement the total amount of external funding to bring the student up to their guaranteed university fellowship or to the minimum university financial support for PhD students.

Students who receive external fellowship or stipendiary awards providing annual stipends that total more than the university financial support will retain the full external award(s) and will receive no additional university financial support for the duration of the external award.

- *Example One:* A student has a university award of \$38,000. The student receives a \$34,000 external award; the university will supplement the external award by \$4,000 to bring the student up to their university award of \$38,000.
- *Example Two:* A student has a university award of \$38,000. The student receives an external foundation award of \$42,000. Since the external award is greater, no university funds will be distributed while the student is supported by the external award.

Option 2: Deferral of University Fellowship or Stipendiary Award

Students receiving an external fellowship or stipendiary award during years one through five of study may, with program approval, defer up to one year of the university fellowship or stipendiary award made at the time of admission, if permissible based upon the award criteria from the external funding agency.

The university fellowship program and/or the student's home department or program can assist students when considering the benefits of each option. For cases in which a student has access to multiple sources of funding, external funds must be used before university funds are applied. University, school, and degree program funds will be the last source of funds to be applied to a student's financial support.

Schools and departments/programs may choose to offer an additional financial incentive to students who are awarded competitive external funding. Any such incentives must be uniformly awarded to all qualifying students within a degree program. Incentive awards given by school or degree programs to students who win external awards do not count toward the total university financial support; these incentive awards are in addition to the fellowship or stipendiary award.

All financial support will be applied in accordance with the terms and conditions of each funding source. In consultation with the student, departments/programs should ensure financial support is dispersed in the correct amount and in accordance with applicable policy.

* Limited exceptions may occur for instances in which the external award is explicitly contingent on the continuation of the university stipendiary award. In such instances, the decision on stacking is at the discretion of the school dean or their designee for support provided by the school or by a cross-school interdisciplinary program and at the discretion of the fellowship administrator for university-wide fellowships (e.g., OCF, MISA).

PhD Student Employment

Full-Time Employment

University financial support that is provided at or above the university-wide PhD minimum stipend rate is intended to enable students to focus exclusively (i.e., full time) on their studies. Students who receive university financial support at or above the university-wide minimum PhD stipend rate are not permitted to hold full-time employment.

Students who perform full-time employment during the summer term will have their university fellowship or stipendiary award stopped for the duration of their full-time employment. Students are also subject to any school or program-based policies regarding employment, which may be more restrictive. Students should consult their school and degree program for approval.

Part-Time Employment

To ensure that students receiving university financial support can focus on their programmatic requirements and make expeditious progress toward degree completion, part-time employment should not exceed an average of 10 hours per week. This allowance may be restricted by schools/departments/programs to a smaller number of hours per week to conform with a student's funding source policies and with federal time and effort reporting guidelines (as applicable).

If a student and that student's advisor(s) believe that additional part-time employment will enhance the student's outcomes and is unlikely to hinder timely progress toward degree completion, the student may request approval for an exception through their school's graduate program office. Any such exceptions will be documented and kept on file in the school. For students supported on federal grants, it is the school's responsibility to ensure adherence to any constraints derived from time and effort reporting.

To reiterate, students are also subject to any school or department/program-based policies regarding employment, which may be more restrictive. Students should consult their school and degree program for approval prior to undertaking any part-time employment.

Implications for International Students

International students attending WashU on a visa must consult with the Office for International Students and Scholars (OISS) before accepting any external or internal employment, either full-time or part-time.

Tax Implications

Please visit WashU's Financial Services website for more information about the taxability of stipend payments. Students are encouraged to consult a personal tax advisor to ensure that they are adhering to federal and state laws and Internal Revenue Service (IRS) regulations.

PhD General Requirements and Policies

To earn a PhD at WashU, a student must complete all courses required by their department/program; maintain satisfactory academic progress; pass certain examinations; fulfill residence and mentored experience requirements; write, defend, and submit a dissertation; and file an Intent to Graduate in Workday Student. **Note:** Individual schools and departments/programs may have more restrictive policies than the university-wide policies stated herein.

Residence Requirement

Each full-time PhD student must spend at least one academic year enrolled full-time at Washington University in St. Louis. Any exceptions must be approved by the dean of the student's respective school and the Vice Provost for Graduate Education.

Students admitted to a part-time PhD program must be enrolled in at least 3 units for each Fall/Spring semester until the unit requirements for their program are satisfied

Time Limit for PhD Enrollment Eligibility

Full-time PhD students are eligible for enrollment at Washington University in St. Louis for a maximum of 14 Fall/Spring semesters (seven years). Enrollment includes traditional course registration and 0-unit courses that carry a full-time enrollment status. Semesters of approved leaves of absence do not count toward this time limit.

Students admitted to a part-time PhD program are eligible for enrollment at Washington University in St. Louis for 18 Fall/Spring semesters (nine years). Semesters of approved leaves of absence do not count toward this time limit.

Full-time PhD students and those admitted to part-time PhD programs may petition for an enrollment eligibility extension for a maximum of one academic year. Petitions must be directed to the student's dean or their designee. Supplemental petitions will not be permitted. In unusual circumstances, the dean or their designee may appeal to the Vice Provost for Graduate Education on behalf of a particular student.

Qualifying Examinations

Progress toward the PhD is contingent upon the student passing examinations that are variously called *preliminary*, *qualifying*, *general*, *comprehensive*, or *major field exams*. The qualifying examination process varies considerably according to the department/program, and the structure and schedule of the qualifying exam are set by the department/program in accordance with best practices within their field. The department/program is responsible for documenting the process properly and ensuring the process is clearly outlined to their students. Each PhD program is responsible for notifying the school registrar or the appropriate record custodian of the student's outcome, whether successful or unsuccessful.

Mentored Experience Requirement

As part of the university-wide degree requirements, PhD students and some master's students (i.e., MFA in Writing and MFA in Dance) at WashU must complete a department-/program-defined Mentored Experience Requirement (MER). The MER is an accomplishment that is noted on the student's academic record when complete. Each department/program established a Mentored Experience Implementation Plan (MEIP) in which required MER units and pathways for completion are defined and specified. The MEIP typically consists of Mentored Teaching Experiences (mentored activities designed to achieve competencies in teaching at basic and advanced levels) and/or Mentored Professional Experiences (mentored activities focused on the development of skills relevant to individual, intended career and professional outcomes). Students enroll in Mentored Teaching Experience courses and/or Mentored Professional Experience courses to signify progression toward completing the MER.

Dissertation

As evidence of the mastery of a specific field of knowledge and of the capacity for original scholarly work, each candidate must complete a dissertation. Each PhD candidate will form a Research Advisory Committee (RAC) approved by their department/program and by their school's graduate program oversight body. The RAC will approve the subject and approach of the dissertation, which will be evidenced by the student's completion of the Title, Scope and Procedure requirement.

The RAC should consist of at least three full-time Washington University in St. Louis faculty members who are authorized to supervise PhD students and who have appropriate expertise in the proposed field of study. One of these faculty members must be the student's primary research advisor/mentor. Additional members, including external members with active research programs at outside institutions, may serve on the RAC subject to approval by the school's graduate program oversight body.

- For cross-school/interdisciplinary PhD programs, the approvals referenced above should be obtained from the graduate program oversight body of the school of the primary research advisor/mentor.
- For a PhD program offered in partnership with an external academic institution, one full-time faculty member of the partner institution who is authorized to supervise PhD students and who has appropriate expertise in the proposed field of study may serve on the RAC as part of the three-member minimum requirement.

A Title, Scope and Procedure form for the dissertation must be signed by the RAC members and by the program chair. Full-time students must submit the Title, Scope and Procedure form to the school registrar or the appropriate record custodian at least six months before the degree is expected to be conferred or before the beginning of the fifth year of full-time enrollment, whichever is earlier. Students enrolled in a part-time PhD program must submit the Title, Scope

and Procedure form to the school registrar or the appropriate record custodian at least six months before the degree is expected to be conferred or before the beginning of the sixth year of enrollment, whichever is earlier.

A Doctoral Dissertation Guide and a template that provides instructions regarding the format of the dissertation are available through the website of the Office of the Provost; both of these should be read carefully at every stage of dissertation preparation.

Each student is required to make the full text of the dissertation available to the committee members for their review at least one week before the dissertation defense. Most degree programs require two or more weeks for the review period; students should check their department/program's policies.

Dissertation Defense

Approval of the written dissertation by the Research Advisory Committee (RAC) is strongly recommended before the student can orally defend the dissertation. The doctoral dissertation committee that examines the student during the defense consists of at least five members. Normally, the members of the RAC also serve on the Doctoral Dissertation Committee. The dissertation committee is then additionally augmented to ensure that the following criteria are met:

1. Three of the five members (or a similar proportion of a larger committee) must be full-time Washington University in St. Louis faculty members or, for programs offered by Washington University in St. Louis-affiliated partners, full-time members of a Washington University in St. Louis-affiliated partner institution who are authorized to supervise PhD students and who have appropriate expertise in the proposed field of study. One of these three members must be the PhD student's primary thesis advisor, and one may be a member of the emeritus faculty.
2. All other committee members must be active in research/scholarship and have appropriate expertise in the proposed field of study whether at Washington University in St. Louis, at another university, in government, or in industry.
3. At least one of the five members must bring expertise outside of the student's field of study to the committee, as judged by the relevant school's graduate program oversight body.

The approval processes outlined under RAC in the Doctoral Council bylaws also apply to the doctoral dissertation committee, including approval of each dissertation committee by the host school's graduate program oversight body/bodies.

The student is responsible for making the full text of the dissertation accessible to their committee members for their review in advance of the defense according to program rules. Washington University in St. Louis community members and guests of the student who are interested in the subject of the dissertation are normally welcome to attend all or part of the defense but may ask questions only at the discretion of the committee chair. Although there is some variation among degree programs, the defense ordinarily focuses on the dissertation itself and its relation to the student's field of expertise.

Attendance by a minimum of four members of the Doctoral Dissertation Committee, including the committee chair and an outside member, is required for the defense to take place. This provision is designed to permit the student's defense to proceed in case of a situation that unexpectedly prevents one of the five members from attending. Students should not plan in advance to only have four members in attendance; if one of those four cannot attend, the defense must be rescheduled. The absence of all outside members or of the committee chair would necessitate rescheduling the defense.

Students, with the support of their Doctoral Dissertation Committee chair, may opt to hold their dissertation defense in-person or by utilizing a virtual or hybrid format.

Dissenting Vote(s) at a Dissertation

Faculty members of the Doctoral Dissertation Committee normally will examine the PhD candidate and vote on whether to approve the dissertation. In the vast majority of cases, these votes are unanimously for approval. In the rare case that there are faculty concerns that cannot be resolved through subsequent revisions and which therefore result in dissenting (negative) vote(s), the committee chair will refer the case to the Vice Provost for Graduate Education for resolution.

In the case of a single dissenting vote, the committee chair and the dissenting voter will be asked to explain the reasons for the dissent in a letter to the Vice Provost for Graduate Education. After consulting with these and other members of the committee, the Vice Provost for Graduate Education may then decide to accept the majority opinion and approve the dissertation, or they may seek the opinion of an additional reader. After considering this additional evidence, the Vice Provost for Graduate Education may approve or decline to approve the dissertation.

In the case of two or more dissenting votes, the committee chair and the dissenting voters will again be asked to explain the reasons for the dissent. The Vice Provost for Graduate Education may then decide to decline to approve the dissertation. Alternatively, they may ask the department or graduate program to name a Resolution Committee, consisting of three tenured or tenure-track professors at Washington University in St. Louis or elsewhere who did not serve on the original committee, to reexamine the dissertation and the candidate. A unanimous positive recommendation from this committee will be required in order for the Vice Provost for Graduate Education to approve the dissertation. Failure of a department or graduate program to identify three faculty members to serve on this Resolution Committee will be tantamount to a rejection of the dissertation.

Dissertation Submission

After the successful defense of their dissertation, the student must submit an electronic copy of the dissertation online to the university by the established deadline for their graduation term. Dissertations must be submitted no later than three months after the oral defense of the dissertation. Petitions for an extension to the three-month limit may be submitted to the Director of Graduate Studies for consideration and approval. The submission website requires students

to choose from among publishing and copyrighting services offered by ProQuest ETD Administrator, but the university permits students to make whichever choices they prefer. Washington University in St. Louis doctoral students may initially request to embargo the public release of their dissertation for a specified period of six months, one year, or two years. Renewals beyond the initial embargo may be granted by the Vice Provost for Graduate Education. Students are asked to submit the Survey of Earned Doctorates separately. The degree program is responsible for delivering the final approval form, signed by the committee members at the defense and then by the department/program chair or director, to the school registrar or the appropriate record custodian. Students who complete all degree requirements and defend their dissertations successfully have not completed their PhD requirements; they finish earning their degree only when their dissertation submission has been accepted by their school of record.

Degree Candidacy Extension

Degree Candidacy Extension (DCE) refers to a non-enrolled status available, under exceptional circumstances, to full-time PhD students who have completed all PhD degree requirements with the exception of the dissertation.

Extended degree candidates are not registered for any courses, have no enrollment status, and are ineligible for financial awards or support, benefits, and resources available to enrolled Washington University in St. Louis students. Once a student enters DCE, they may not register or enroll with Washington University in St. Louis as a student in their intended degree program in a future term.

DCE status may be assigned to full-time students in a variety of situations, including but not limited to the following:

- PhD students who do not complete their dissertation after exhausting the time allowable for PhD enrollment status due to circumstances beyond their control (see Time Limit for PhD Enrollment Eligibility earlier on this page);
- PhD students who secure full-time employment prior to the completion of their dissertation and who have established a timeline for the completion of the dissertation requirement; and
- PhD students who have exhausted their university financial support period as defined by their school or program prior to the completion of their dissertation and who have established a timeline for the completion of the dissertation requirement.

DCE status may be inappropriate for international students dependent on a U.S. visa, and such students may not be eligible for this status. International students should always consult with an OISS advisor prior to making an enrollment status change. In addition, students admitted as part-time PhD students are not eligible for DCE status.

DCE status is not the rule. Rather, it is assigned as an exception. Students must obtain the recommendation of their department/program leadership and petition the Vice Dean for Graduate Education (or equivalent) within their school to request to enter DCE status. If the petition is successful, the DCE status is conferred for the period of one year, after which an additional petition should be made and approved. Students seeking to remain in DCE status are obligated to provide a written report on their dissertation's progress annually to



their department to secure their approval for subsequent petitions. Individual departments may require additional checkpoints to ensure progression. Students may remain a PhD candidate in this status for a maximum of three calendar years.

If three calendar years pass from the first semester in which a student was placed on DCE and the student has not successfully completed all degree requirements, then that student has officially forfeited their eligibility to earn the PhD degree. Under these circumstances, the student may petition the Vice Provost of Graduate Education with the support of their department chair and school vice dean to be allowed to complete the degree outside of the three-year extension period. The petition will include a timeline for completion. The Vice Provost of Graduate Education reserves the right to deny any such request.

PhD Mentored Experiences

The Mentored Experience Requirement (MER)

As part of the university-wide degree requirements, PhD students and students in certain master's programs (i.e., MFA in Writing and MFA in Dance) at Washington University in St. Louis must complete a program-defined Mentored Experience Requirement (MER). The MER is an accomplishment that is noted on the student's academic record when complete. Each program established a Mentored Experience Implementation Plan (MEIP) in which required MER units and pathways for completion are defined and specified. The MEIP typically consists of Mentored Teaching Experiences (mentored activities designed to achieve competencies in teaching at basic and advanced levels) and/or Mentored Professional Experiences (mentored activities focused on the development of skills relevant to individual, intended career, and professional outcomes). Students enroll in Mentored Teaching Experience (MTE) courses and/or Mentored Professional Experience (MPE) courses to signify progression toward completing their MER.

Mentored Experience Implementation Plan (MEIP)

An MEIP is a program-defined plan for students to complete their MER and engage in mentored teaching activities and/or mentored professional activities. MEIPs include the philosophy related to the role of teaching or professional experiences within the discipline, the program's plan for preparatory engagement, the normal sequence of opportunities for a student, and the number of MER units required. Each of these terms are defined within this section.

MEIPs were updated by programs during the 2024-25 academic year, and new plans are available under each program's "Mentored Experience Implementation Plan" tab in the *Bulletin*. Plans were effective as of Fall 2025 and applied to all students who had not yet completed their MER. Any revised plans in this Bulletin would be effective for students entering their program in Fall 2026.

Preparatory Engagement

Preparatory Engagement activities represent an introduction to the foundational skills associated with teaching or communication. Preparatory Engagement represents an important foundational component to training in pedagogy. As such, all MEIPs contain required pedagogical preparation before students are permitted to engage in assisting or teaching in a classroom.

Mentored Teaching Experiences (MTEs)

An MTE represents a collaborative engagement between a student and a faculty mentor wherein the student reflects on and interprets disciplinary knowledge; identifies multiple ways to represent disciplinary content; adapts content to students' abilities and prior knowledge; and develops methods to assess and improve the teaching and learning process in a discipline. A student engaged in an MTE will have an assigned faculty mentor supporting the student's development into an educator able to communicate and/or evaluate disciplinary knowledge.

Two categories of MTE exist at WashU: Assistantships in Instruction (AI) and Mentored Independent Teaching (MIT). Each MTE engagement is weighted by MER units to recognize the different levels of effort involved.

Assistant in Instruction (AI)

An AI experience is one in which the student is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. During the AI, the student receives mentorship from the faculty member in best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students receive regular informal feedback or evaluation from the mentor throughout the semester, as well as a final evaluation from the mentor and course evaluations from students enrolled in the course as part of the normal course evaluation process.

The student is formally listed as instructional support via Workday in the course listings. In general, AI assignments connect to undergraduate courses or to lower-level graduate courses that the student has taken previously.

MER units for AI experiences are determined by the program based on the level of activity needed for each assignment:

- 5 MER units are equivalent to an average of 5 hours per week of engagement; students enroll in their program's course numbered 8005 during the semester of engagement.
- 10 MER units are equivalent to an average of 10 hours per week of engagement; students enroll in their program's course numbered 8010 during the semester of engagement.
- 15 MER units are equivalent to an average of 15 hours per week of engagement; students enroll in their program's course numbered 8015 during the semester of engagement.

Mentored Independent Teaching (MIT)

An MIT is a semester-long experience for students who engage as the primary instructor or co-instructor of a course *under the mentorship of a faculty member* as part of their MER. Throughout the semester, students receive regular feedback from a faculty mentor based on classroom observation conducted a few times per semester or other acceptable review mechanisms. The student should ask for guidance and support from the faculty mentor while navigating the responsibilities of independent teaching. Faculty mentors are also required to complete the final evaluation for the student.

An MIT experience may not be a requirement or option under every program's MEIP. Each MIT engagement will equate to 20 MER units. The 20 MER unit assignment accounts for the considerable level of preparation and consultation each PhD student needs to engage in as part of this introductory experience toward acquiring the skills required for independent teaching. Students enroll for the semester of engagement under their program's course numbered 8020.

Mentored Professional Experiences (MPEs)

MPEs are unpaid experiences that allow students to develop skills and experiences relevant to their intended career outcomes. These experiences could include, for example, opportunities in industry, communication and outreach, government or policy, consulting, or higher education administration. The duties and responsibilities of the MPE should be intellectually substantive and offer opportunities for the student to develop new skills and experiences.

An MPE experience may not be a requirement or option under every program's MEIP. Each MPE engagement will equate to 20 MER units. The 20 MER unit assignment accounts for the considerable level of preparation and time needed for this engagement. An MPE should involve at least 150 hours (and not more than 180 hours) per engagement. Students enroll for the semester of engagement under their program's course 8120.

Optional MER Activities

Some programs allow for students to participate in additional, optional MTE or MPE engagements. If allowed, the program's MEIP will list the requirements for a Teaching Intensive Pathway (TIP) or a Professional Intensive Pathway (PIP).

Teaching Intensive Pathway (TIP)

The TIP is an optional pathway for those students whose career interests lie in academia or another field that would benefit from extended MTEs. This immersive experience allows students to further explore the breadth and depth of teaching best practices and pedagogy related to their respective field.

Students who are interested in participating in this elective experience must formally request to participate, which is subject to program approval. Due to this experience being an elective, unpaid experience, students who participate in the TIP will not receive compensation.

Professional Intensive Pathway (PIP)

The PIP is an optional pathway for those students whose career interests lie outside of academia or want to benefit from MPEs. An MPE is an unpaid professional experience for PhD students that allows students to develop skills and experiences relevant to their intended career outcomes. Students and mentors complete a mentorship plan prior to the start of each MPE. Students who are interested in participating in this elective experience must formally request to participate, which is subject to program approval. Similar to normal MPE experiences, students who participate in the PIP do not receive compensation associated with their MPE.

Post-MER Completion Teaching Activities

To be eligible to participate in an additional teaching activity at WashU, students must complete their MER as defined by their program's MEIP prior to undertaking optional elective instructional activity. Any independent teaching for pay that occurs after the completion of the MER must meet the spirit of the part-time employment policy or otherwise students must request an exception.

Instructional Support

At the completion of the student's MER as defined in the MEIP, students may elect to pursue additional instructional opportunities at WashU as a non-MTE AI or a similarly situated role. These additional opportunities are subject to the approval of their primary advisor and their department/program as well as the existence of such a position. These students will be paid an hourly rate.

Instructor or Co-Instructor of Record

At the completion of a student's MER requirements as defined in the MEIP, the student may elect to pursue instructor opportunities at WashU as an independent instructor. These opportunities are subject to the approval of the student's primary advisor and their department/program as well as the existence of such a position. Students who have completed their MERs must demonstrate the requisite experience and training in pedagogy to engage in teaching at the fully independent level. These students are eligible for compensation in accordance with the adjunct professor collective bargaining agreement.

Current MEIPs

Arts & Sciences

- Anthropology, PhD, Archeology Concentration
- Anthropology, PhD, Biological Anthropology Concentration
- Anthropology, PhD, Sociocultural Anthropology Concentration
- Art History & Archaeology, PhD
- Chemistry, PhD
- Classics, PhD
- Comparative Literature, PhD
- Dance, MFA
- Earth, Environmental, and Planetary Sciences, PhD
- East Asian Languages and Cultures, PhD
- Ecology and Evolutionary Biology, PhD
- Economics, PhD
- Education, PhD
- English and American Literature, PhD
- English and Comparative Literature, PhD
- French and Francophone Studies and Comparative Literature, PhD
- French and Francophone Studies, PhD
- German and Comparative Literature, PhD
- Germanic Languages and Literatures, PhD
- Hispanic Studies and Comparative Literature, PhD
- Hispanic Studies, PhD
- History, PhD
- Mathematics, PhD
- Music, PhD, Music Theory Concentration
- Music, PhD, Musicology Concentration
- Philosophy, PhD
- Philosophy-Neuroscience-Psychology, PhD
- Physics, PhD
- Political Science, PhD
- Psychological & Brain Sciences, PhD
- Sociology, PhD
- Statistics and Data Sciences, PhD
- Writing, MFA

Business

- PhD Program

Engineering

- Biomedical Engineering PhD (p. 52)
- Biomedical Engineering PhD-MD (p. 54)
- Computational & Data Sciences, PhD (p. 58)
- Computer Engineering, PhD (p. 73)

- Computer Science, PhD (p. 71)
- Electrical Engineering, PhD (p. 90)
- Energy, Environmental, & Chemical Engineering, PhD (p. 109)
- Imaging Science, PhD (p. 116)
- Materials Science & Engineering, Interdisciplinary PhD (p. 122)
- Mechanical Engineering, PhD (p. 133)
- Systems Science & Mathematics, PhD (p. 91)

Medicine

- Division of Biology & Biomedical Sciences Programs
 - Biochemistry, Biophysics & Structural Biology, PhD
 - Biomedical Informatics & Data Science, PhD
 - Cancer Biology, PhD
 - Computational & Systems Biology, PhD
 - Developmental, Regenerative, & Stem Cell Biology, PhD
 - Immunology, PhD
 - Molecular Cell Biology, PhD
 - Molecular Genetics & Genomics, PhD
 - Molecular Microbiology & Microbial Pathogenesis, PhD
 - Neurosciences, PhD
 - Plant & Microbial Biosciences, PhD
- Medical Physics, PhD
- Movement Science, PhD
- Nursing Science, PhD
- Rehabilitation and Participation Science, PhD
- Speech and Hearing Sciences, PhD

Public Health

- Public Health Sciences, PhD

Brown School

- Social Work, PhD

Additional information including forms, resources, and FAQs are available on the Mentored Experiences page of the Office of the Provost website.

McKelvey School of Engineering

The McKelvey School of Engineering at Washington University in St. Louis consists of six academic departments and three interdisciplinary PhD programs offering both master's and doctoral degrees in a wide range of engineering disciplines.

We offer master's, master's of science (MS) and master's of engineering (MEng) degrees, many of which can be completed on either a full-time or part-time basis. We also offer a large number of full-time doctor of philosophy (PhD) degrees and some part-time options.

Our mission is to promote independent inquiry in engineering research and education with an emphasis on scientific excellence, innovation and collaboration without boundaries. McKelvey engineers produce new knowledge that changes the world, and our faculty are educating students to explore and create in a world we cannot yet imagine. Through research and education, we are making a positive impact on the local community, the country and the world.

Contact Information

McKelvey School of Engineering — Office of Graduate Programs
Lopata Hall, Suite 203
Washington University in St. Louis
MSC 1100-122-303
One Brookings Drive
St. Louis, MO 63130-4899
314-935-5830

Email: eng-gradstudserv@wustl.edu
Website: <http://engineering.wustl.edu/>

Fields of Study

- Biomedical Engineering (p. 41)
- Computational & Data Sciences (Interdisciplinary PhD) (p. 55)
- Computer Science & Engineering (p. 59)
- Electrical & Systems Engineering (p. 83)
- Energy, Environmental & Chemical Engineering (p. 101)
- Imaging Science (p. 111)
- Materials Science & Engineering (p. 118)
- Mechanical Engineering & Materials Science (p. 122)
- Henry Edwin Sever Institute (p. 138)

Biomedical Engineering

Biomedical engineering (BME) seeks to advance and integrate life science knowledge with engineering methods and innovations that contribute to improvements in human health and well-being. Our vision is that lasting knowledge of biomedical systems and paradigm-shifting engineering technology will arise from integrating engineering concepts and basic science knowledge from the molecular level to the whole-body level. We believe that those taught to work across multiple disciplines and to integrate modeling and experimental systems approaches will be uniquely positioned to advance and generate new disciplines in biomedical engineering.

With this vision in mind, we are committed to educating the next generation of biomedical engineers. We have leveraged our interdisciplinary strengths in engineering and clinical and life sciences to build a biomedical engineering department around research programs of excellence and translational potential: Biomedical & Biological Imaging; Cardiovascular Engineering; Cellular & Molecular Bioengineering; Neural Engineering; Orthopedic Engineering; Regenerative Engineering in Medicine; and Women's Health Technologies. These areas provide exciting opportunities for students with a variety of backgrounds and interests.

Students seeking the **Master of Science (MS) in Biomedical Engineering** will need to complete 30 course credits, which include a core curriculum. MS students pursuing the thesis option perform research on a topic approved by the research mentor. Results of the study are published in a thesis that is defended in front of a committee of faculty members prior to graduation. The results should be of quality high enough to be published as a paper in a peer-reviewed journal. A total of 30 credits can be completed in two to four semesters.

Students seeking the **PhD in Biomedical Engineering** may choose to study in one of seven multidisciplinary research programs that represent frontiers in biomedical engineering. Our core faculty work collaboratively with more than 130 affiliated faculty to offer students the opportunity to learn in a diverse and rich spectrum of BME research areas. Students graduating with the PhD in Biomedical Engineering are prepared to pursue paths in research and development in academic and industry settings, and they are also ready to contribute to teaching and research translation. The **MD/PhD in Biomedical Engineering**, which is offered jointly with the top-ranked School of Medicine, gives students in-depth training in modern biomedical research and clinical medicine. The typical MD/PhD career combines patient care and biomedical research but leans toward research.

Email: bme@wustl.edu
Website: <https://bme.wustl.edu/academics/graduate-programs/index.html>

Faculty

Chair

Lori A. Setton

Lucy and Stanley Lopata Distinguished Professor of Biomedical Engineering
PhD, Columbia University
Biomaterials for local drug delivery; tissue regenerations specific to the knee joints and spine

Endowed Professor

Rohit V. Pappu

Gene K. Beare Distinguished Professor of Biomedical Engineering
PhD, Tufts University
Macromolecular self assembly and function; computational biophysics

Professors

Dennis L. Barbour

MD, PhD, Johns Hopkins University
Application of novel machine learning tools to diagnose and treat disorders of perception and cognition

Cory Berkland

PhD, University of Illinois
Developing new therapeutics and biomaterials for improving human health

Hong Chen

PhD, University of Washington
Physical acoustics; therapeutic ultrasound and ultrasound imaging

Jianmin Cui

PhD, State University of New York–Stony Brook
Ion channels; channel structure-function relationship; biophysics

Song Hu

PhD, Washington University in St. Louis
Optical and photoacoustic technologies for high-resolution structural, functional, metabolic and molecular imaging in vivo

Daniel Moran

PhD, Arizona State University
Motor control; neural engineering; neuroprosthetics; movement biomechanics

Baranidharan Raman

PhD, Texas A&M University
Computational and systems neuroscience; neuromorphic engineering; pattern recognition; sensor-based machine olfaction

Jin-Yu Shao

PhD, Duke University
Cell mechanics; receptor and ligand interactions; molecular biomechanics

Jon Silva

PhD, Washington University
Ion channel biophysics

Yan Yu

Art Krieg Professor of Chemistry and of Biomedical Engineering
PhD, University of Illinois, Urbana-Champaign
Integrate nanotechnology and imaging techniques to study, detect, and manipulate the immune system and diseases

Chao Zhou

PhD, University of Pennsylvania
Optical coherence tomography

Quing Zhu

Edwin H. Murty Professor of Engineering
PhD, University of Pennsylvania
Biophotonics and multimodality ultrasound and optical imaging

Associate Professors

Nate Huebsch

PhD, Harvard University
Cell-material Interactions, iPSC-based tissue modeling to study cardiac development and disease

Abhinav Kumar Jha

PhD, University of Arizona
Development of computational-imaging solutions for diagnosing and treating diseases

Jai S. Rudra

PhD, Louisiana Tech University
Peptide-based biomaterials; immunoengineering; immunology of nanoscale aggregates; development of vaccines and immunotherapies

Kurt A. Thoroughman

PhD, Johns Hopkins University
Human motor control and motor learning; neural computation

Michael D. Vahey

PhD, Massachusetts Institute of Technology
Biophysical mechanisms of infectious disease; fluorescence microscopy; microfluidics

Assistant Professors

Yifan Dai

PhD, Case Western Reserve University
Decodes and encodes the physical chemistry of biological soft matter to understand biology and engineering precision medicine

Christine M. O'Brien

PhD, Vanderbilt University
Developing optical spectroscopy and imaging tools to solve global problems in maternal-fetal health and reproductive diseases

Alexandra Rutz

PhD, Northwestern University
Engineering of electronic tissues using materials design and fabrication-based approaches



Ismael Seáñez

PhD, California Institute of Technology

Neuro-rehabilitation tools and programs that promote active use of residual mobility and maximize recovery through the use of body-machine interfaces

Teaching Professor

Patricia Widder

MS, Washington University

Senior Lecturer

Katherine Schreiber

PhD, Saint Louis University

Professor of Practice

Joseph Klaesner

PhD, Vanderbilt University

Senior Professor

Larry Taber

PhD, Stanford University

Mechanics of growth and development; cardiac mechanics

Senior Emeritus Professors

Yoram Rudy

Fred Saigh Distinguished Professor of Engineering

PhD, Case Western Reserve University

Cardiac electrophysiology; modeling of the cardiac system

Frank Yin

MD, PhD, University of California, San Diego

Degree Requirements

Please visit the following pages for information about our graduate programs:

- Biomedical Engineering, MS (p. 47)
- Biomedical Engineering, PhD (p. 50)
- Biomedical Engineering, Combined MD/PhD (p. 53)

Courses

BME 5050 Professional and Personal Pathways to the PhD Program

This course is designed to guide PhD students as they embark on their first year in the Biomedical Engineering program. Topics include choosing a thesis lab and mentor, creating individual development plans, career exploration, and building mentor relationships through networking.

Credit 1 unit.

Typical periods offered: Fall

BME 5190 Advanced Cognitive, Computational, and Systems Neuroscience

This course will develop critical thinking and analysis skills with regard to topics in Cognitive, Computational and Systems Neuroscience. A focus of the course will be aimed toward quantitative literacy, statistical methodology, and experience with the tools and best practices needed to conduct state-of-the-art research in modern studies of brain and behavior. Particular topics include machine learning, Big Data, reproducibility, equitable research and scientific visualization. Students will be provided with foundational and theoretical tools to ensure maximal scientific rigor in their own research by enabling them to think carefully about core issues in experimental design, and about key challenges and controversies that arise in relation to hypothesis testing, statistical inference and data management.

Credit 3 units.

Typical periods offered: Spring

BME 5230 Biomaterials Science

An understanding of the interactions between biological systems and artificial materials is of vital importance in the design of medical devices. This course will introduce the principles of biomaterials science, unifying knowledge from the fields of biology, materials science, surface science, and colloid science. The course will be taught from the primary scientific literature, focusing on the study of protein/surface interactions and hydrogel materials.

Credit 3 units.

Typical periods offered: Fall

BME 5300 Molecular Cell Biology for Engineers

This course is designed for upper-level undergraduates and first-year graduate students with a background in engineering. It covers the biology of cells of higher organisms: protein structure and function; cellular membranes and organelles; cell growth and oncogenic transformation; cellular transport, receptors, and cell signaling; and the cytoskeleton, the extracellular matrix, and cell movement. Emphasis will be placed on examples relevant to biomedical engineering. In addition to lecture material, a focus will be placed on understanding the experimental techniques used in cell biology and the critical analysis of primary literature. Note that this course does not count for engineering topics credits and that it is meant to fulfill a life science requirement for engineering or physical sciences graduate students.

Credit 3 units.

Typical periods offered: Spring

BME 5320 Biomolecular Interaction Networks

This course builds on the core concepts taught in Bioengineering Thermodynamics (BME 3200). It will cover topics pertaining to the foundations of equilibrium statistical physics, the statistical thermodynamics and kinetics of folding and binding, enzyme catalyzed reactions, polymer physics concepts that are useful for understanding the functions of intrinsically disordered proteins, physical concepts of macromolecular phase transitions, topics from soft matter physics that are relevant to understanding material properties of biomolecular condensates, concepts from network science, and emerging topics that lie at the intersection of equilibrium and non-equilibrium statistical physics. The emphasis of the course will be on teaching concepts, formulating problems, and applying the concepts to solve key problems in cell signaling, cellular-level decision making, and process control, all influenced by biomolecular interaction networks. The course will lean heavily on numerical methods that are crucial

to understanding and modeling biomolecular interaction networks. No assumptions will be made regarding prior knowledge beyond familiarity taught in a first course on thermodynamics. Fluency with multivariate calculus and a first course in differential equations will be helpful. Performance in the course will be based on homework assignments and take-home projects that emphasize absorption and understanding of concepts.

Credit 3 units.

Typical periods offered: Spring

BME 5330 Biomedical Signal Processing

This course is designed for graduate students with little or no background in biomedical signal processing, with an emphasis on time- and frequency-domain analyses of biomedical signals and their applications to a variety of real-world biomedical problems. Technical topics of this course include a review of linear signals and systems theory, biomedical system modeling, time-domain analysis, frequency transforms, frequency-domain analysis, linear filter design, signal truncation and sampling, discrete Fourier transform, and fast Fourier transform. Application topics include noise analysis of biomedical signals and frequency analysis and machine learning in biomedical image processing. Concepts learned in class will be applied using software tools to biomedical signals such as biological rhythms, EMG, ECG, EEG, and biomedical images.

Credit 3 units.

Typical periods offered: Spring

BME 5340 Biophysical chemistry

This course examines the physical principles that govern the structure, dynamics, functions and organization of biological molecules and systems. We will cover foundational topics such as molecular forces, thermodynamics of folding and binding, phase equilibrium, kinetics of biomolecular reactions, transport phenomena, and the role of water and ions in biological processes. Special emphasis will be placed on experimental techniques—including spectroscopy, calorimetry, microscopy, and molecular simulations—that reveal the physical chemistry of biomolecules and systems. To connect theory with practice, the course will integrate contemporary research drawn from primary literature, highlighting case studies such as protein folding diseases, phase transition, biomolecular condensates, enzyme catalysis, cellular electrochemistry and cellular energetics. Through critical reading and discussion of these works, students will learn how biophysical chemistry informs modern biological research and biotechnological innovation.

Credit 3 units.

Typical periods offered: Spring

BME 5380 Cell Signal Transduction

This course will cover the elements of cell signal transduction important to human development, homeostasis and disease. Lectures will be combined with primary literature review to cover canonical signaling and current topics within the field. Spatial, time and dose-dependent aspects of signaling will be of particular focus. Topics include G protein-coupled receptors, receptor tyrosine kinases, adhesion signaling, the MAPK cascade, lipid signaling, the DNA damage response, and autocrine, paracrine and juxtacrine signaling.

Credit 3 units.

Typical periods offered: Fall, Spring

BME 5401 Biomedical Data Science

This course will cover data analysis, statistical methods, AI, machine learning, predictive modeling, and data visualization, with applications to medicine and health. As part of the course, BME faculty will present biomedical data science topics from their research areas.

Students will learn to prepare, transform, visualize, validate, model, and communicate information about datasets, and they will design and implement an independent project to address a biomedical data science problem. Prior Python experience required.

Credit 3 units.

Typical periods offered: Fall

BME 5420 Principles of Biomolecular Spectroscopy

This course focuses on the core principles of biomolecular spectroscopy and how photon-protein interactions across wavelengths reveal a molecule's structure, conformation, and dynamics. Students will explore the physical foundations of spectroscopic methods, including UV-Vis, fluorescence, circular dichroism, infrared, Raman, X-ray, and emerging techniques. They will learn how each technique targets specific structural features, secondary, tertiary, and quaternary, and how environmental changes, folding, and ligand binding produce characteristic spectral signals. The curriculum integrates spectroscopy with biophysical concepts related to stability, folding landscapes, and conformational behavior. Industry-relevant applications span biotherapeutics, diagnostics, formulation, and process monitoring. Eight modules using the Python-based visualization software PyMOL, combined with five practical labs, provide hands-on experience in data collection and interpretation of structure-spectrum relationships. Additionally, two to three lectures will cover transformer-based ML methods for the de novo design and development of biomolecules, as well as the engineering of natural proteins for advanced functions. The course will devote two modules to translation challenges, regulatory considerations (FDA), validation, data integrity, and pathways for industry deployment. The course is designed for undergraduates with an interest in biomolecular research and a willingness to engage with both theory and practical data analysis, with the expectation that students will develop the skills to design spectroscopic experiments, interpret results in structural terms, and consider regulatory implications for real-world applications.

Credit 3 units.

Typical periods offered: Spring

BME 5430 Molecular and Cellular Engineering

The ability to engineer biological function at the cellular level holds tremendous potential for both basic and applied science. This course aims to provide knowledge and practical proficiency in the methods available for measuring and controlling the molecular organization of eukaryotic cells. Topics to be covered include genome engineering using viral- and CRISPR-Cas systems; spatial and temporal control of proteins and their interactions; methods for characterizing and engineering post-translational modifications; and the relationship between cellular organization and function in migration, immune cell target recognition, and differentiation. Examples from recent scientific literature will provide the foundation for these topics.

Credit 3 units.

Typical periods offered: Spring

BME 5440 Biomedical Instrumentation

This course will include operational and instrumentation amplifiers for bioelectric event signal conditioning, interfacing and processing; instrumentation noise analysis and filter design; A/D converters and hardware and software principles as related to sampling, storing, processing, and display of biosignals; modeling, analysis, and operation of transducers, sensors, and electrodes, for physiological and imaging systems; and an introduction to ultrasound, X-ray, and optical imaging systems. In addition, students will be involved in three projects of designing and building instrumentation amplifier and filter systems, ultrasound systems, and optical systems.

Credit 3 units.

Typical periods offered: Spring



BME 5501 Translational Neuroengineering

This course focuses on the design of bioelectric devices for use in clinical patients. Neural stimulators (e.g., deep brain, vagal) will be the basis for a case-study approach to designing and developing new bioelectrical medical devices. This project-based course will introduce the student to the use of finite element solvers to design novel stimulators. In addition to the engineering design aspects, issues such as product liability, FDA approval, and so on will be discussed. Credit 3 units.

Typical periods offered: Spring

BME 5590 Intermediate Biomechanics

This course covers several of the fundamental theories of solid mechanics that are needed to solve problems in biomechanics. The theories of nonlinear elasticity, viscoelasticity, and poroelasticity are applied to a large range of biological tissues including bone, articular cartilage, blood vessels, the heart, skeletal muscle, and red blood cells. Other topics include muscle activation, the biomechanics of development and functional adaptation, and the mechanics of hearing.

Credit 3 units.

Typical periods offered: Fall

BME 5642 Human-Machine Interfaces

This course will provide an overview of neurorehabilitation technologies for individuals with neuromotor disorders. Topics will include the neurophysiology of human motor and sensory systems, motor control and adaptation, and neuroplasticity in the damaged brain and spinal cord. Human-machine interface systems including prostheses, orthoses and exoskeletons, wheelchairs, neuroprosthetics, brain-machine interfaces, and wearable robots will be discussed with an emphasis on their clinical applications for restoration of motor and sensory functions. Lecture material and assignments will draw from current scientific literature and research. Registration will be split between undergraduate and graduate students.

Credit 3 units.

Typical periods offered: Fall, Spring

BME 5650 Biosolid Mechanics

Introduction to the mechanical behaviors of biological tissues of musculoskeletal, cardiac and vascular systems. Topics to be covered include static force analysis and nonlinear optimization theory; linearly elastic models for stress-strain analysis and solutions to relevant problems in bioelasticity; models of active structures (e.g., muscles); strain energy methods and nonlinear tissue behaviors; and introductory theory for finite element analysis. Emphasis will be placed on modeling stress-strain relations with relevance to biological tissues. Credit 3 units.

Typical periods offered: Fall, Spring

BME 5690 Cardiac Electrophysiology

This course is an introduction to cardiac electrophysiology with an emphasis on arrhythmia mechanisms, experimental methods, and clinical applications. Topics will include modeling of cardiac arrhythmias, mapping of cardiac electric activity, pacemakers and defibrillators, and ablation of cardiac tissue.

Credit 3 units.

Typical periods offered: Fall

BME 5700 Mathematics of Imaging Science

This course will expose students to a unified treatment of the mathematical properties of images and imaging. This will include an introduction to linear vector space theory, operator theory on Hilbert spaces, and concepts from applied functional analysis. Further, concepts from generalized functions, Fourier analysis, and radon transform will be discussed. These tools will be applied to conduct deterministic analyses of imaging systems that are described as continuous-to-continuous, continuous-to-discrete, and discrete-to-discrete mappings from object properties to image data. In addition, imaging systems will be analyzed in a statistical framework where stochastic models for objects and images will be introduced. Familiarity with Engineering-level mathematics, Calculus, Linear algebra, introduction to Fourier analysis is expected.

Credit 3 units.

Typical periods offered: Fall

BME 5720 Biological Neural Computation

This course will consider the computations performed by the biological nervous system with a particular focus on neural circuits and population-level encoding/decoding. Topics include, Hodgkin-Huxley equations, phase-plane analysis, reduction of Hodgkin-Huxley equations, models of neural circuits, plasticity and learning, and pattern recognition & machine learning algorithms for analyzing neural data. Note: Graduate students in psychology or neuroscience who are in the Cognitive, Computational, and Systems Neuroscience curriculum pathway may register in L41 5657 for three credits. For non-BME majors, conceptual understanding, and selection/application of right neural data analysis technique will be stressed. Hence homework assignments/examinations for the two sections will be different, however all students are required to participate in a semester long independent project as part of the course.

Credit 3 units.

Typical periods offered: Spring

BME 5744 Open Challenges in Systems Neuroscience

The objective of this course is to introduce advanced graduate engineering students to key challenges for the next generation of systems neuroscientists. One-half of the course will introduce students to the neural bases of canonical behavioral motifs. One-half of the course will have students identify and present a proposal for how to study an open challenge in the treatment of neurological/psychiatric disorders (e.g., dystonia, epilepsy, depression, addiction) at either circuit or system level. Grades will be assigned to correspond with performance on the written report covering an open-challenge. This course will also be open to non-engineers upon request.

Credit 3 units.

Typical periods offered: Spring

BME 5750 Molecular Basis of Bioelectrical Excitation

Ion channels are the molecular basis of membrane excitability in all cell types, including neuronal, heart, and muscle cells. This course presents the structure and the mechanism of function of ion channels at the molecular level. It introduces the basic principles and methods in the ion channel study as well as the structure-function relation of various types of channels. Exemplary channels that have been best studied will be discussed to illustrate the current understanding.

Credit 3 units.

Typical periods offered: Fall

BME 5771 Biomedical Product Development

Advances in science and technology have opened the healthcare field to innovation now more than any other time in history. Engineers and inventors can make real and rapid improvements to patient treatments, length of hospital stay, procedure time, cost containment,

and accessibility to treatment. However, a successful transition from idea to implementation requires careful market analysis and strategy planning. This course will address the steps in this process, including personal and team strength assessment, medical need validation, brainstorming initial solutions, market analysis, solution evaluation, regulatory, patent, and intellectual property concerns, manufacturability, risk assessment and mitigation, and global considerations. Students will be expected to review resource material prior to coming to class in order to facilitate active class discussion and team-based application of the material during class; regular attendance will be key to course success. The course will focus on applying product development techniques to several real unmet medical needs; students will thus perform analysis and create reports and presentations for several different product solutions. Peer and faculty evaluations will provide feedback to improve individual technique. In addition, throughout the semester, local biomedical entrepreneurs will visit to share their expertise and experiences.

Credit 3 units.

Typical periods offered: Fall, Spring

BME 5780 Engineering for Women's Health

Engineering approaches have many uses in improving women's health across the lifespan and across the globe, from basic science understanding through to clinical implementation at the point of care. This course will include female reproductive anatomy and physiology across the lifespan and touch on several challenges and pathologies in women's health. Topics will include menstruation, contraception, endometriosis, pain, pregnancy complications, sexually transmitted infections, infertility, pelvic floor disorders, cancers of the female reproductive tract, menopause, cardiovascular disease, and osteoporosis. There will be a focus on unmet needs in women's health based on different contexts of care, including well-funded tertiary medical centers, US healthcare deserts, and underserved settings within the US and around the world. The current clinical standard of care and emerging engineering research and startup technologies for each topic will be covered and enhanced by inclusion of expert women's health engineering speakers with backgrounds in academic research, women's health engineering startups, large companies, and device manufacturing. Students will complete case studies, one business pitch for a women's health technology of their choosing, and one in-depth project on a women's health engineering topic of their choosing.

Credit 3 units.

Typical periods offered: Fall

BME 5901 Integrative Cardiac Electrophysiology

Quantitative electrophysiology of the heart, integrating from the molecular level (ion channels, regulatory pathways, cell signaling) to the cardiac cell (action potential and calcium transient), multicellular tissue (cell-cell communication) and the whole heart.

Credit 3 units.

Typical periods offered: Fall

BME 5910 Biomedical Optics I: Principles

This course covers the principles of optical photon transport in biological tissue. This course covers the principles and applications of optical photon transport in biological tissue. Topics include a brief introduction to biomedical optics, single-scatterer theories, Monte Carlo modeling of photon transport, convolution for broad-beam responses, radiative transfer equation, diffusion theory and applications, sensing of optical properties and spectroscopy, and photoacoustic imaging principles and applications.

Credit 3 units.

Typical periods offered: Fall

BME 5911 Cardiovascular Biophysics Journal Club

This journal club is intended for beginning graduate students, advanced undergraduates, and MSTP students with a background in the quantitative sciences (engineering, physics, math, chemistry, etc). The subjects covered are inherently multidisciplinary. We will review landmark and recent publications in quantitative cardiovascular physiology, mathematical modeling of physiologic systems and related topics such as chaos theory and nonlinear dynamics of biological systems. Familiarity with calculus, differential equations, and basic engineering/thermodynamic principles is assumed. Knowledge of anatomy/physiology is optional.

Credit 1 unit.

Typical periods offered: Fall, Spring

BME 5920 Biomedical Optics II: Imaging

This course covers optical imaging technologies. Topics include ballistic imaging, optical coherence tomography, Mueller optical coherence tomography, diffuse optical tomography, photoacoustic tomography, and ultrasound-modulated optical tomography.

Credit 3 units.

Typical periods offered: Spring

BME 5940 Ultrasound Imaging

Ultrasound imaging is the most widely used medical imaging modality in the world. This course offers an introduction to the medical ultrasound field. It exposes students to fundamental physical principles of ultrasound, ultrasound imaging, and ultrasound therapy. It will also introduce emerging ultrasound technologies in industry and clinics. Students will learn via lectures, homework, lab exercises, and a final project to gain knowledge, learn the ability to think critically, and develop problem-solving skills.

Credit 3 units.

Typical periods offered: Fall

BME 5950 Drug Delivery Systems: Principles and Applications

The course will introduce approaches for delivering pharmaceuticals including; routes of administration, dosage forms, transport out of dosage forms, transport across biological barriers, and pharmacokinetics. The course will examine classical approaches to drug delivery and survey the latest products and research in the field. Students will achieve a quantitative understanding of drug delivery practice and theory emphasizing principles in mass transport phenomena.

Credit 3 units.

Typical periods offered: Spring

BME 5999 Independent Study

Independent research investigation on a topic of special interest for graduate students. This course is restricted to PhD students in Biomedical Engineering and Master's students in both Biomedical Engineering and Imaging Science programs. Students must complete and submit required registration forms prior to enrollment.

Credit 9 units.

Typical periods offered: Fall, Spring, Summer

BME 6030 Teaching Assistantship - Advanced

This is a pass/no pass course for the fulfillment of the advanced teaching requirement which is required for the Ph.D. degree. A form obtained from the BME department must be submitted to their thesis mentor upon completion of requirements for approval in order to receive a grade.

Credit 0 units.

Typical periods offered: Spring



BME 6993 Teaching Assistantship - Basic

This is a pass/no pass course for the fulfillment of the basic teaching requirement which is required for the Ph.D. degree. A form obtained from the BME department must be submitted to the instructor at the end of the semester for approval in order to receive a grade.

Credit 0 units.

Typical periods offered: Spring

BME 7998 Masters Research

Independent research investigation on a topic of special interest for thesis-track students. This course is restricted to students enrolled in the Master of Science in Biomedical Engineering or Master of Science in Imaging Science programs. Students must complete and submit required registration forms prior to enrollment.

Credit 6 units.

Typical periods offered: Fall, Spring

BME 8887 BME Doctoral Seminar Series

This is a credit option for BME students who attend regularly scheduled BME seminars (or approved substitute seminars). A satisfactory grade is obtained by submission of a two-page peer-reviewed paper written by one of the regularly scheduled BME seminar speakers whose seminar the student attended. Papers are to be submitted to the Graduate Student Administrator for review by the Director of Doctoral Studies.

Credit 1 unit.

Typical periods offered: Fall, Spring

BME 8888 Graduate Seminar

This is a pass/no-pass course which is required for the Ph.D. degree. A passing grade is required for each semester of full-time enrollment (6 units or more). A passing grade is received by attendance at the regularly scheduled BME seminars.

Credit 0 units.

Typical periods offered: Fall, Spring

BME 8991 Research Rotation for BME Doctoral Students

This course provides doctoral students with the opportunity to gain hands-on research experience by working in multiple labs or research settings. Students will rotate through various research labs, allowing them to learn different techniques, methodologies, and approaches to scientific inquiry. The rotations help students identify their primary research interests and potential dissertation advisors. Throughout the course, students will be expected to actively participate in research activities, present their findings, and submit reports on their experiences. The goal is to broaden students' perspectives, enhance their technical skills, and facilitate informed decisions about their future research focus. This course awards no course credit.

Credit 0 units.

Typical periods offered: Fall, Spring

BME 8992 Research Rotation for BME Doctoral Students

This course provides doctoral students with the opportunity to gain hands-on research experience by working in multiple labs or research settings during their first year of study. Students will rotate through various research labs, allowing them to learn different techniques, methodologies, and approaches to scientific inquiry. The rotations help students identify their primary research interests and potential dissertation advisors. Throughout the course, students will be expected to actively participate in research activities, present their findings, and submit reports on their experiences. The goal is

to broaden students' perspectives, enhance their technical skills, and facilitate informed decisions about their future research focus. A maximum of six credits are allowed to count toward the BME PhD coursework requirement.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

BME 8998 Doctoral Research

This course is designed for doctoral candidates to conduct advanced, original research in their field of study, leading to the completion of their dissertation. Students will engage in in-depth literature reviews, formulate research questions, develop and implement research methodologies, collect and analyze data, and write their dissertation under the guidance of their faculty advisor and dissertation committee. The course emphasizes critical thinking, scholarly integrity, and the advancement of knowledge. Regular meetings with the advisor and periodic progress reports are required. Successful completion is necessary for the awarding of the doctoral degree.

Credit 9 units.

Typical periods offered: Fall, Spring

Biomedical Engineering, MS (BME)

Requirements

The Masters of Science (MS) in Biomedical Engineering requires the completion of 30 credit units, beyond the bachelor's degree, including 15 credit units from the Required Core Biomedical Engineering Courses lists below (9 credit units from BME Requirement, 3 credit units from Life Science, and 3 credit units from Math/Computer Science) and the remaining credits from the elective list.

24 of the 30 credits must be taken at the 5000 level or above; up to 6 of the 30 credits can be at the 4000 level. 6 of the 30 credits may be transferred from another university, if the credits were not used for another degree. All courses for the MS-BME must be taken for a letter grade. At least 15 credits must be Engineering courses.

There are two options to obtain the degree: thesis and non-thesis.

Thesis Option

Candidates must accumulate 30 credit units. A minimum of 24 of these units must be course credit, and a maximum of 6 units may be master's research (BME 7998 Masters Research). The course credits must fulfill the core curriculum requirements.

The remainder of the coursework is generally driven by the student's research interests. Upon completion of the thesis, the candidate must pass an oral defense conducted by their thesis committee. This will consist of a public presentation followed by questions from the committee. Candidates must have a cumulative grade point average of 2.7 or better to receive the degree.

Non-Thesis Option

Candidates must accumulate a total of 30 graduate credits, have a cumulative GPA of 2.7 or better, and satisfy the core curriculum requirements. Students may count up to 3 credit units of graduate-level independent study in biomedical engineering (BME 5999 Independent Study) toward their degree. The balance of the course credits should be selected with a view toward coherence reflecting a specialization in a research area.

Courses

Required Core Biomedical Engineering Courses (15 units)

BME Requirement (9 units)

Code	Title	Units
BBS 5014	Biotech Industry Innovators	3
BBS 5075	Introduction to Coding and Statistical Thinking for Genetics and Genomics	2
BBS 5146	Principles and Applications of Biological Imaging	3
BBS 5147	Contrast Agents for Biological Imaging	3
BBS 5311	Dynamics in Mesoscopic Molecular Systems	3
BBS 5312	Macromolecular Interactions	3
BME 4400	Biomedical Data Science	3
BME 4710	Bioelectric Phenomena	3
BME 4960	Design and Development of Optical Imaging Systems	3
BME 5190	Advanced Cognitive, Computational, and Systems Neuroscience	3
BME 5230	Biomaterials Science	3
BME 5320	Biomolecular Interaction Networks	3
BME 5330	Biomedical Signal Processing	3
BME 5340	Biophysical chemistry	3
BME 5420	Principles of Biomolecular Spectroscopy	3
BME 5430	Molecular and Cellular Engineering	3
BME 5440	Biomedical Instrumentation	3
BME 5501	Translational Neuroengineering	3
BME 5590	Intermediate Biomechanics	3
BME 5642	Human-Machine Interfaces	3
BME 5650	Biosolid Mechanics	3

BME 5690	Cardiac Electrophysiology	3
BME 5700	Mathematics of Imaging Science	3
BME 5720	Biological Neural Computation	3
BME 5744	Open Challenges in Systems Neuroscience	3
BME 5750	Molecular Basis of Bioelectrical Excitation	3
BME 5771	Biomedical Product Development	3
BME 5780	Engineering for Women's Health	3
BME 5790	Biofabrication & Medical Devices	3
BME 5901	Integrative Cardiac Electrophysiology	3
BME 5910	Biomedical Optics I: Principles	3
BME 5920	Biomedical Optics II: Imaging	3
BME 5940	Ultrasound Imaging	3
BME 5950	Drug Delivery Systems: Principles and Applications	3
CHEM 5680	Special Topics in Inorganic Chemistry (Interface Science for Soft Materials and Biomedicine)	3
CSE 5807	Algorithms for Computational Biology	3
EECE 5190	Molecular Biochemical Engineering	3
ESE 4380	Applied Optics	3
ESE 4480	Control Systems Design Laboratory	3
ESE 4820	Digital Signal Processing	3
ESE 5460	Dynamics & Control in Neuroscience & Brain Medicine	3
ESE 5820	Fundamentals and Applications of Modern Optical Imaging	3
ESE 5890	Biological Imaging Technology	3
MEDPHYS 5010	Radiological Physics and Dosimetry	3
MEDPHYS 5060	Radiobiology	2
MEDPHYS 5070	Radiation Oncology Physics	3
MEDPHYS 5080	Radiation Protection and Safety	2
MEMS 5562	Cardiovascular Mechanics	3
MEMS 5565	Mechanobiology of Cells and Matrices	3
MEMS 5566	Engineering Mechanobiology	3
MEMS 5606	Soft Nanomaterials	3
MEMS 5607	Introduction to Polymer Blends and Composites	3
MEMS 5608	Introduction to Polymer Science and Engineering	3
MEMS 5613	Biomaterials Processing	3
MEMS 5614	Polymeric Materials Synthesis and Modification	3
MEMS 5910	Biomechanics Journal Club	1
PSYCH 4450	Functional Neuroimaging Methods	3



Life Science (3 units)

Code	Title	Units
ANTHRO 4581	Principles of Human Anatomy and Development	3
ANTHRO 4598	Biomarkers: Measuring Population Health, Reproductive, and Social Endocrinology	3
BBS 5053	Immunobiology I	4
BBS 5068	Fundamentals of Molecular Cell Biology	4
BBS 5224	Molecular, Cell and Organ Systems	3
BBS 5285	Current Topics in Human and Mammalian Genetics	3
BBS 5319	Molecular Foundations of Medicine	3
BBS 5357	Chemistry and Physics of Biomolecules	3
BBS 5392	Molecular Microbiology & Pathogenesis	4
BBS 5480	Nucleic Acids & Protein Biosynthesis	3
BBS 5488	Genomics	4
BBS 5501	Biology of the Visual System	3
BBS 5571	Cellular Neurobiology	6
BBS 5651	Neural Systems	6
BBS 5663	Neurobiology of Disease	2
BBS 5928	Experimental Cancer Biology	3
BBS 5940	Foundations in Cancer Biology and Experimental Cancer Biology	3
BIOL 4030	Biological Clocks	3
BIOL 4040	Laboratory of Neurophysiology	4
BIOL 4181	Population Genetics	3
BIOL 4270	Problem Based Learning in Biomedical Sciences	3
BIOL 4310	Biology of Aging	3
BIOL 4381	Cell-Based Tissue Engineering and Regenerative Medicine	3
BIOL 4510	General Biochemistry	4
BIOL 5114	Neuroplasticity Wiring and Rewiring of the Brain	3
BIOL 5181	Population Genetics	3
BIOL 5241	Immunology	4
BIOL 5309	Biology of Aging	3
BIOL 5352	Developmental Biology	3
BIOL 5716	Advanced Cancer Biology	3
BME 5300	Molecular Cell Biology for Engineers	3
BME 5380	Cell Signal Transduction	3
CHEM 4810	General Biochemistry I	3
CHEM 4820	General Biochemistry II	3
CHEM 4833	Protein Biochemistry	3
IPMS 5611	Movement Science III--Biocontrol Mechani	3
MEDPHYS 5060	Radiobiology	2

PHTPS 6012	Global Reproductive Health	3
PSYCH 5631	Introduction to Computational Cognitive Science	3
PSYCH 5665	The Science of Behavior	3
REPRSCI 5000	Human Reproductive Physiology	3

Math/Computer Science (3 units)

Code	Title	Units
Mathematics		
BBS 5075	Introduction to Coding and Statistical Thinking for Genetics and Genomics	2
BBS 5648	Coding and Statistical Thinking in the Neurosciences	3
BME 5300	Molecular Cell Biology for Engineers	3
BME 5700	Mathematics of Imaging Science	3
CLNV 5151	Intermediate Statistics for the Health Sciences	3
EECE 5030	Mathematical Methods in EECE	3
ESE 5010	Mathematics of Modern Engineering I	3
ESE 5020	Mathematics of Modern Engineering II	3
ESE 5200	Probability and Stochastic Processes	3
MATH 4501	Numerical Applied Mathematics	3
MATH 4540	Partial Differential Equations	3
PHFN 5001	Biostatistics	3
PHYSICS 5010	Theoretical Physics	3
PHYSICS 5020	Methods of Theoretical Physics II	3
PHYSICS 5027	Introduction to Computational Physics	3
PHYSICS 5810	Critical Analysis of Scientific Data (1 credit for math, 2 credits general elective)	3
SDS 4020	Mathematical Statistics	3
SDS 5020	Mathematical Statistics	3
SDS 5210	Statistical Computation	3
SDS 5480	Topics in Statistics (Tpics in Statistics: Machine Learning Methods in Biological Sciences)	3
Computer Science		
BDSAI 5003	Introduction to Biomedical Data Science	2
BME 4400	Biomedical Data Science	3
BME 5401	Biomedical Data Science	3
BME 5501	Translational Neuroengineering	3
CSE 4102	Introduction to Artificial Intelligence	3
CSE 4107	Introduction to Machine Learning	3
CSE 5105	Bayesian Methods in Machine Learning	3
CSE 5107	Machine Learning	3
CSE 5306	Rapid Prototype Development and Creative Programming	3
CSE 5401	Advanced Algorithms	3
CSE 5403	Algorithms for Nonlinear Optimization	3

CSE 5504	Geometric Computing for Biomedicine	3
CSE 5509	Computer Vision	3
CSE 5515	Computational Photography	3
CSE 5804	Algorithms for Biosequence Comparison	3
CSE 5807	Algorithms for Computational Biology	3
ESE 4170	Introduction to Machine Learning and Pattern Classification	3
PHIL 6005	Applied Machine Learning Using Health Data	3

Electives (15 units)

Students may choose from the list below and the lists above to meet the elective requirement. In addition, BME, CSE, EECE, ESE, and MEMS courses that are 4000- or 5000-level courses and that carry Engineering Topics units will count toward elective credit, with the exception of the following, which will not count toward the degree: BME 4000 Independent Study, BME 4001 Independent Study, BME 4002 Independent Study, BME 4003 Independent Study, BME 4970 Senior Capstone Design A, BME 4971 Senior Capstone Design B, BME 4980 Biomedical Engineering Design, and BME 4981 Senior Design II.

Code	Title	Units
BDSAI 5004	Introduction to Biomedical Informatics	2
BME 5999	Independent Study (non-thesis track, may count up to 3 credit units toward degree)	3
BME 7998	Masters Research (thesis track, may count up to 6 credit units toward degree)	6
CHEM 4511	Synthetic Polymer Chemistry	3
CHEM 5811	Introduction to Biomolecules	3
CHEM 5830	Bioorganic Chemistry	3
DAT 5561	Introduction to Python and Data Science	3
MGT 5240	Business Planning for New Enterprises [the Hatchery]	3
MGT 5775	Launching and Scaling New Enterprises (The League)	3
PHYSICS 5810	Critical Analysis of Scientific Data	3
PSYCH 4631	Introduction to Computational Cognitive Science	3
PSYCH 8373	Neural Systems of Behavior and Psychopathology	3
SDS 5800	Topics in Statistics	3
SDS 5480	Topics in Statistics (Machine Learning Methods in Biological Data)	3

Biomedical Engineering, PhD (BME)

The Biomedical Engineering doctoral degree requires a minimum of 72 credits beyond the bachelor's level, with a minimum of 30 being course credits (including the core curriculum) and a minimum of 24 credits of doctoral dissertation research.

The core curriculum that must be satisfied by all PhD students consists of the following:

- One graduate-level course (≥ 3 credits) in life science from an approved list
- One graduate-level course (≥ 3 credits) in mathematics from an approved list
- One graduate-level course in (≥ 3 credits) computer science from an approved list or exemption by proficiency
- Four BME courses (≥ 12 credits) from an approved list

Up to 3 credits of BME 5999 Independent Study and/or 3 credits of BME 8887 BME Doctoral Seminar Series may be counted toward the 30 credits of graduate courses required for the PhD. A total of 24 additional credits, including the core curriculum, are required for the PhD. Up to two 4000-level courses may be counted toward the PhD coursework requirements. Graduate courses may be transferred in (up to 24 credits) but must be evaluated and approved by the Director of Doctoral Studies. The evaluation and approval may occur at any time, but course transfer does not become official until after one year in residence at Washington University.

Students seeking the PhD in Biomedical Engineering enroll in two to three courses each semester. Before the end of their first 10 months of enrollment in the program, students take their oral qualifying exam, which consists of a presentation of their research done to date in the mentor's laboratory followed by an oral exam addressing any issues directly related to their qualifying exam report or their oral presentation. Upon successfully passing the qualifying examination, they advance to candidacy and complete the balance of their requirements. During the second and third years, students complete their remaining courses, participate in a mentored teaching experience, and begin their thesis research. By the end of the third year, students must complete their thesis proposal.

Courses

BME Requirement (12 credits)

Code	Title	Units
BBS 5014	Biotech Industry Innovators	3
BBS 5146	Principles and Applications of Biological Imaging	3
BBS 5147	Contrast Agents for Biological Imaging	3



BBS 5311	Dynamics in Mesoscopic Molecular Systems	3
BBS 5312	Macromolecular Interactions	3
BME 4710	Bioelectric Phenomena	3
BME 4960	Design and Development of Optical Imaging Systems	3
BME 5190	Advanced Cognitive, Computational, and Systems Neuroscience	3
BME 5230	Biomaterials Science	3
BME 5320	Biomolecular Interaction Networks	3
BME 5330	Biomedical Signal Processing	3
BME 5340	Biophysical chemistry	3
BME 5420	Principles of Biomolecular Spectroscopy	3
BME 5430	Molecular and Cellular Engineering	3
BME 5440	Biomedical Instrumentation	3
BME 5501	Translational Neuroengineering	3
BME 5590	Intermediate Biomechanics	3
BME 5642	Human-Machine Interfaces	3
BME 5650	Biosolid Mechanics	3
BME 5690	Cardiac Electrophysiology	3
BME 5720	Biological Neural Computation	3
BME 5744	Open Challenges in Systems Neuroscience	3
BME 5750	Molecular Basis of Bioelectrical Excitation	3
BME 5771	Biomedical Product Development	3
BME 5780	Engineering for Women's Health	3
BME 5790	Biofabrication & Medical Devices	3
BME 5901	Integrative Cardiac Electrophysiology	3
BME 5910	Biomedical Optics I: Principles	3
BME 5920	Biomedical Optics II: Imaging	3
BME 5940	Ultrasound Imaging	3
BME 5950	Drug Delivery Systems: Principles and Applications	3
CHEM 5680	Special Topics in Inorganic Chemistry (Interface Science for Soft Materials and Biomedicine)	3
EECE 5190	Molecular Biochemical Engineering	3
ESE 4380	Applied Optics	3
ESE 4480	Control Systems Design Laboratory	3
ESE 4820	Digital Signal Processing	3
ESE 5460	Dynamics & Control in Neuroscience & Brain Medicine	3
ESE 5820	Fundamentals and Applications of Modern Optical Imaging	3
ESE 5890	Biological Imaging Technology	3
MEDPHYS 5010	Radiological Physics and Dosimetry	3
MEDPHYS 5060	Radiobiology	2
MEDPHYS 5070	Radiation Oncology Physics	3
MEDPHYS 5080	Radiation Protection and Safety	2
MEMS 5562	Cardiovascular Mechanics	3

MEMS 5565	Mechanobiology of Cells and Matrices	3
MEMS 5566	Engineering Mechanobiology	3
MEMS 5606	Soft Nanomaterials	3
MEMS 5607	Introduction to Polymer Blends and Composites	3
MEMS 5608	Introduction to Polymer Science and Engineering	3
MEMS 5613	Biomaterials Processing	3
MEMS 5614	Polymeric Materials Synthesis and Modification	3
MEMS 5910	Biomechanics Journal Club	1
PSYCH 4450	Functional Neuroimaging Methods	3

Life Science (3 credits)

Code	Title	Units
ANTHRO 4581	Principles of Human Anatomy and Development	3
ANTHRO 4598	Biomarkers: Measuring Population Health, Reproductive, and Social Endocrinology	3
BBS 3532	Developmental Biology	3
BBS 4071	Developmental Biology	
BBS 5053	Immunobiology I	4
BBS 5068	Fundamentals of Molecular Cell Biology	4
BBS 5224	Molecular, Cell and Organ Systems	3
BBS 5285	Current Topics in Human and Mammalian Genetics	3
BBS 5319	Molecular Foundations of Medicine	3
BBS 5357	Chemistry and Physics of Biomolecules	3
BBS 5392	Molecular Microbiology & Pathogenesis	4
BBS 5480	Nucleic Acids & Protein Biosynthesis	3
BBS 5488	Genomics	4
BBS 5501	Biology of the Visual System	3
BBS 5571	Cellular Neurobiology	6
BBS 5651	Neural Systems	6
BBS 5663	Neurobiology of Disease	2
BBS 5928	Experimental Cancer Biology	3
BBS 5940	Foundations in Cancer Biology and Experimental Cancer Biology	3
BIOL 4030	Biological Clocks	3
BIOL 4040	Laboratory of Neurophysiology	4
BIOL 4181	Population Genetics	3
BIOL 4270	Problem Based Learning in Biomedical Sciences	3
BIOL 4310	Biology of Aging	3
BIOL 4381	Cell-Based Tissue Engineering and Regenerative Medicine	3
BIOL 4510	General Biochemistry	4



BIOL 5114	Neuroplasticity Wiring and Rewiring of the Brain	3
BIOL 5181	Population Genetics	3
BIOL 5241	Immunology	4
BIOL 5309	Biology of Aging	3
BIOL 5716	Advanced Cancer Biology	3
BME 5300	Molecular Cell Biology for Engineers	3
BME 5380	Cell Signal Transduction	3
CHEM 4810	General Biochemistry I	3
CHEM 4820	General Biochemistry II	3
CHEM 4833	Protein Biochemistry	3
IPMS 5611	Movement Science III--Biocontrol Mechani	3
PHTPS 6012	Global Reproductive Health	3
PSYCH 5631	Introduction to Computational Cognitive Science	3
PSYCH 5665	The Science of Behavior	3
REPRSCI 5000	Human Reproductive Physiology	3

Mathematics (3 credits)

Code	Title	Units
BBS 5075	Introduction to Coding and Statistical Thinking for Genetics and Genomics (Fundamentals of Biostatistics for Graduate Students)	2
BBS 5648	Coding and Statistical Thinking in the Neurosciences	3
BME 5700	Mathematics of Imaging Science	3
CLNV 5151	Intermediate Statistics for the Health Sciences	3
EECE 5030	Mathematical Methods in EECE	3
ESE 5010	Mathematics of Modern Engineering I	3
ESE 5020	Mathematics of Modern Engineering II	3
ESE 5200	Probability and Stochastic Processes	3
MATH 4501	Numerical Applied Mathematics	3
MATH 4540	Partial Differential Equations	3
PHFN 5001	Biostatistics	3
PHYSICS 5010	Theoretical Physics	3
PHYSICS 5020	Methods of Theoretical Physics II	3
PHYSICS 5027	Introduction to Computational Physics	3
PHYSICS 5810	Critical Analysis of Scientific Data (1 credit for math, 2 credits for general electives)	3
SDS 4020	Mathematical Statistics	3
SDS 5020	Mathematical Statistics	3
SDS 5210	Statistical Computation	3
SDS 5480	Topics in Statistics	3

Computer Science (3 credits)

Code	Title	Units
BME 4400	Biomedical Data Science	3
BME 5401	Biomedical Data Science	3
CSE 4102	Introduction to Artificial Intelligence	3
CSE 4107	Introduction to Machine Learning	3
CSE 5105	Bayesian Methods in Machine Learning	3
CSE 5107	Machine Learning	3
CSE 5306	Rapid Prototype Development and Creative Programming	3
CSE 5401	Advanced Algorithms	3
CSE 5403	Algorithms for Nonlinear Optimization	3
CSE 5504	Geometric Computing for Biomedicine	3
CSE 5509	Computer Vision	3
CSE 5515	Computational Photography	3
CSE 5804	Algorithms for Biosequence Comparison	3
CSE 5807	Algorithms for Computational Biology	3
ESE 4170	Introduction to Machine Learning and Pattern Classification	3
PHEL 6005	Applied Machine Learning Using Health Data	3

Electives (9 credits)

To meet the elective requirement students may choose from BBS, BME, CHEM, CSE, EECE, ESE, MEDPHYS, MEMS, PHYSICS, and REPRSCI courses at the 4000 and 5000 levels. Courses taken from departments outside of those listed can also be allowed to apply to the elective requirement (i.e., 4000 and 5000 level) with approval from the research mentor and department. Only 6 credits of 4000-level coursework can apply to the PhD coursework requirements.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.



Mentored Experience Requirement (MER)

Philosophy of Teaching

We are educating students for careers in industry, in government, and in academia with a concentration on research. Therefore, it is important that our graduates know how to convey technical knowledge in both lecture and interactive settings to a wide audience (from peers in the field to trainees with a limited understanding of the nuances of the topic). At present, our program requires the mentored teaching experience, not the mentored professional experience.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Two preparatory courses that have been approved by the Biomedical Engineering graduate committee are required.

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

Each student will be the AI for one course at 10 MER units by registering for EGS 8010 for the semester of engagement or for a two-semester long course at 5 MER units per semester by registering for EGS 8005 for the two semesters of engagement. Students are eligible for an AI assignment after they pass the qualifying exam and typically when they are beginning the second year of the program. Students work with their department coordinator or graduate program advisor on the timing of their AI assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement

Pathway #1

EGS 8010	Students register one time for the semester of the AI assignment
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Pathway #2

EGS 8005	Students register twice, one time for each of the AI assignment semesters
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Biomedical Engineering, Combined MD/PhD (BME)

The department offers programs that lead to the Doctor of Philosophy (PhD) in Biomedical Engineering as well as combined MD/PhD degrees. The latter degrees are conferred jointly with the School of Medicine.

The doctoral degree requires a minimum of 72 credits beyond the bachelor's level, with a minimum of 30 being course credits (including the core curriculum) and a minimum of 24 credits of doctoral dissertation research.

The core curriculum that must be satisfied by all PhD students consists of the following:

- One graduate-level course in life science from an approved list
- One graduate-level course in mathematics from an approved list
- One graduate-level course in computer science from an approved list or exemption by proficiency
- Four BME courses from an approved list

Please visit the Biomedical Engineering (BME) website for a comprehensive list of the approved courses.

Up to 3 credits of BME 8887 BME Doctoral Seminar Series may be counted toward the 30 credits of graduate courses required for the PhD, so a total of 27 additional credits (usually nine courses, including the core curriculum) are required for the PhD. Up to two 4000-level courses may be counted toward the nine courses required for the PhD. Graduate courses may be transferred in (up to 24 credits) but

must be evaluated and approved by the Director of Doctoral Studies. The evaluation and approval may occur at any time, but course transfer does not become official until after one year in residence at Washington University.

Students seeking the **PhD in Biomedical Engineering** enroll in two to three courses each semester. Before the end of their first 10 months of enrollment in the program, students take their oral qualifying exam, which consists of a presentation of their research done to date in the mentor's laboratory followed by an oral exam addressing any issues directly related to their rotation report or their oral presentation. Upon successfully passing the qualifying examination, they advance to candidacy and complete the balance of their requirements. During the second and third years, students complete their remaining courses, participate in one semester of a mentored teaching experience, and begin their thesis research. By the end of the third year, students must complete their thesis proposal.

Students pursuing the combined **MD/PhD in Biomedical Engineering** must complete the degree requirements in both schools. MD/PhD students typically complete the first two years of the medical school preclinical curriculum while also performing one or more research rotations, then the remaining requirements for the doctoral degree, and finally the clinical training years of the medical degree. The department generally gives graduate course credits for some of the medical school courses toward the fulfillment of course requirements for the PhD degree. This is arranged on an individual basis between the student, their academic advisor and the Director of Doctoral Studies.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

We are educating students for careers in industry, in government, and in academia with a concentration on research. Therefore, it is important that our graduates know how to convey technical knowledge in both lecture and interactive settings to a wide audience (from peers in the field to trainees with a limited understanding of the nuances of the topic). At present, our program requires the mentored teaching experience, not the mentored professional experience.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Two preparatory workshops that have been approved by the Biomedical Engineering graduate committee are required.

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

Each student will be the AI for one course at 10 MER units by registering for EGS 8010 MTE - Assistant in Instruction Experience for the semester of engagement. Students are eligible for an AI assignment after they pass the qualifying exam and typically when they are beginning the second year of the program. Students work with their department coordinator or graduate program advisor on the timing of their AI assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement

Pathway #1

EGS 8010	Students register one time for the semester of the AI assignment
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Computational & Data Sciences (Interdisciplinary PhD)

The Division of Computational & Data Sciences (DCDS) at Washington University in St. Louis trains students interested in problems from across a range of disciplines that share a common reliance on data and computing.

The introduction of now-standard tools from statistical analysis and hypothesis testing transformed the practice of natural and social science in the mid-20th century. Emerging tools from computational and data science have the potential to bring about an even larger transformation of scientific practice, especially in the social sciences. The questions raised by data generated by and about human behavior are engaging and profound. However, many if not most of these questions can only be tackled using a multidisciplinary approach that combines a deep knowledge of the capabilities and operation of data science techniques with the domain expertise needed to apply them effectively to the problems under consideration.

Doctoral students in Computational & Data Sciences receive strong methodological training in modern computational and statistical methods, and they also acquire expertise in a particular social science application area.

The program is inherently interdisciplinary and brings together leading experts from across the university who are using data to solve some of the greatest challenges that our world faces today. Faculty include both data and computing experts as well as domain experts from different application areas.

Faculty

Eunhye Ahn

Assistant Professor, Brown School
PhD, University of Southern California

Ruopeng An

Assistant Professor, Brown School
PhD, Pardee RAND Graduate School

Dennis Barbour

Associate Professor, Biomedical Engineering
MD, Johns Hopkins University
PhD, Johns Hopkins University

Deanna Barch

Professor and Chair, Psychological & Brain Sciences
PhD, University of Illinois

Janine Bijsterbosch

Assistant Professor, Radiology
PhD, University of Sheffield

Ryan Bogdan

Associate Professor, Psychological & Brain Sciences
PhD, Harvard University

Todd Braver

Professor, Psychological & Brain Sciences, Radiology, and
Neuroscience
PhD, Carnegie Mellon University

Michael Brent

Henry Edwin Sever Professor of Engineering, Computer Science &
Engineering
PhD, Massachusetts Institute of Technology

Derek Brown

Associate Professor, Brown School
PhD, Duke University

Sheretta Butler-Barnes

Associate Professor, Brown School
PhD, Wayne State University

David Carter

Associate Professor, Political Science
PhD, University of Rochester

Yixin Chen

Professor, Computer Science & Engineering
PhD, University of Illinois

Dino Christenson

Associate Professor, Political Science
PhD, Ohio State University

Brett Drake

Professor, Brown School
PhD, University of California, Los Angeles

Ted Enamorado

Assistant Professor, Political Science
PhD, Princeton University

Randi Foraker

Associate Professor of Public Health, Brown School
PhD, The University of North Carolina at Chapel Hill

Patrick Fowler

Track Chair, Social Work & Public Health
Associate Professor, Brown School
PhD, Wayne State University

Roman Garnett

Assistant Professor, Computer Science & Engineering
PhD, University of Oxford

Aimilia Gastouni

Assistant Professor, Radiology
PhD, National Technical University of Athens

Chris Gill

Professor, Computer Science & Engineering
DSc, Washington University in St. Louis

Brian Gordon

Assistant Professor, Radiology
PhD, University of Illinois

Roch Guérin

Professor and Chair, Computer Science & Engineering
PhD, California Institute of Technology

Shenyang Guo

Professor, Brown School
PhD, University of Michigan–Ann Arbor

Ross Hammond

Associate Professor, Brown School
PhD, University of Michigan

Jenine Harris

Associate Professor, Brown School
PhD, Saint Louis University

Chien-Ju Ho

Assistant Professor, Computer Science & Engineering
PhD, University of California, Los Angeles

Josh Jackson

Associate Professor, Psychological & Brain Sciences
PhD, University of Illinois Urbana-Champaign

Nathan Jacobs

Professor, Computer Science & Engineering
PhD, Washington University in St. Louis

Kim Johnson

Associate Professor, Brown School
PhD, University of Minnesota

Melissa Jonson-Reid

Professor, Brown School
PhD, University of California, Berkeley

Brendan Juba

Assistant Professor, Computer Science & Engineering
PhD, Massachusetts Institute of Technology

Thomas Kannampallil

Assistant Professor, Anesthesiology
PhD, University of Illinois

Caitlin Kelleher

Associate Professor, Computer Science & Engineering
PhD, Carnegie Mellon University

Wouter Kool

Assistant Professor, Psychological & Brain Sciences
PhD, Princeton University

Matt Kreuter

Professor, Social Work & Public Health
PhD, The University of North Carolina at Chapel Hill

Albert Lai

Associate Professor and Deputy Director, Institute for Informatics
Associate Professor, Computer Science & Engineering
PhD, Columbia University

Calvin Lai

Assistant Professor, Psychological & Brain Sciences
PhD, University of Virginia

Matthew Lew

Assistant Professor, Electrical & Systems Engineering
PhD, Stanford University

Jr-Shin Li

Professor, Electrical & Systems Engineering
PhD, Harvard University

Fangqiong Ling

Assistant Professor, Energy, Environmental & Chemical Engineering
PhD, University of Illinois Urbana-Champaign

Chenyang Lu

Professor, Computer Science & Engineering
PhD, University of Virginia

Christopher Lucas

Assistant Professor, Political Science
PhD, Harvard University

Doug Luke

Professor, Brown School
PhD, University of Illinois

Phillip Marotta

Assistant Professor, Brown School
PhD, Columbia University

Andrew D. Martin

Professor, Political Science and Law
Chancellor, Washington University in St. Louis
PhD, Washington University in St. Louis

Timothy McBride

Professor, Brown School
PhD, University of Wisconsin–Madison

Jacob Montgomery

Track Chair, Political Science
Associate Professor, Political Science
PhD, Duke University

William Nomikos

Assistant Professor, Political Science
PhD, Yale University

Alvitta Ottley

Assistant Professor, Computer Science & Engineering
PhD, Tufts University

Neal Patwari

Professor, Electrical & Systems Engineering
Professor, Computer Science & Engineering
PhD, University of Michigan

Philip R.O. Payne

Professor and Director, Institute for Informatics
Professor, Computer Science & Engineering
PhD, Columbia University

Netanel Raviv

Assistant Professor, Computer Science & Engineering
PhD, Technion – Israel Institute of Technology

Zachariah Reagh

Assistant Professor, Psychological & Brain Sciences
PhD, University of California, Irvine

Andrew Reeves

Associate Professor, Political Science
PhD, Harvard University

Guillermo Rosas

Associate Professor, Political Science
PhD, Duke University

Betsy Sinclair

Professor, Political Science
PhD, California Institute of Technology

Bruno Sinopoli

Professor and Chair, Electrical & Systems Engineering
PhD, University of California, Berkeley

Aristeidis Sotiras

Assistant Professor, Radiology
PhD, École Centrale Paris

Fred Ssewamala

Associate Dean for Transdisciplinary Faculty Research, Brown School
PhD, Washington University in St. Louis

Joe Steensma

Professor of Practice, Brown School
EdD, Indiana Wesleyan University

Joshua Swamidass

Associate Professor, Pathology & Immunology
Associate Professor, Biomedical Engineering
MD, University of California, Irvine
PhD, University of California, Irvine

Jessie Sun

Assistant Professor, Psychological & Brain Sciences
PhD, University of California, Davis

Yevgeniy Vorobeychik

Associate Professor, Computer Science & Engineering
PhD, University of Michigan

Chenguang Wang

Assistant Professor, Computer Science & Engineering
PhD, Peking University

Yong Wang

Associate Professor, Electrical & Systems Engineering

Emily Willroth

Assistant Professor of Psychological & Brain Sciences
PhD, University of California, Berkeley

William Yeoh

Track Chair, Computational Methodologies
Associate Professor, Computer Science & Engineering
PhD, University of Southern California

Jeffrey Zacks

Track Chair, Psychological & Brain Sciences
Professor and Associate Chair, Psychological & Brain Sciences
PhD, Stanford University

Shen Zeng

Assistant Professor, Electrical & Systems Engineering
PhD, University of Stuttgart

Ning Zhang

Assistant Professor, Computer Science & Engineering
PhD, Virginia Polytechnic Institute and State University

Xuan Zhang

Assistant Professor, Electrical & Systems Engineering
PhD, Cornell University

Degree Requirements

- Computational & Data Sciences, PhD (p. 57)

Computational & Data Sciences, PhD (CDS)

Upon joining the PhD program, each student is assigned an initial advisor from the DCDS faculty. This advisor meets with the student to assess their background and to advise them on course selection.

All students complete a common core curriculum as well as a domain depth requirement in a social science area. The focus of the first year is on acquiring a common set of tools and an understanding of the ranges and types of problems students may work on as they progress through the program. The entire incoming cohort takes a unique two-semester seminar sequence solely for DCDS students, which includes both general topics and a series of data-driven dives into the types of research questions that may be encountered in each of the domain areas.

Curriculum

Required Core Courses

Please refer to the DCDS Doctoral Student Handbook for the most up-to-date core course requirements.

Domain Depth Tracks

Students will choose one of four focus tracks: Political Science, Psychological & Brain Sciences, Social Work & Public Health, or Computational Methodologies. Please refer to the DCDS Doctoral Student Handbook for the most up-to-date domain depth track requirements.

Further Requirements

Additional requirements for this program are as follows:

- A minimum of 72 credit units beyond the bachelor's level, with a minimum of 37 being course credits (including the core curriculum)
- A minimum of 24 credit units of doctoral dissertation research
- Students must maintain a cumulative average grade of B (3.0 grade-point average) for all 72 credit units.
- Required courses must be completed with no more than one grade below a B–.
- Up to 24 graduate credit units may be transferred with the approval of the Graduate Studies Committee, which is chaired by the director of graduate studies.

In addition to fulfilling the course and research credit requirements, students must do the following:

- Pass a qualifying exam.
- Successfully defend a thesis proposal.
- Present and successfully defend a dissertation.
- Complete a teaching requirement consisting of two semesters of mentored teaching experience.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

We embrace the significance of Mentored Teaching Experiences (MTEs) as integral to the comprehensive preparation of PhD students. Engaging in MTEs not only provides students with opportunities to develop pedagogical skills and classroom management techniques but

also fosters a deeper understanding of their discipline and enhances their ability to communicate complex ideas effectively. Students will learn to engage diverse audiences, adapt instructional strategies, and foster inclusive learning environments, all of which are essential competencies for success in academia and beyond. Moreover, MTEs instill a sense of responsibility, professionalism, and ethical conduct, preparing students to navigate the complex landscape of higher education with confidence and integrity. Whether students pursue careers within academia or choose alternative pathways, the skills honed through MTEs equip them to excel as educators, mentors, and leaders making meaningful contributions to their communities and professions.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Two Preparatory Engagement activities are required:

1. Center for Teaching and Learning Teaching Orientation
2. One 90-minute teaching workshop offered by the Center for Teaching and Learning

—or—

1. McKelvey Teaching Orientation (Canvas course)
2. McKelvey Teaching Workshop (Canvas course)

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

The Division of Computational & Data Sciences requires two AI assignments at 10 MER units each. Each student works with their graduate supervisor on the timing and content of those assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement

EGS 8010

Take two times

Computer Science & Engineering

During the past two decades, society has experienced unprecedented growth in digital technology. This revolution continues to redefine our way of life, our culture and our economy. Computer science and engineering education plays an irreplaceable role in this trend by preparing future technology leaders and innovators. It opens our minds to new horizons, unlocks doors to a broad range of career paths, accelerates professional advancement, and exposes us to ideas that are advancing the frontiers of science and technology beyond the field of computing. Alumni and students continually remind us that pursuing a degree in the Department of Computer Science & Engineering is an experience rarely matched elsewhere.

Master's Programs

The Department of Computer Science & Engineering offers four master's degrees: **Master of Science in Computer Science**, **Master of Science in Computer Engineering**, **Master of Science in Cybersecurity Engineering**, and **Master of Engineering in Computer Science and Engineering**. We accept both full-time and part-time students, offering class schedules that are flexible enough for part-time students but that provide enough classes for students to attend full-time. Obtaining a master's degree from the Department of Computer Science & Engineering can be done as a pure course option (MS in Computer Science and MS in Computer Engineering degrees only), or it can incorporate a specialized research experience. Master's research is a great way for our students to easily transition into future doctoral studies. Graduates of our program are also prepared to enter the industry, with many accepting positions at companies like Boeing, Google and Microsoft. Applicants to our master's programs are expected to have completed an undergraduate degree. A major or minor in computer science or computer engineering is helpful, but it is not required. Background requirements are listed within each degree program, along with options for meeting them.

PhD Programs

The Department of Computer Science & Engineering offers **PhD programs in Computer Science and in Computer Engineering**. Computer science research encompasses the fundamentals of software and algorithm design, machine learning and bioinformatics, visual and cyber-physical computing, and human-computer interaction. Computer engineering focuses on the interaction of software and hardware in the design of computing systems and networks. Our research groups have extensive interdisciplinary ties across the university, with collaborations in medicine, science, the humanities and social work. Recent graduates have accepted research and teaching faculty positions as well as research and engineering positions in leading technology companies.

Both PhD programs require a combination of courses, research and teaching. The required courses are often completed early in the program, since students are integrated into research groups during their first year and the program's emphasis is on creative research. The program has milestones that involve both written and oral components, and these provide structure for the five- to six-year degree. The program considers applicants with either bachelor's or master's degrees and has had successful applicants in the past whose backgrounds were outside of the field of computer science.

Phone:

314-935-6132

Email:

admissions@cse.wustl.edu

Website:

<https://cse.wustl.edu/academics/graduate/index.html>

Faculty

Chair

Roch Guérin

Harold B. and Adelaide G. Welge Professor of Computer Science
PhD, California Institute of Technology
Computer networks and communication systems

Professors

Kunal Agrawal

PhD, Massachusetts Institute of Technology
Parallel computing, cyber-physical systems and sensing, theoretical computer science

Sanjoy Baruah

PhD, University of Texas at Austin
Real-time and safety-critical system design, cyber-physical systems, scheduling theory, resource allocation and sharing in distributed computing environments

Aaron Bobick

James M. McKelvey Professor and Dean
PhD, Massachusetts Institute of Technology
Computer vision, graphics, human-robot collaboration

Ian Bogost

PhD, University of California, Los Angeles
Philosopher, computationalist and award-winning game designer

Michael R. Brent

Henry Edwin Sever Professor of Engineering
PhD, Massachusetts Institute of Technology
Systems biology, computational and experimental genomics,
mathematical modeling, algorithms for computational biology,
bioinformatics

Jeremy Buhler

PhD, University of Washington
Computational biology, genomics, algorithms for comparing and
annotating large biosequences

Roger D. Chamberlain

DSc, Washington University in St. Louis
Computer engineering, parallel computation, computer architecture,
multiprocessor systems

Yixin Chen

PhD, University of Illinois at Urbana-Champaign
Mathematical optimization, artificial intelligence, planning and
scheduling, data mining, learning data warehousing, operations
research, data security

Patrick Crowley

PhD, University of Washington
Computer and network systems, network security

Christopher D. Gill

DSc, Washington University
Parallel and distributed real-time embedded systems, cyber-physical
systems, concurrency platforms and middleware, formal models and
analysis of concurrency and timing

Nathan Jacobs

PhD, Washington University in St. Louis
Develops learning-based computer vision algorithms, with a focus on
geospatial and medical applications

Raj Jain

Barbara J. & Jerome R. Cox Jr. Professor of Computer Science
PhD, Harvard University
Network security, blockchains, medical systems security, industrial
systems security, wireless networks, unmanned aircraft systems,
internet of things, telecommunications networks, traffic management

Caitlin Kelleher

Hugo F. & Ina Champ Urbauer
Career Development Associate Professor
PhD, Carnegie Mellon University
Human-computer interaction, programming environments, and
learning environments

Tao Ju

PhD, Rice University
Computer graphics, visualization, mesh processing, medical imaging
and modeling

Chenyang Lu

Fullgraf Professor in the Department of Computer Science &
Engineering
PhD, University of Virginia
Internet of things, real-time, embedded, and cyber-physical systems,
cloud and edge computing, wireless sensor networks

Yevgeniy Vorobeychik

PhD, University of Michigan
Artificial intelligence, machine learning, computational economics,
security and privacy, multi-agent systems

Associate Professors

Roman Garnett

PhD, University of Oxford
Active learning (especially with atypical objectives), Bayesian
optimization, and Bayesian nonparametric analysis

Chien-Ju Ho

PhD, University of California, Los Angeles
Design and analysis of human-in-the-loop systems, with techniques
from machine learning, algorithmic economics, and online behavioral
social science

Brendan Juba

PhD, Massachusetts Institute of Technology
Theoretical approaches to artificial intelligence founded on
computational complexity theory and theoretical computer science
more broadly construed

I-Ting Angelina Lee

PhD, Massachusetts Institute of Technology
Designing linguistics for parallel programming, developing runtime
system support for multi-threaded software, and building novel
mechanisms in operating systems and hardware to efficiently support
parallel abstractions

Fuhai Li

PhD, Peking University
Associate Professor of Pediatrics, School of Medicine
Integration and interpretation of diverse and heterogeneous
pharmacogenomics data using statistical and machine learning

Alvitta Ottley

PhD, Tufts University
Designing personalized and adaptive visualization systems, including
information visualization, human-computer interaction, visual
analytics, individual differences, personality, user modeling and
adaptive interfaces

William Yeoh

PhD, University of Southern California
Artificial intelligence, multi-agent systems, distributed constraint
optimization, planning and scheduling



Chongjie Zhang

PhD, University of Massachusetts Amherst
Deep reinforcement learning, multi-agent systems, human-AI interaction

Ning Zhang

Spencer T. Olin Career Development Associate Professor
PhD, Virginia Polytechnic Institute and State University
System security, software security

Assistant Professors

Jiaxin Huang

PhD, University of Illinois at Urbana-Champaign
Leverages large language models to enable label-efficient knowledge acquisition and utilization

Umar Iqbal

PhD, University of Iowa
Computer security and privacy

Gregory Kehne

PhD, Harvard University
Works on online and approximation algorithms and using computer science to study and improve collective decision-making.

Netanel Raviv

PhD, Technion, Haifa, Israel
Mathematical tools for computation, privacy and machine learning

Hussein Sibai

PhD, University of Illinois, Urbana-Champaign
Trustworthy autonomy, spanning the areas of cyber-physical systems (CPS), formal methods, control theory and machine learning

Teaching Professors

Marion Neumann

PhD, University of Bonn, Germany
Machine learning with graphs; solving problems in agriculture and robotics

Bill Siever

PhD, Missouri University of Science and Technology
Computer architecture, organization, and embedded systems

Todd Sproull

PhD, Washington University
Computer networking and mobile application development

Professor of the Practice

Dennis Cosgrove

BS, University of Virginia
Programming environments and parallel programming

Senior Lecturers

Steve Cole

PhD, Washington University in St. Louis
Parallel computing, accelerating streaming applications on GPUs

David Ferry

PhD, Washington University in St. Louis
Real-time systems, parallel runtime systems, and cyber-physical systems design

Brian Garnett

PhD, Rutgers University
Discrete mathematics and probability, generally motivated by theoretical computer science

James Orr

PhD, Washington University
Real-time systems theory and implementation, cyber-physical systems, and operating systems

Jonathan Shidal

PhD, Washington University
Computer architecture and memory management

Douglas Shook

MS, Washington University
Imaging sensor design, compiler design and optimization

Lecturers

Ilan Goodman

MS, Stanford University
Mathematical computer science, data structures, algorithms, machine learning/AI, and data science/engineering

Michael Hall

PhD, Washington University
Reconfigurable logic, circuit and PCB design, networking, software engineering, parallel programming, optimization, and data science

Cynthia Ma

PhD, Washington University
Data Mining

Athena Tabakhi

PhD, Washington University
AI and multi-agent systems, including constraint-based systems and preference elicitation

Senior and Emeritus Professors

Ron K. Cytron

PhD, University of Illinois at Urbana-Champaign
Programming languages, middleware, real-time systems

Jonathan S. Turner

PhD, Northwestern University

Design and analysis of internet routers and switching systems, networking and communications, algorithms

Takayuki D. Kimura

PhD, University of Pennsylvania

Communication and computation, visual programming

Degree Requirements

Please visit to the following pages for information about computer science and engineering graduate programs:

- Computer Science, PhD (p. 70)
- Computer Engineering, PhD (p. 72)
- Computer Science, MS (p. 74)
- Computer Engineering, MS (p. 76)
- Cybersecurity Engineering, MS (p. 78)
- Computer Science & Engineering, MEng (p. 80)
- Data Mining & Machine Learning Certificate (p. 82)
- Cybersecurity Engineering Certificate (p. 82)

Courses

CSE 5100 Deep Reinforcement Learning

Deep Reinforcement Learning (RL) is a cutting-edge field at the intersection of artificial intelligence and decision-making. This course provides an in-depth exploration of the fundamental principles, algorithms, and applications of deep reinforcement learning. It covers basic algorithms, including value-based, policy-based, actor-critic, and model-based methods, as well as advanced topics, such as meta RL, offline RL, and multi-agent RL. By combining deep learning techniques with reinforcement learning, this course equips students with the necessary skills to build intelligent systems that can learn from experiences and make optimal decisions in complex environments. Evaluation of this course is based on written and programming assignments, and a final course project.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5101 Introduction to Artificial Intelligence

The discipline of artificial intelligence (AI) is concerned with building systems that think and act like humans or rationally on some absolute scale. This course is an introduction to the field, with special emphasis on sound modern methods. The topics include knowledge representation, problem solving via search, game playing, logical and probabilistic reasoning, planning, dynamic programming, and reinforcement learning. Programming exercises concretize the key methods. The course targets graduate students and advanced undergraduates. Evaluation is based on written and programming assignments, a midterm exam and a final exam.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5103 Theory of Artificial Intelligence and Machine Learning

Mathematical foundations for Artificial Intelligence and Machine Learning. An introduction to the PAC-Semantics (Probably Approximately Correct) as a common semantics for knowledge obtained from learning and declarative sources, and the computational problems underlying the acquisition and processing of such knowledge. We emphasize the design and analysis of efficient algorithms for these problems, and examine for which representations these problems are known or believed to be tractable.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5104 Data Mining

With the vast advancements in science and technology, the acquisition of large quantities of data is routinely performed in many fields. Examples of large data include various types of data on the internet, high-throughput sequencing data in biology and medicine, extraterrestrial data from telescopes in astronomy, and images from surveillance cameras in security settings. Analyzing a large amount of data through data mining has become an effective means of extracting knowledge from data. This course introduces the basic concepts and methods of data mining and provides hands-on experience for processing, analyzing and modeling structured and unstructured data. Homework problems, exams, and programming assignments will be administered throughout the course to enhance students' learning.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5105 Bayesian Methods in Machine Learning

This course will cover machine learning from a Bayesian probabilistic perspective. Bayesian probability allows us to model and reason about all types of uncertainty. The result is a powerful, consistent framework for approaching many problems that arise in machine learning, including parameter estimation, model comparison, and decision making. We will begin with a high-level introduction to Bayesian inference and then proceed to cover more advanced topics. These will include inference techniques (e.g., exact, MAP, sampling methods, the Laplace approximation), Bayesian decision theory, Bayesian model comparison, Bayesian nonparametrics, and Bayesian optimization.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5106 Multi-Agent Systems

This course introduces the foundations and methods of multi-agent systems, with a focus on how autonomous agents can plan, coordinate, and reason effectively in shared environments. Core topics include distributed problem solving, cooperative planning, task and resource allocation, and algorithms for coordination under uncertainty. The course also examines emerging directions in agentic AI, highlighting how large language models (LLMs) and other AI techniques can enhance multi-agent reasoning, communication, and collaboration.

Credit 3 units.

Typical periods offered: Fall

CSE 5107 Machine Learning

This course is the second course of a two course sequence on machine learning. It assumes a fundamental understanding of the machine learning foundations (both theoretical and practical) and introduces probabilistic machine learning approaches in-depth as well as advanced topics at the frontier of the field. Topics to be covered include discriminative and generative probabilistic models, kernel



methods (e.g., support vector machines, Gaussian processes), neural networks (deep learning), unsupervised learning techniques, and practical machine learning (e.g., feature engineering, dimensionality reduction, model comparison).

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5108 Human-In-The-Loop Computation

This course is an exploration of the opportunities and challenges of human-in-the-loop computation, an emerging field that examines how humans and computers can work together to solve problems neither can solve alone yet. We will explore ways in which techniques from machine learning, game theory, optimization, online behavioral social science, and human-computer interactions can be used to model and analyze human-in-the-loop systems such as crowdsourcing markets, prediction markets, and user-generated content platforms. We will also look into recent developments in the interactions between humans and AIs, such as learning with the presence of strategic behavior and ethical issues in AI systems.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5109 Advanced Machine Learning

This course provides a close look at advanced machine learning algorithms, including their theoretical guarantees (computational learning theory) and tricks to make them work in practice. In addition, this course focuses on more specialized learning settings, including unsupervised learning, semi-supervised learning, domain adaptation, multi-task learning, structured prediction, metric learning, and learning of data representations. Learning approaches may include graphical models, non-parametric Bayesian statistics, and technical topics such as sampling, approximate inference, and non-linear function optimization. Mathematical maturity and general familiarity with machine learning are required.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5114 Data Manipulation and Management at Scale

Harnessing the full potential of large-scale data requires advanced techniques and robust tools. This course delves into the methodologies and technologies essential for managing and manipulating substantial data volumes efficiently and responsibly. In taking this course, students will learn key concepts about storing, organizing, transforming, and using large quantities of data and will get hands-on experience using industry-standard tools such as Spark, Airflow, and Kafka.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5180 Heuristic Search and Constraint Processing

The course has three main parts and covers the main topics of heuristic search and constraint processing. The first part focuses on single-agent heuristic search problems and algorithms. The second part deals with adversary game playing problems, strategies and algorithms. The third part considers constraint problems and constraint processing techniques. The course will cover basic and advanced search techniques as well as their performance analysis. It will also provide ample examples of real-world problems and applications. The students will have opportunity to write programs to solve some selected search problems. Prerequisites: CSE 247 and CSE 511A.

Credit 3 units.

CSE 5200 Real-Time Systems

This course covers software systems and network technologies for real-time applications such as automobiles, avionics, industrial automation, and the Internet of Things. Topics include real-time scheduling, real-time operating systems and middleware, quality of service, industrial networks, and real-time cloud computing.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5201 Wireless Sensor Networks

Dense collections of smart sensors networked to form self-configuring pervasive computing systems provide a basis for a new computing paradigm that challenges many classical approaches to distributed computing. Naming, wireless networking protocols, data management, and approaches to dependability, real-time, security, and middleware services all fundamentally change when confronted with this new environment. Embedded sensor networks and pervasive computing are among the most exciting research areas with many open research questions. This course will study a large number of research papers that deal with various aspects of wireless sensor networks. Students will perform a project on a real wireless sensor network comprised of tiny devices, each consisting of sensors, a radio transceiver, and a microcontroller.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5202 Advanced Operating Systems

This course offers an in-depth hands-on exploration of advanced uses of key OS abstractions, mechanisms and policies, with an increasing focus on understanding and evaluating their behaviors and interactions. Readings, lecture material, studio exercises, and a semester-long project chosen by students are closely integrated in an active-learning environment in which students gain experience and proficiency writing, tracing, and evaluating user-space and kernel-space code. Topics include how memory, processes and threads, virtual file systems, and other mechanisms can be used by hypervisors, containers, and other advanced OS abstractions, as well as forensic techniques for examining and managing system behavior.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5203 Systems Security

This course examines the intersection between computer design and information security. While performance and efficiency in digital systems have improved markedly in recent decades, computer security has worsened overall in this time frame. To understand why, we will explore the role that design choices play in the security characteristics of modern computer and network systems. Students will use and write software to illustrate mastery of the material. Projects will include identifying security vulnerabilities, exploiting vulnerabilities, and detecting and defending against exploits.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5205 Computation in Economics and Social Choice

This course covers the mathematical and algorithmic foundations of problems of reconciling agent preferences. By specifying the kinds of agents, alternatives, and objectives, this captures algorithm design problems as diverse as how to sell goods to buyers, how to match medical residents to hospitals, and how to elect representatives to legislatures. Topics include algorithm and mechanism design for the allocation of private goods; choosing public goods and shared alternatives; and participatory budgeting.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5270 Natural Language Processing

Natural language processing (NLP) is an important part of artificial intelligence (AI), endowing computers with the ability to process human language. NLP techniques are used in applications such as question answering, automatic language translation, and extracting structured information from text. This course will introduce fundamental ideas and recent research trends in NLP. Students will gain theoretical and practical experience with various NLP techniques (e.g., deep learning) and applications.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5271 Data-Driven Privacy and Security

It is becoming increasingly hard for users to use the internet while keeping their privacy and security intact. It is a routine practice for online services to surreptitiously collect excessive amounts of user data, use user data for undisclosed purposes, and even engage in blatant trading of user data. This research-oriented course takes a deep-dive into surfacing data collection by online services and its harms to users, exploring solutions that aim to mitigate these harms, investigating emerging threats that still need to be addressed, and reviewing new directions to systematically improve the state of user privacy and security on the internet. Major topics: Web privacy and security, IoT privacy and security, Large language model (LLM) security and privacy, and Technology policy.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5300 Database Management Systems

A study of data models and the database management systems that support these data models. The design theory for databases is developed and various tools are utilized to apply the theory. General query languages are studied and techniques for query optimization are investigated. Integrity and security requirements are studied in the context of concurrent operations on a database, where the database may be distributed over one or more locations. The unique requirements for engineering design databases, image databases, and long transaction systems are analyzed.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5302 Advanced Multiparadigm Software Development

Intensive focus on advanced design and implementation of concurrent and distributed system software in C++. Topics covered include concurrency and synchronization features and software architecture patterns.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5306 Rapid Prototype Development and Creative Programming

This course uses web development as a vehicle for developing skills in rapid prototyping. Students acquire the skills to build a Linux web server in Apache, to write a web site from scratch in PHP, to run an SQL database, to perform scripting in Python, to employ various web frameworks, and to develop modern web applications in client-side and server-side JavaScript. The course culminates with a creative project in which students are able to synthesize the course material into a project of their own interest. The course implements an interactive studio format: after a formal presentation of a topic, students develop a related project under the supervision of the instructor.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CSE 5307 Software Security

In this course, students will be introduced to the foundations of software security. We will explore different classes of software vulnerabilities and analyze the fundamental problems behind these vulnerabilities, and we will study the methods and techniques used to discover, exploit, prevent, and mitigate these vulnerabilities. Topics of interest include buffer overflow, integer overflow, type confusion, use-after-free, and so on. Throughout the course, we take a defense-in-depth mentality and see how systems can be protected. Students are expected to have a solid understanding of assembly language, C/C++, and operating systems. Prerequisite: CSE 361S.

Credit 3 units.

CSE 5308 Modeling and Performance Evaluation of Computer Systems

Modern computing systems consist of multiple interconnected components that all influence performance. The focus of this course is on developing modeling tools aimed at understanding how to design and provision such systems to meet certain performance or efficiency targets and the trade-offs involved. The course covers Markov chains and their applications to simple queues, and it proceeds to explore more complex systems, including server farms and how to optimize their performance through scheduling and task assignment policies. The course includes a brief review of the necessary probability and mathematical concepts.

Credit 3 units.

Typical periods offered: Fall

CSE 5309 Concepts in Multicore Computing

Nowadays, the vast majority of computer systems are built using multicore processor chips. This fundamental shift in hardware design impacts all areas of computer science - one must write parallel programs in order to unlock the computational power provided by modern hardware. The goal of this course is to study concepts in multicore computing. We will examine the implications of the multicore hardware design, discuss challenges in writing high performance software, and study emerging technologies relevant to developing software for multicore systems. Topics include memory hierarchy, cache coherence protocol, memory models, scheduling, high-level parallel language models, concurrent programming (synchronization and concurrent data structures), algorithms for debugging parallel software, and performance analysis.

Credit 3 units.

Typical periods offered: Spring

CSE 5310 AI for Health

Artificial Intelligence (AI) has emerged as a powerful tool for solving complex health problems using advanced data-driven techniques. AI for health is fueled by both the advancement in AI methods and the availability of health data provided by electronic health records (EHR) and wearables. This course will cover recent literature in the interdisciplinary field of AI for health. Students will read and critique research papers and perform a project on AI for health.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5313 Coding and Information Theory for Data Science

Coding/information theory emerged in mid 20'th century as a mathematical theory of communication with noise. In latter decades it has developed to a vast topic encompassing most aspects of handling large datasets. The course will begin by surveying the classical mathematical theory and its basic applications in communication,



and continue to contemporary applications in storage, computation, privacy, machine learning, and emerging technologies such as networks, blockchains, and DNA storage. There will be 4-5 homework assignments, one in-person midterm, and a final reading assignment. Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5360 Distributed System Design: Models and Languages

Modern computing environments are highly distributed. This has been the result of major advances in networking technology and their rapid assimilation by a society that functions in a highly distributed and decentralized manner. The goal of this course is to familiarize students with basic concepts, models, and languages that shaped recent developments in distributed computing. The focus is on exploring new ways of thinking about computing and communication that made the development of distributed software systems possible. Competing concepts and design strategies will be examined both from a theoretical and a practical perspective.

Credit 3 units.

Typical periods offered: Fall

CSE 5370 Trustworthy Autonomy

Cyber-physical systems are becoming increasingly capable. These are systems consisting of digital and physical components. They are deployed to increase autonomy in critical settings where failure is costly, such as driving, aviation, medicine, and manufacturing. This course covers several approaches for assuring that such systems meet their specifications. We will discuss: (1) how to mathematically model these systems and their specifications, (2) how to formally verify and synthesize models which meet their specifications, and (3) how to address the challenges resulting from incorporating machine-learned components, such as neural networks, as perception and control components in these systems.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5401 Advanced Algorithms

Provides a broad coverage of fundamental algorithm design techniques with the focus on developing efficient algorithms for solving combinatorial and optimization problems. The topics covered include: review of greedy algorithms, dynamic programming, NP-completeness, approximation algorithms, use of linear and convex programming for approximation, and on-line algorithms. Throughout this course there is an emphasis on correctness proofs and the ability to apply the techniques taught to design efficient algorithms for problems from a wide variety of application areas.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5402 Concurrency and Memory Safe System Software Development

As multi-core processors and multi-threaded programming are ever more prevalent in modern computing systems, ensuring correctness of programs depends strongly on avoiding hazards that may arise from concurrency and memory management semantics in those contexts. This course focuses on the memory safety and concurrency safety models in Rust, with an emphasis on the language's syntax and semantics related to those models, both separately and in combination, as well as a general coverage of the language as a whole. Lectures and assigned readings will be augmented with studio exercises and laboratory assignments in which key language features will be explored and applied hands-on.

Credit 3 units.

Typical periods offered: Fall

CSE 5403 Algorithms for Nonlinear Optimization

The course will provide an in-depth coverage of modern algorithms for the numerical solution of multidimensional optimization problems. Unconstrained optimization techniques including Gradient methods, Newton's methods, Quasi-Newton methods, and conjugate methods will be introduced. The emphasis is on constrained optimization techniques: Lagrange theory, Lagrangian methods, penalty methods, sequential quadratic programming, primal-dual methods, duality theory, nondifferentiable dual methods, and decomposition methods. The course will also discuss applications in engineering systems and use of state-of-the-art computer codes. Special topics may include large-scale systems, parallel optimization, and convex optimization. Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5404 Special Topics in Computer Science Theory

The material for this course varies among offerings, but this course generally covers advanced or specialized topics in computer science theory.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5406 Computational Geometry

Computational geometry is the algorithmic study of problems that involve geometric shapes such as points, lines, and polygons. Such problems appear in computer graphics, vision, robotics, animation, visualization, molecular biology, and geographic information systems. This course covers data structures that are unique to geometric computing, such as convex hull, Voronoi diagram, Delaunay triangulation, arrangement, range searching, KD-trees, and segment trees. Also covered are algorithms for polygon triangulation, path planning, and the art gallery problem.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5409 Theory of Parallel Systems

The course covers various aspects of parallel programming such as algorithms, schedulers and systems from a theoretical perspective. We will cover both classic and recent results in parallel computing. Topics include parallel algorithms and analysis in the work/span model, scheduling algorithms, external memory algorithms and their analysis, cache-coherence protocols etc. The focus will be on design and analysis.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5414 Special Topics in Application

The material for this course varies among offerings, but this course generally covers advanced or specialized topics in computer application.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5430 Advanced Secure Software Engineering

The aim of this course is to provide students with broader and deeper knowledge as well as hands-on experience in understanding security techniques and methods needed in software development. Students complete an independent research project which will involve synthesizing multiple software security techniques and applying them to an actual software program or system.

Credit 3 units.

CSE 5440 Special Topics in Machines:

The material for this course varies among offerings, but this course generally covers advanced or specialized topics in computer science machines.

Credit 0 units.

Typical periods offered: Fall, Spring

CSE 5445 Special Topics in Systems

The material for this course varies among offerings, but this course generally covers advanced or specialized topics in computer science systems.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5500 Mobile Robotics

An introduction to the design and implementation of intelligent mobile robot systems. This course will cover the fundamental elements of mobile robot systems from a computational standpoint. Issues such as software control architectures, sensor interpretation, map building and navigation will be covered, drawing from current research in the field. Students will also design and build a small mobile robot and program it to perform simple tasks in real-world environments. Prerequisites: CSE 247 and either ESE 326 or Math 320.

Credit 3 units.

CSE 5504 Geometric Computing for Biomedicine

With the advance of imaging technologies deployed in medicine, engineering and science, there is a rapidly increasing amount of spatial data sets (e.g., images, volumes, point clouds) that need to be processed, visualized, and analyzed. This course will focus on a number of geometry-related computing problems that are essential in the knowledge discovery process in various spatial-data-driven biomedical applications. These problems include visualization, segmentation, mesh construction and processing, and shape representation and analysis. This course consists of lectures that cover theories and algorithms, and it includes a series of hands-on programming projects using real-world data collected by various imaging techniques (e.g., CT, MRI, electron cryomicroscopy).

Credit 3 units.

Typical periods offered: Fall

CSE 5505 Adversarial AI

This course will introduce students to concepts, theoretical foundations, and applications of adversarial reasoning in Artificial Intelligence. Topics will include the use of machine learning in adversarial settings, such as security, common attacks on machine learning models and algorithms, foundations of game theoretic modeling and analysis in security, with a special focus on algorithmic approaches, and foundations of adversarial social choice, with a focus on vulnerability analysis of elections.

Credit 3 units.

Typical periods offered: Spring

CSE 5506 Human-Computer Interaction Methods

An introduction to user centered design processes. The course covers a variety of HCI techniques for use at different stages in the software development cycle, including techniques that can be used with and without users. Students will gain experience using these techniques through in-class exercises and then apply them in greater depth through a semester long interface development project. Students who enroll in this course are expected to be comfortable with building user

interfaces in at least one framework and be willing to learn whatever framework is most appropriate for their project. Over the course of the semester, students will be expected to present their interface evaluation results through written reports and in class presentations.

Credit 3 units.

Typical periods offered: Fall

CSE 5507 Advanced Visualization

We are in an era where it is possible to have all of the world's information at our fingertips. However, the more information we can access, the more difficult it is to obtain a holistic view of the data or to determine what's important to make decisions. Computer-based visualization systems provide the opportunity to represent large or complex data visually to aid comprehension and cognition. In this course, we learn about the state of the art in visualization research and gain hands-on experience with the research pipeline. We also learn how to critique existing work and how to formulate and explore sound research questions. We will cover advanced visualization topics including user modeling, adaptation, personalization, perception, and visual analytics for non-experts.

Credit 3 units.

Typical periods offered: Spring

CSE 5509 Computer Vision

This course introduces the fundamentals of designing computational systems that can look at images and reason about the physical objects and scenes they represent. Topics include the estimation of color, shape, geometry, and motion from images; image classification, segmentation, and object detection; and image restoration, enhancement, and synthesis. The focus of this course will be on mathematical foundations and practical algorithmic approaches, including: the physics and geometry of image formation; robust methods for estimating image motion and geometry; and deep-learning approaches for semantic image understanding. Students will be required to program in Python.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5515 Computational Photography

Computational Photography describes the convergence of computer graphics, computer vision, and the Internet with photography. Its goal is to overcome the limitations of traditional photography using computational techniques to enhance the way we capture, manipulate, and interact with visual media. In this course we will study many interesting, recent image based algorithms and implement them to the degree that is possible. Topics may include: cameras and image formation, human visual perception, image processing (filtering, pyramids), image blending and compositing, image retargeting, texture synthesis and transfer, image completion / inpainting, super-resolution, deblurring, denoising, image based lighting and rendering, high dynamic range, depth and defocus, flash / no flash photography, coded aperture photography, single / multi view reconstruction, photo quality assessment, non photorealistic rendering, modeling and synthesis using Internet data, and others. Pre-requisites: CSE 452A, CSE 554A, or CSE 559A

Credit 3 units.

CSE 5519 Advances in Computer Vision

Computer vision is a fast-moving field, with the past few years seeing tremendous advances in the development of computational algorithms for solving visual tasks. This course is designed to introduce students to advanced and recently published techniques, including



work in the areas of attention-based architectures, self-supervised/few-shot/zero-shot learning, explainable models, deep geometric methods, neural fields, generative image modeling, and vision language models.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5550 Multimedia Signals and Systems

An exploration of algorithms, architectures, and compilers for media processing. Introduces algorithms in image, video, audio, and graphics processing. Examines the characteristics of multimedia (e.g. the extensive data parallelism) and how those characteristics facilitate the design of efficient multimedia systems. Contrasts media processors with general-purpose processors, distinguishing specialized media processing features, including subword parallelism and application-specific hardware. Coursework includes written assignments, some lab and programming exercises, and a final project. Formerly CS 525M. Prerequisites: CSE 361S or equivalent.

Credit 3 units.

CSE 5600 Computer Systems Architecture I

An exploration of the central issues in computer architecture: instruction set design, addressing and register set design, control unit design, memory hierarchies (cache and main memories, virtual memory), pipelining, instruction scheduling, and parallel systems. The course emphasizes understanding the performance implications of design choices, using architecture modeling and evaluation using simulation techniques.

Credit 3 units.

Typical periods offered: Fall

CSE 5601 Computer Systems Architecture II

Advanced techniques in computer system design. Selected topics from: processor design (multithreading, VLIW, data flow, chip-multiprocessors, application specific processors, vector units, large MIMD machines), memory systems (topics in locality, prefetching, reconfigurable and special-purpose memories), system specification and validation, and interconnection networks. Prerequisites: CSE 560M

Credit 3 units.

CSE 5605 Acceleration of Algorithms in Reconfigurable Logic

Reconfigurable logic, in the form of Field-Programmable Gate Arrays (FPGAs), enables the deployment of custom hardware for individual applications. To exploit this capability, the application developer is required to specify the design at the register-transfer level. This course explores techniques for designing algorithms that are amenable to hardware acceleration as well as provides experience in actual implementation. Example applications are drawn from a variety of fields, such as networking, computational biology, etc.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5606 High Performance Computer Systems

Many applications make substantial performance demands upon the computer systems upon which those applications are deployed. In this context, performance is frequently multidimensional, including resource efficiency, power, execution speed (which can be quantified via elapsed run time, data throughput, or latency), etc. Modern computing platforms exploit parallelism and architectural diversity (e.g., co-processors such as graphics engines and/or reconfigurable logic) to achieve the desired performance goals. This course addresses the practical aspects of achieving high performance on modern

computing platforms. This includes questions ranging from how the computing platform is designed to how are applications and algorithms expressed to exploit the platform's properties. Particular attention is given to the role of application development tools.

Credit 3 units.

Typical periods offered: Spring

CSE 5607 Computer Systems Analysis

A comprehensive course on performance analysis techniques. The topics include common mistakes, selection of techniques and metrics, summarizing measured data, comparing systems using random data, simple linear regression models, other regression models, experimental designs, 2**k experimental designs, factorial designs with replication, fractional factorial designs, one factor experiments, two factor full factorial design w/o replications, two factor full factorial designs with replications, general full factorial designs, introduction to queueing theory, analysis of single queues, queueing networks, operational laws, mean-value analysis, time series analysis, heavy tailed distributions, self-similar processes, long-range dependence, random number generation, analysis of simulation results, and art of data presentation. Prerequisites: CSE 260M

Credit 3 units.

CSE 5608 Imaging Sensors

This course will cover topics on digital imaging sensors including basic operations of silicon photodetectors; CCD and CMOS passive and active sensor operation; temporal and spatial noise in CMOS sensors; spatial resolution and MTF; SNR and dynamic range; high dynamic range architectures and application specific imaging sensors such as polarization imaging and fluorescent imaging sensors. Prereqs: CSE 260M and ESE 232

Credit 3 units.

CSE 5610 Large Language Models

Large Language Models (LLMs) have revolutionized the field of artificial intelligence, offering unprecedented capabilities in understanding and generating human-like text. This is a research-oriented course that explores the capabilities and challenges of LLMs. Students will gain a comprehensive understanding of the underlying mechanisms that power these models, as well as reading frontier papers and working on projects to gain hands-on experience. Topics to be covered include LLM training, LLM capabilities, safety, ethical considerations, approaches to augment LLMs, efficiency of modeling and training LLMs, etc.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5619 Recent Advances in Computer Security and Privacy

The aim of this course is to provide students with knowledge and hands-on experience in understanding the security techniques and methods needed for IoT, real-time, and embedded systems. Students complete an independent research project which will involve synthesizing multiple security techniques and applying them to an actual IoT, real-time, or embedded system or device.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5700 Recent Advances in Networking

This course covers the latest advances in networking. The topics include Networking Trends, Data Center Network Topologies, Data Center Ethernet, Server Virtualization, Storage Virtualization, Carrier Ethernet, Application Delivery Networking, Virtual Bridging, Big Data, Networking Issues for Big Data, LAN Extension and Virtualization using Layer 3 Protocols, Multi-Tenant Isolation and Network Virtualization in Cloud Data Centers, OpenFlow, OpenFlow Controllers and Tools,

Software Defined Networking (SDN), Network Function Virtualization (NFV), Internet of Things (IoT), Networking Protocols for IoT, Blockchains, and Quantum Communications. Students also do a project/survey involving application of these topics.

Credit 3 units.

Typical periods offered: Fall

CSE 5701 Network Security

This course covers principles and techniques in securing computer networks. Real world examples will be used to illustrate the rationales behind various security designs. There are three main components in the course, preliminary cryptography, network protocol security and network application security. Topics include IPSec, SSL/TLS, HTTPS, network fingerprinting, network malware, anonymous communication, and blockchain. The class project allows students to take a deep dive into a topic of choice in network security.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5703 Protocols for Computer Networks

An introduction to the design, performance analysis, and implementation of existing and emerging computer network protocols. Protocols include multiple access protocols (e.g., CSMA/CD, token ring), internetworking with the Internet Protocol (IP), transport protocols (e.g., UDP, TCP), high-speed bulk transfer protocols, and routing protocols (e.g., BGP, OSPF). General topics include error control, flow control, packet switching, mechanisms for reliable, ordered and bounded-time packet delivery, host-network interfacing and protocol implementation models. Substantial programming exercises supplement lecture topics. Prerequisite: CSE 473S or permission of the instructor.

Credit 3 units.

CSE 5704 Recent Advances in Wireless and Mobile Networking

This course provides a comprehensive treatment of wireless data and telecommunication networks. Topics include recent trends in wireless and mobile networking, wireless coding and modulation, wireless signal propagation, IEEE 802.11a/b/g/n/ac wireless local area networks, 60 GHz millimeter wave gigabit wireless networks, vehicular wireless networks, white spaces, Bluetooth and Bluetooth Smart, wireless personal area networks, wireless protocols for the Internet of Things, cellular networks: 1G/2G/3G, LTE, LTE-Advanced, and 5G.

Credit 3 units.

Typical periods offered: Fall

CSE 5801 Approximation Algorithms

Numerous optimization problems are intractable to solve optimally. The intractability of a problem could come from the problem's computational complexity, for instance the problem is NP-Hard, or other computational barriers. To cope with the inability to find an optimal algorithm, one may desire an algorithm that is guaranteed to return a solution that is comparable to the optimum. Such an algorithm is known as an approximation algorithm. Approximation algorithms are a robust way to cope with intractability and they are widely used in practice or are used to guide the development of practical heuristics. The area of approximation algorithms has developed a vast theory, revealing the underlying structure of problems as well as their different levels of difficulty. The majority of this course will focus on fundamental results and widely applicable algorithmic and analysis techniques for approximation algorithms. Prerequisite: CSE 347

Credit 3 units.

CSE 5802 Complexity Theory

An introduction to the quantitative theory of computation with limited resources. The course examines the relative power of limited amounts of basic computational resources, such as time, memory, circuit size, and random bits, as well as parallel, nondeterministic, alternating, and interactive machine models. Models that capture special kinds of computational problems, such as counting problems or approximate solutions, will also be introduced and related to the standard models. This examination will emphasize surprising relationships between seemingly disparate resources and kinds of computational problems. The course will also discuss some meta-theory, illuminating the weaknesses of standard mathematical techniques of the field against its notorious open conjectures. Prerequisites: CSE 347

Credit 3 units.

CSE 5804 Algorithms for Biosequence Comparison

This course surveys algorithms for comparing and organizing discrete sequential data, especially nucleic acid and protein sequences. Emphasis is on tools to support search in massive biosequence databases and to perform fundamental comparison tasks such as DNA short-read alignment. Prerequisite: CSE 347 or permission of instructor. These techniques are also of interest for more general string processing and for building and mining textual databases. Algorithms are presented rigorously, including proofs of correctness and running time where feasible. Topics include classical string matching, suffix array string indices, space-efficient string indices, rapid inexact matching by filtering (including BLAST and related tools), and alignment-free algorithms. Students complete written assignments and implement advanced comparison algorithms to address problems in bioinformatics. This course does not require a biology background.

Credit 3 units.

Typical periods offered: Spring

CSE 5805 Sparse Modeling for Imaging and Vision

Sparse modeling is at the heart of modern imaging, vision, and machine learning. It is a fascinating new area of research that seeks to develop highly effective data models. The core idea in sparse modeling theory is a novel redundant transform, where the number of transform coefficients is larger compared to the original data dimension. Together with redundancy comes an opportunity of seeking the sparsest possible representation, or the one with the fewest non-zeros. This core idea leads to a series of beautiful theoretical and practical results with many applications such as regression, prediction, restoration, extrapolation, compression, detection, and recognition. In this course, we will explore sparse modeling by covering theoretical as well as algorithmic aspects with applications in computational imaging and computer vision. Prerequisites: ESE 318, Math 233, Math 309, and Math 429, or equivalents. Coding with MATLAB or Python.

Credit 3 units.

CSE 5806 Analysis of Imaging Data

This course focuses on an in-depth study of advanced topics and interests in image data analysis. Students will learn about hardcore imaging techniques and gain the mathematical fundamentals needed to build their own models for effective problem solving. Topics of deformable image registration, numerical analysis, probabilistic modeling, data dimensionality reduction, and convolutional neural networks for image segmentation will be covered. The main focus might change from semester to semester. Prerequisites: Math 309, ESE 326, and CSE 247.

Credit 3 units.



CSE 5807 Algorithms for Computational Biology

This course is a survey of algorithms and mathematical methods in biological sequence analysis (with a strong emphasis on probabilistic methods) and systems biology. Sequence analysis topics include introduction to probability, probabilistic inference in missing data problems, hidden Markov models (HMMs), sequence alignment, and identification of transcription-factor binding sites. Systems biology topics include the mapping of gene regulatory networks, quantitative modeling of gene regulatory networks, synthetic biology, and applications of deep learning in computational biology.

Credit 3 units.

Typical periods offered: Fall

CSE 5990 Introduction to Graduate Study in CSE

Introduces students to the different areas of research conducted in the department. Provides an introduction to research skills, including literature review, problem formulation, presentation, and research ethics. Lecture and discussion are supplemented by exercises in the different research areas and in critical reading, idea generation, and proposal writing.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 5999 Independent Study

Master's Graduate Independent Study registrations are rare for the CSE Department, as this registration does not count toward CSE Master's Degrees. Students will need to email the CSE Graduate Coordinator to confirm that they would be eligible to do an Ind. Study. If they are confirmed as eligible, they will then receive the departmental proposal form, which must be completed in order for them to then be enrolled.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 7900 Research Seminar On Computer Science Pedagogy

This seminar will examine research, techniques, approaches, and strategies for teaching computer science at the undergraduate and graduate levels. Participants will take turns presenting a particular paper or concept and then leading an ensuing discussion. While this seminar may be especially helpful for those contemplating an academic career, the seminar is open to all interested participants.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7901 Research Seminar On AI for Medicine

Artificial intelligence (AI) has emerged as a powerful tool for solving complex medical problems using advanced data-driven techniques. AI for medicine is fueled by both the advancement in AI methods and the availability of clinical data provided by electronic health records (EHR) and wearables. This seminar will discuss recent literature in the interdisciplinary field of AI for medicine.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7905 Research Seminar On Machine Learning

Research seminars examine publications, techniques, approaches, and strategies within an area of computer science and engineering. Seminars are highly participational: students are expected to take turns presenting material, to prepare for seminar by reading any required material, and to contribute to the group's discussions. The actual topics covered in a seminar will vary by semester and instructor. Interested students are encouraged to obtain a syllabus from the instructor's web page or by contacting the instructor.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7910 Research Seminar On Robotics and Human-Computer Interaction

Research seminars examine publications, techniques, approaches, and strategies within an area of computer science and engineering. Seminars are highly participational: students are expected to take turns presenting material, to prepare for seminar by reading any required material, and to contribute to the group's discussions. The actual topics covered in a seminar will vary by semester and instructor. Interested students are encouraged to obtain a syllabus from the instructor's web page or by contacting the instructor.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7915 Research Seminar On Software Systems

Research seminars examine publications, techniques, approaches, and strategies within an area of computer science and engineering. Seminars are highly participational: students are expected to take turns presenting material, to prepare for seminar by reading any required material, and to contribute to the group's discussions. The actual topics covered in a seminar will vary by semester and instructor. Interested students are encouraged to obtain a syllabus from the instructor's web page or by contacting the instructor.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7920 Research Seminar On Algorithms and Theory

Research seminars examine publications, techniques, approaches, and strategies within an area of computer science and engineering. Seminars are highly participational: students are expected to take turns presenting material, to prepare for seminar by reading any required material, and to contribute to the group's discussions. The actual topics covered in a seminar will vary by semester and instructor. Interested students are encouraged to obtain a syllabus from the instructor's web page or by contacting the instructor.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7925 Research Seminar On Graphics and Vision

Research seminars examine publications, techniques, approaches, and strategies within an area of computer science and engineering. Seminars are highly participational: students are expected to take turns presenting material, to prepare for seminar by reading any required material, and to contribute to the group's discussions. The actual topics covered in a seminar will vary by semester and instructor. Interested students are encouraged to obtain a syllabus from the instructor's web page or by contacting the instructor.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7930 Research Seminar On Analog Computing

This seminar will focus on classic and recent papers on analog, stochastic and neuromorphic computing. Students will read, present, and discuss journal papers on analog techniques for implementing sensors and processors. Focus will be placed on fundamental advances and challenges of implementing analog processors.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7935 Research Seminar On Networking and Communications

Research seminars examine publications, techniques, approaches, and strategies within an area of computer science and engineering. Seminars are highly participational: students are expected to take turns presenting material, to prepare for seminar by reading any required material, and to contribute to the group's discussions. The actual topics covered in a seminar will vary by semester and instructor. Interested students are encouraged to obtain a syllabus from the instructor's web page or by contacting the instructor.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7940 Research Seminar On Computational Systems Biology

Research seminars examine publications, techniques, approaches, and strategies within an area of computer science and engineering. Seminars are highly participational: students are expected to take turns presenting material, to prepare for seminar by reading any required material, and to contribute to the group's discussions. The actual topics covered in a seminar will vary by semester and instructor. Interested students are encouraged to obtain a syllabus from the instructor's web page or by contacting the instructor.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7945 Research Seminar On Parallel Computing

This seminar will focus on classic and recent papers on parallel computing. Students will read, present, and discuss papers on parallel models, algorithms, and architectures from top conferences and journals. Focus will be placed on fundamental advances and theoretical models and algorithms, rather than on implementation papers.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7950 Research Seminar On AI for Health

This seminar will study and discuss recent research papers on the applications of advanced AI technologies to health care and public health.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7955 Research Seminar On Experimental Networked Systems

This seminar will explore the design, implementation, evaluation, and use of experimental computer and network systems. Participants will read and discuss research papers, and demonstrate small performance & reliability experiments using research infrastructure developed at Washington University, with a focus on observability and multi-platform operation.

Credit 1 unit.

Typical periods offered: Spring

CSE 7960 Concurrent and Parallel Embedded Systems Seminar

This seminar will focus on classic and recent papers on concurrent and parallel embedded systems. Students will read, present, and discuss papers on topics including but not limited to real-time and/or cyber-physical system design and analysis, computer architectural techniques, and heterogeneous computational devices. The focus will be primarily on fundamental advances and theoretical models and algorithms, rather than on implementation papers.

Credit 1 unit.

Typical periods offered: Fall, Spring

CSE 7998 Master's Capstone

Students will need to complete the Master's Research Proposal Form (the form can be found at this page: <https://cse.washu.edu/academics/graduate/current-students/Resources-for-Current-Masters-Students.html>) and they will need to email the proposal form to the CSE Graduate Coordinator at least 72 hours before the add/drop deadline, so that the form can be DocuSigned and approved. If the form is approved, the student will be enrolled in the course. If the Proposal Form is sent to the Grad Coordinator within the final 72 hours of the add/drop deadline, students are at risk of not being enrolled by the deadline.

Credit 3-6 units.

Typical periods offered: Fall, Spring, Summer

CSE 8001 Pedagogy

A student taking this course studies the fundamentals of teaching in the discipline of computer science and computer engineering. A student enrolled in this course staffs some other course taught by our department, serving as its primary instructor or co-instructor. That student receives frequent mentoring and feedback on his or her preparation and delivery. This course is recommended especially for doctoral students who seek a career in computer science and engineering education.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 8002 Mentored Teaching Experience

This course is available only for our department's doctoral students who are involved in a mentored teaching experience.

Credit 3 units.

Typical periods offered: Fall, Spring

CSE 8998 Doctoral Research

Students will be working in a lab setting supervised by their mentor.

Credit 3-9 units.

Typical periods offered: Fall, Spring

Computer Science, PhD (CSE)

Students can choose to pursue a PhD in Computer Science. Here are the core requirements:

- Complete 72 units of regular — including graded — courses (at least 33 units, of which 9 must fulfill breadth requirements), seminars (at least 3 units), and research credits (at least 24 units).
- Satisfy fundamental teaching requirements by participating in mentored teaching experiences and complete scholarly communication requirements by participating in the Doctoral Student Research Seminar.

- Pass milestones that demonstrate the ability to understand research literature, to communicate orally and in writing, and to formulate a detailed research plan. These milestones include an oral qualifying examination, a dissertation proposal defense, and a dissertation defense.

For more information, please refer to the Doctoral Program Guide available on the Computer Science & Engineering website.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

Teaching is a fundamental responsibility for PhD graduates pursuing faculty positions in Computer Science & Engineering (CSE). CSE faculty at first-class research institutions are expected to teach at least one course per semester. In more teaching-focused schools, the teaching load may be three or four courses per semester. Even for graduates entering an industrial rather than a university career, there may be opportunities to teach workshops or courses internal to their organization. Beyond this fundamental requirement, graduates who remain active in CSE research will frequently present their research in highly competitive academic conferences, at invited colloquia (including job talks), and in other public forums. The mission of the CSE department in graduate teaching training is twofold. First, we will provide all doctoral students with sufficient teaching training and practicum to enable them to compete for and to succeed in CSE faculty positions at top research institutions. This training is also sufficient for students who choose to pursue careers in industry. Students interested in pursuing positions primarily as teaching faculty will have the opportunity for enhanced teaching training and practicum to support their ambitions. Second, we will train all doctoral students in the standards of scholarly oral communication needed to succeed in CSE research. This training will take place through individual mentoring by faculty and peers, through observation and critique of other speakers, and through students' presentations in internal and external scholarly forums.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Three Preparatory Engagement activities are required:

1. McKelvey Teaching Orientation (Canvas course)
2. McKelvey Teaching Workshop (Canvas course)
3. Enrollment in CSE 7900 Research Seminar On Computer Science Pedagogy (This can be done in advance of the Mentored Teaching Experience [MTE] semester or concurrently with the MTE.)

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

Students AI one course at 10 MER units by registering for EGS 8010 MTE - Assistant in Instruction Experience for the semester of assignment. Students could also AI two courses, with one course in each semester at 5 MER units each, by registering for EGS 8005 MTE - Assistant in Instruction Experience in the given semester. Students work with their graduate supervisor on the timing and content of those assignments. Students will need to register for CSE 8002 Mentored Teaching Experience for graded credit during their MTE semester. Students will also need to complete their Doctoral Student Research Seminar requirement as well, although this portion can be completed before, during, or after the semester during which they complete their AI duties.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

Pathway #1

Preparatory Engagement	
EGS 8005	Enroll two times (one enrollment during each semester of engagement)
CSE 8002	Enroll one time during the semester of engagement

Pathway #2

Preparatory Engagement	
EGS 8010	Enroll one time during the semester of engagement
CSE 8002	Enroll one time during the semester of engagement

Optional Activity: Teaching Intensive Pathway (TIP)

The TIP is an optional pathway for those students whose career interests lie in academia or another field that would benefit from extended teaching experiences. This immersive experience allows students to further explore the breadth and depth of teaching best practices and pedagogy related to their respective field. Students who are interested in participating in this elective experience must formally request to participate, which is subject to program approval. Due to this experience being an elective, unpaid experience, students who participate in the TIP will not receive compensation.

The TIP is outlined in our Doctoral Program Guide as follows: "Doctoral students interested in academic careers have the option to undertake additional training to better prepare them for the challenges of teaching. Specifically, in cooperation with the department's Associate Chair and with the approval of their advisor, students can opt to teach a one semester course in the CSE department. This option can be exercised only once during a student's PhD program and requires that the student enroll in EGS 8020 MTE - Mentored Independent Teaching Experience in the semester(s) during which she/he is teaching such a course. The student would additionally need to register for CSE 8001 Pedagogy in the semester of engagement. Teaching a course does not translate into additional compensation and will result in a reduction in the amount of time the student is able to devote to research by 40% to 60% depending on the course. A student must, therefore, ensure that the approval of her/his advisor is officially conveyed to the Director of Graduate Studies before enrolling in EGS 8020 MTE - Mentored Independent Teaching Experience. Selection of a suitable course will then be performed in collaboration with the Associate Chair, who will also coordinate supervision of the student's teaching during the semester."

This track will require the student to have completed their Preparatory Engagement and to have completed one semester as an AI before they then request to tack on this additional training. This teaching intensive track will count for 20 units of Mentored Independent Teaching. (Students register under EGS 8020 MTE - Mentored Independent Teaching Experience and will be listed in the course listing. They will still need to submit a commitment form to the department as well.)

Optional TIP Pathway A

EGS 8010	Enroll one time during the semester of engagement
CSE 8002	Enroll one time during the semester of engagement
EGS 8020	Enroll one time during the semester of engagement
CSE 8001	Enroll one time during the semester of engagement

Optional TIP Pathway B

EGS 8005	Enroll two times (one enrollment during each semester of engagement)
CSE 8002	Enroll one time during the semester of engagement
EGS 8020	Enroll one time during the semester of engagement
CSE 8001	Enroll one time during the semester of engagement

Computer Engineering, PhD (CSE)

Students can choose to pursue a PhD in Computer Engineering. Here are the core requirements:

- Complete 72 units of regular — including graded — courses (at least 33 units, of which 9 must fulfill breadth requirements), seminars (at least 3 units), and research credits (at least 24 units).
- Satisfy fundamental teaching requirements by participating in mentored teaching experiences and complete scholarly communication requirements by participating in the Doctoral Student Research Seminar.
- Pass milestones that demonstrate the ability to understand research literature, to communicate orally and in writing, and to formulate a detailed research plan. These milestones include an oral qualifying examination, a dissertation proposal defense, and a dissertation defense.

For more information, please refer to the Doctoral Program Guide available on the Computer Science & Engineering website.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

Teaching is a fundamental responsibility for PhD graduates pursuing faculty positions in Computer Science & Engineering (CSE). CSE faculty at first-class research institutions are expected to teach at least one course per semester. In more teaching-focused schools, the teaching load may be three or four courses per semester. Even for graduates entering an industrial rather than a university career, there may be opportunities to teach workshops or courses internal to their organization. Beyond this fundamental requirement, graduates who remain active in CSE research will frequently present their research in highly competitive academic conferences, at invited colloquia (including job talks), and in other public forums. The mission of the CSE department in graduate teaching training is twofold. First, we will provide all doctoral students with sufficient teaching training and practicum to enable them to compete for and to succeed in CSE faculty positions at top research institutions. This training is also sufficient for students who choose to pursue careers in industry. Students interested in pursuing positions primarily as teaching faculty will have the opportunity for enhanced teaching training and practicum to support their ambitions. Second, we will train all doctoral students in the standards of scholarly oral communication needed to succeed in CSE research. This training will take place through individual mentoring by faculty and peers, through observation and critique of other speakers, and through students' presentations in internal and external scholarly forums.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Three Preparatory Engagement activities are required:

1. McKelvey Teaching Orientation (Canvas course)
2. McKelvey Teaching Workshop (Canvas course)
3. Enrollment in CSE 7900 Research Seminar On Computer Science Pedagogy (This can be done in advance of the Mentored Teaching Experience [MTE] semester or concurrently with the MTE.)

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

Students AI one course at 10 MER units by registering for EGS 8010 MTE - Assistant in Instruction Experience for the semester of assignment. Students could also AI two courses, with one course in each semester at 5 MER units each, by registering for EGS 8005 MTE - Assistant in Instruction Experience in the given semester. Students work with their graduate supervisor on the timing and content of those assignments. Students will need to register for CSE 8002 Mentored Teaching Experience for graded credit during their MTE semester. Students will also need to complete their Doctoral Student Research Seminar requirement as well, although this portion can be completed before, during, or after the semester during which they complete their AI duties.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

Pathway #1

Preparatory Engagement	
EGS 8005	Enroll two times (one enrollment during each semester of engagement)
CSE 8002	Enroll one time during the semester of engagement

Pathway #2

Preparatory Engagement	
EGS 8010	Enroll one time during the semester of engagement
CSE 8002	Enroll one time during the semester of engagement

Optional Activity: Teaching Intensive Pathway (TIP)

The TIP is an optional pathway for those students whose career interests lie in academia or another field that would benefit from extended teaching experiences. This immersive experience allows students to further explore the breadth and depth of teaching best practices and pedagogy related to their respective field. Students who are interested in participating in this elective experience must formally request to participate, which is subject to program approval. Due to this experience being an elective, unpaid experience, students who participate in the TIP will not receive compensation.

The TIP is outlined in our Doctoral Program Guide as follows: "Doctoral students interested in academic careers have the option to undertake additional training to better prepare them for the challenges of teaching. Specifically, in cooperation with the department's Associate Chair and with the approval of their advisor, students can opt to teach a one semester course in the CSE department. This option can be exercised only once during a student's PhD program and requires that the student enroll in EGS 8020 MTE - Mentored Independent Teaching Experience in the semester(s) during which she/he is teaching such a course. The student would additionally need to register for CSE 8001 Pedagogy in the semester of engagement. Teaching a course does not translate into additional compensation and will result in a reduction in the amount of time the student is able to devote to research by 40% to 60% depending on the course. A student must, therefore, ensure that the approval of her/his advisor is officially conveyed to the Director of Graduate Studies before enrolling in EGS 8020 MTE - Mentored Independent Teaching Experience. Selection of a suitable course will then be performed in collaboration with the Associate Chair, who will also coordinate supervision of the student's teaching during the semester."

This track will require the student to have completed their Preparatory Engagement and to have completed one semester as an AI before they then request to tack on this additional training. This teaching intensive track will count for 20 units of Mentored Independent Teaching. (Students register under EGS 8020 MTE - Mentored Independent Teaching Experience and will be listed in the course listing. They will still need to submit a commitment form to the department as well.)

Optional TIP Pathway A

EGS 8010	Enroll one time during the semester of engagement
CSE 8002	Enroll one time during the semester of engagement
EGS 8020	Enroll one time during the semester of engagement
CSE 8001	Enroll one time during the semester of engagement

Optional TIP Pathway B

EGS 8005	Enroll two times (one enrollment during each semester of engagement)
CSE 8002	Enroll one time during the semester of engagement
EGS 8020	Enroll one time during the semester of engagement
CSE 8001	Enroll one time during the semester of engagement

Computer Science, MS (CSE)

The Master of Science (MS) in Computer Science is directed toward students with a computer science background who are looking for a program and courses that are more focused on software. This can be either a pure course option program, or it can incorporate either a project or a thesis. If a student chooses a degree option that incorporates a research experience, this MS degree may provide a solid stepping stone to future doctoral studies. All students in the MS in Computer Science program must have previously completed (as documented by their undergraduate transcript), successfully test to place out of, or complete at the start of their program the following courses: CSE 1301 Introduction to Computer Science and CSE 2407 Data Structures and Algorithms (or equivalent courses offered at other institutions).

Course Option

This option requires 30 units of graduate credit. Students must also follow the general degree requirements listed below and complete the breadth requirements.



Thesis/Project Option

Beginning in Fall 2025, students seeking to take the project or thesis option in our degree programs will register for CSE 7998 Master's Capstone. CSE 7998 Master's Capstone does not count toward the student's 30 required units of coursework to complete the degree until the student has successfully defended the project or thesis.

Students have the following options:

- Upon successful defense of a 3-unit master's project, 3 units of CSE 7998 Master's Capstone will count toward the student's degree as a 5000-level CSE departmental course. These units may be used to satisfy a 5000-level breadth requirement if the work is deemed to match that requirement.
- Upon successful defense of a 6-unit master's project, 6 units of CSE 7998 Master's Capstone will count toward the student's degree. 3 of these units may be used to satisfy a 5000-level breadth requirement if the work is deemed to match that requirement. The remaining units will satisfy a 5000-level CSE departmental course.
- Upon successful defense of a master's thesis, 6 units of CSE 7998 Master's Capstone will count toward the student's coursework at the CSE 5000 level. In addition, breadth requirements will be waived for the student. The student must still complete 12 units of 5000-level departmental coursework alongside 6 units of CSE 7998 Master's Capstone for a total of 18 units of departmental coursework at the 5000 level.

A student who successfully defends one of the three options listed above will have a notation added to their transcript to clearly indicate exactly which option (3-unit master's project, 6-unit master's project, or master's thesis) was completed. Each semester, CSE 7998 Master's Capstone will be graded with a letter grade. A grade of a C– or above is required in the first semester of a 6-unit project or thesis to continue the work in the final semester. As a master's project or thesis is considered to have unique content each semester, CSE 7998 Master's Capstone is not a retakeable course, and a grade from a previous semester cannot be replaced. Students must also follow the general degree requirements listed below. Thesis students are exempt from the breadth requirements following the successful defense of their thesis. Students should refer to the department's Master's Program Handbook for additional details and guidance regarding projects and theses.

The Progress Report (two-semester theses and projects only)

Near the end of the first semester of a two-semester thesis or project, the student will submit a written progress report to the committee. The progress report will be used by the committee to evaluate student progress and to provide an opportunity to give feedback to the student.

Preparing and Submitting the Progress Report

The progress report should include the following:

- A copy of the original scope and duration of the work to be performed (this can be obtained from the original proposal form). Students can contact the Graduate Coordinator to receive a copy of their original proposal form.
- A discussion of any major modifications/changes to the scope of the work to be performed
- An overview of the work that has been completed during the first semester of the thesis or project
- A discussion of the work yet to be completed and a timeline for completion

The progress report should be submitted via email to all members of the committee at least one week prior to the last official day of classes for the given semester.

Outcomes

Once submitted, the committee will confer privately to discuss the student's progress made during the first semester of the thesis or project. The committee will decide on one of three possible outcomes:

1. *Thesis or project should continue without concern*, indicating the student is making consistent progress and is on track to successfully complete the thesis or project on time.
2. *Thesis or project should continue with concern*, indicating the student is making some progress but is falling behind. Without change, the student is not likely to successfully complete the thesis or project.
3. *Thesis or project should not continue*, indicating the student is not making sufficient progress and the project or thesis should be terminated.

The outcome determined by the committee will be communicated to the student by the department's Graduate Coordinator prior to the official end of the semester. If the outcome is that the thesis or project should not continue, the student will not be enrolled in the second semester's units.

Process for Termination of a Project or Thesis

Please note, starting in Fall 2024 and onward, master's project/thesis students will not be allowed to have an N grade submitted for a terminated project. Please contact the Graduate Coordinator as soon as possible regarding any questions for terminating a project/thesis. With that in mind, please review the following scenarios:

- For a one-semester project:
 - If it is terminated before the add/drop deadline, it will have no effect on the student's record.
 - If it is terminated after the add/drop deadline but before the Withdrawal deadline, it would leave a W on the student's transcript.
 - If it is terminated after the Withdrawal deadline, it could result in a failing letter grade on the student's transcript.
- For a two-semester project or thesis:
 - If the project/thesis is terminated during the first semester, it would follow the same timeline as the scenarios above for a one-semester project.
 - If the second semester of the project/thesis is terminated before the add/drop deadline, the second-semester credits of CSE 7998 Master's Capstone would be dropped.
 - If the second semester of the project/thesis is terminated after the add/drop deadline but before the Withdrawal deadline, the second-semester credits of CSE 7998 Master's Capstone would leave a W on the student's transcript.
 - If the second semester of the project/thesis is terminated after the Withdrawal deadline, it could result in a failing letter grade on the student's transcript.
 - For each of the three second-semester scenarios listed above: The student, pending advisor approval, would have the option to defend their first semester's work as a 3-credit project. (Any CSE 7998 Master's Capstone units completed without a successful defense will not count toward the student's degree requirements.)

General Degree Requirements

- Breadth requirements include one departmental course from each of the following categories: Theory (T), Software Systems (S), and either Machines (M) or Applications (A). These courses must be at the 5000 level or above. Students may find a full list of S, M, T, and A courses on the CSE department's Resources for Current Master's Students page.
- 18 of the 30 required units must be CSE departmental courses at the 5000 level or above.
- Students may count up to 6 units of coursework taken outside of the CSE department toward their degree. In order for out-of-department courses to count toward a student's degree, the student must request that the course be reviewed and approved by the department by contacting the Graduate Coordinator. The department will review the courses to ensure that they offer suitably technical graduate-level content. No more than 6 out-of-department units may be counted except in extraordinary circumstances, and no more than 12 units may be counted in any case. Once approved by the department, the out-of-department courses can only count toward the Electives section of the degree.
- Up to 12 units of 4000-level courses can count for graduate credit in the Electives section of the degree.

- None of the 30 units may be taken as independent study (i.e., CSE 4000 Independent Study or CSE 5999 Independent Study).
- Courses with an N designation do not count toward the master's degree.
- All 30 units required for the degree must be taken for a grade (i.e., not Pass/No Pass), and the grade received in each course must be C– or better.
- Per School of Engineering guidelines, students must maintain a grade point average of at least 2.70.

Computer Engineering, MS (CSE)

The Master of Science (MS) in Computer Engineering is best suited for students who are looking to focus on computer engineering (hardware) aspects. The MS in Computer Engineering program can be a pure course option program, or it can incorporate either a project or a thesis. If appropriate research experiences are included in the degree option, this can also lead toward future doctoral studies. All students in the MS in Computer Engineering program must have previously completed (as documented by their undergraduate transcript), successfully test to place out of, or complete at the start of their program the following courses: CSE 1301 Introduction to Computer Science and CSE 2600 Introduction to Digital Logic and Computer Design (or equivalent courses offered at other institutions).

The Master of Science in Computer Engineering degree is jointly administered by the Department of Computer Science and Engineering and the Department of Electrical and Systems Engineering.

Course Option

This option requires 30 units of graduate credit. Students must also follow the general degree requirements listed below.

Thesis/Project Option

Beginning in fall 2025, students seeking to take the project or thesis option in our degree programs will register for CSE 7998 Master's Capstone. CSE 7998 Master's Capstone does not count toward the student's 30 required units of coursework to complete the degree until the student has successfully defended the project or thesis. Students must also follow the general degree requirements listed below.



- Upon successful defense of a 3-unit master's project, 3 units of CSE 7998 Master's Capstone will count toward the student's degree as a 5000-level CSE departmental course.
- Upon successful defense of a 6-unit master's project, 6 units of CSE 7998 Master's Capstone will count toward the student's coursework at the 5000 level.
- Upon successful defense of a master's thesis, 6 units of CSE 7998 Master's Capstone will count toward the student's coursework at the 5000 level.

A student who successfully defends one of the three options listed above will have a notation added to their transcript to clearly indicate exactly which option (3-unit master's project, 6-unit master's project, master's thesis) was completed. Each semester, CSE 7998 Master's Capstone will be graded with a letter grade. A grade of a C– or above is required in the first semester of a 6-unit project or thesis to continue the work in the final semester. As a master's project or thesis is considered to have unique content each semester, CSE 7998 Master's Capstone is not a retakeable course, and a grade from a previous semester cannot be replaced. Students must also follow the general degree requirements listed below. Students should refer to the department's Master's Program Handbook for additional details and guidance regarding projects and theses.

The Progress Report (two-semester theses and projects only)

Near the end of the first semester of a two-semester thesis or project, the student will submit a written progress report to the committee. The progress report will be used by the committee to evaluate student progress and to provide an opportunity to give feedback to the student.

Preparing and Submitting the Progress Report

- The progress report should include the following:
 - A copy of the original scope and duration of the work to be performed (this can be obtained from the original proposal form). Students can contact the Graduate Coordinator to receive a copy of their original proposal form.
 - A discussion of any major modifications/changes to the scope of the work to be performed
 - An overview of the work that has been completed during the first semester of the thesis or project
 - A discussion of the work yet to be completed and a timeline for completion
- The progress report should be submitted via email to all members of the committee at least one week prior to the last official day of classes for the given semester.

Outcomes

- Once submitted, the committee will confer privately to discuss the student's progress made during the first semester of the thesis or project. The committee will decide on one of three possible outcomes:
 1. *Thesis or project should continue without concern*, indicating that the student is making consistent progress and is on track to successfully complete the thesis or project on time.
 2. *Thesis or project should continue with concern*, indicating that the student is making some progress but is falling behind. Without change, the student is not likely to successfully complete the thesis or project.
 3. *Thesis or project should not continue*, indicating that the student is not making sufficient progress and the thesis or project should be terminated.
- The outcome determined by the committee will be communicated to the student by the department's Graduate Coordinator prior to the official end of the semester. If the outcome is that the thesis or project should not continue, the student will not be enrolled in the second semester's units.

Process for Termination of a Project or Thesis

From Fall 2024 onward, master's project/thesis students will not be allowed to have an N grade submitted for a terminated project. Students should contact the Graduate Coordinator as soon as possible regarding any questions about terminating a project/thesis. With that in mind, please review the following scenarios:

- A one-semester project:
 - If the project is terminated before the add/drop deadline, it will have no effect on the student's record.
 - If the project is terminated after the add/drop deadline but before the withdrawal deadline, there will be a W on the student's transcript.
 - If the project is terminated after the withdrawal deadline, this could result in a failing letter grade on the student's transcript.
- A two-semester project or thesis, during the first semester of the project or thesis:
 - The project or thesis would follow the same timeline and have the same results as the one-semester project scenarios above.
- A two-semester project or thesis, where the first semester has already been completed:



- If the second semester of the project or thesis is terminated before the add/drop deadline, the second-semester credits of CSE 7998 Master's Capstone would be dropped.
- If the second semester is terminated after the add/drop deadline but before the withdrawal deadline, the second-semester credits of CSE 7998 Master's Capstone would be noted as a W on the student's transcript.
- If the second semester is terminated after the withdrawal deadline, the termination could result in a failing letter grade on the student's transcript.

For each of the three scenarios listed above, the student, pending advisor approval, would have the option to defend their first semester's work as a 3-credit project. (Any CSE 7998 Master's Capstone units completed without a successful defense will not count toward the student's degree requirements.)

General Degree Requirements

- 18 of the 30 units must be from the designated graduate-level Computer Engineering courses. Please visit our MS in Computer Engineering website for a comprehensive list.
- Up to 12 units may be taken from outside the two departments. In order for out-of-department courses to count toward a student's degree, they must request the course(s) be reviewed and approved by the department by contacting the Graduate Coordinator. The department will review the courses to ensure that they offer suitably technical graduate-level content. Once approved by the department, the out-of-department courses can only count toward the Electives section of the degree. To count more than 6 units from outside the CSE or ESE department, an appropriate justification for the additional increment must be provided by the advisor and student. Program approval will be evaluated with increasing stringency for each additional increment.
- Up to 12 units of 4000-level courses can count for graduate credit.
- None of the 30 units may be taken as independent study (i.e., CSE 4000 Independent Study, CSE 5999 Independent Study, ESE 4999 Independent Study, or ESE 5999 Independent Study).
- CSE courses with an N designation do not count toward the master's degree.
- All 30 units required for the degree must be taken for a grade (i.e., not Pass/No Pass), and the grade received in each course must be C– or better.
- Per McKelvey School of Engineering guidelines, students must maintain a grade point average of at least 2.70.

Cybersecurity Engineering, MS (CSE)

The Master of Science (MS) in Cybersecurity Engineering at Washington University will give students the skills, knowledge, and expertise needed to work in the rapidly growing field of cybersecurity and to design, engineer, and architect cybersecurity technology and systems. Graduates of this program will be equipped with the theoretical and hands-on engineering expertise required to solve complex cybersecurity problems that affect diverse enterprises worldwide.

The program includes a set of core foundational courses that focus on understanding core principles in information security. Students pursuing this degree may also choose from more advanced cybersecurity elective courses that will build deeper integrative knowledge of key concepts within a variety of domains. Work in the program culminates in either a capstone project or a final thesis. The capstone project should focus on a specific set of technical cybersecurity challenges, with the objective of designing an implementable solution to those challenges. The thesis option allows students to plan, execute, and report on an individual project that addresses a substantial problem, covering both practical and scientific aspects. Students planning to pursue a PhD degree after completing the MS in Cybersecurity Engineering degree are particularly encouraged to pick the thesis option.

All students in the MS in Cybersecurity Engineering program must have previously completed (as documented by their undergraduate transcript), successfully tested to place out of, or completed at the start of their program the following courses: CSE 1301 Introduction to Computer Science and CSE 2407 Data Structures and Algorithms (or equivalent courses offered at other institutions).

Core Courses

Code	Title	Units
CSE 4303	Introduction to Computer Security	3
CSE 5203	Systems Security	3
Total Units		6

Program Electives

Choose six of the following courses:

Code	Title	Units
CSE 4103	Web Privacy and Security	3
CSE 4202	Operating Systems Organization	3
CSE 4304	Reverse Engineering and Malware Analysis	3
CSE 4402	Introduction to Cryptography	3



CSE 4703	Introduction to Computer Networks	3
CSE 5202	Advanced Operating Systems	3
CSE 5271	Data-Driven Privacy and Security	3
CSE 5402	Concurrency and Memory Safe System Software Development	3
CSE 5505	Adversarial AI	3
CSE 5619	Recent Advances in Computer Security and Privacy	3
CSE 5701	Network Security	3

Culminating Experience

Code	Title	Units
CSE 7998	Master's Capstone	6

Thesis/Project

Beginning in Fall 2025, students will register for CSE 7998 Master's Capstone. CSE 7998 Master's Capstone does not count toward the student's 30 required units of coursework to complete the degree until the student has successfully defended the project or thesis. Students in the MS in Cybersecurity Engineering degree must complete all 6 units of CSE 7998 Master's Capstone as a single project or thesis. They are not allowed to complete two separate 3-unit projects for a total of 6 units of project work.

A student who successfully defends one of the two options listed above will have a notation added to their transcript to clearly indicate exactly which option (6-unit master's project or master's thesis) was completed. Each semester, CSE 7998 Master's Capstone will be graded with a letter grade. A grade of a C– or above is required in the first semester of a 6-unit project or thesis to continue the work in the final semester. As a master's project or thesis is considered to have unique content each semester, CSE 7998 Master's Capstone is not a retakeable course, and a grade from a previous semester cannot be replaced. Students should refer to the department's Master's Program Handbook for additional details and guidance regarding projects and theses.

The Progress Report

Near the end of the first semester of a two-semester thesis or project, the student will submit a written progress report to the committee. The progress report will be used by the committee to evaluate student progress and to provide an opportunity to give feedback to the student.

Preparing and Submitting the Progress Report

The progress report should include the following:

- A copy of the original scope and duration of the work to be performed (this can be obtained from the original proposal form). Students can contact the Graduate Coordinator to receive a copy of their original proposal form.
- A discussion of any major modifications/changes to the scope of the work to be performed
- An overview of the work that has been completed during the first semester of the thesis or project
- A discussion of the work yet to be completed and a timeline for completion

The progress report should be submitted via email to all members of the committee at least one week prior to the last official day of classes for the given semester.

Outcomes

Once submitted, the committee will confer privately to discuss the student's progress made during the first semester of the thesis or project. The committee will decide on one of three possible outcomes:

1. *Thesis or project should continue without concern*, indicating the student is making consistent progress and is on track to successfully complete the thesis or project on time.
2. *Thesis or project should continue with concern*, indicating the student is making some progress but is falling behind. Without change, the student is not likely to successfully complete the thesis or project.
3. *Thesis or project should not continue*, indicating the student is not making sufficient progress and the project or thesis should be terminated.

The outcome determined by the committee will be communicated to the student by the department's Graduate Coordinator prior to the official end of the semester. If the outcome is that the thesis or project should not continue, the student will not be enrolled in the second semester's units.

Process for Termination of a Project or Thesis

Please note, starting in Fall 2024 and onward, master's project/thesis students will not be allowed to have an N grade submitted for a terminated project. Please contact the Graduate Coordinator as soon as possible regarding any questions for terminating a project/thesis. With that in mind, please review the following scenarios:

- For a two-semester project or thesis, during the first semester of the project/thesis:
 - If it is terminated before the add/drop deadline, it will have no effect on the student's record.
 - If it is terminated after the add/drop deadline but before the Withdrawal deadline, it would leave a W on the student's transcript.
 - If it is terminated after the Withdrawal deadline, it could result in a failing letter grade on the student's transcript.

- For a two-semester project or thesis, if the first semester has already been completed:
 - If the second semester of the project/thesis is terminated before the add/drop deadline, the second-semester credits of CSE 7998 Master's Capstone would be dropped.
 - If the second semester of the project/thesis is terminated after the add/drop deadline but before the Withdrawal deadline, the second-semester credits of CSE 7998 Master's Capstone would leave a W on the student's transcript.
 - If the second semester of the project/thesis is terminated after the Withdrawal deadline, it could result in a failing letter grade on the student's transcript.

General Degree Requirements

- Students who have already taken core or elective courses specified by the program can, with departmental approval, substitute other courses that are suitably technical and appropriate to the degree program. Departmental approval will require justification and will be evaluated with increasing stringency for each additional substitution.
- None of the 30 units may be taken as independent study (i.e., CSE 4000 Independent Study or CSE 5999 Independent Study).
- All 30 units required for the degree must be taken for a grade (i.e., not Pass/No Pass), and the grade received in each course must be C– or better.
- Per School of Engineering guidelines, students must maintain a grade point average of at least 2.70.

Computer Science & Engineering, MEng (CSE)

The Master of Engineering (MEng) in Computer Science and Engineering is specifically designed for students who would like to combine studies in computer science and computer engineering (possibly in conjunction with graduate-level work in another discipline) or who, for other reasons, need a more flexible structure for their master's studies. The MEng offers more flexibility by allowing approved outside courses (i.e., courses not specifically taken in computer science, such as various business courses) to count toward the degree; in this manner, an MEng student can customize their program by incorporating interdisciplinary components, when and if these are approved by the faculty advisor. Work in the program culminates in a capstone project highlighting each student's ambitions, interests, and accomplishments in the program. MEng students typically move directly into the industry. All students in the MEng program must have previously completed (as documented by their undergraduate transcript), successfully tested to place out of, or

completed at the start of their program the following courses: CSE 1301 Introduction to Computer Science and CSE 2407 Data Structures and Algorithms (or equivalent courses offered at other institutions).

Capstone Project

The MEng requires 30 total units, including 24 units of graduate-level coursework and 6 units of CSE 7998 Master's Capstone work culminating in a successful project defense.

Project Information

Beginning in Fall 2025, students seeking to take the project or thesis option in our degree programs will register for CSE 7998 Master's Capstone. CSE 7998 Master's Capstone does not count toward the student's 30 required units of coursework to complete the degree until the student has successfully defended the project. Once a student has successfully defended their project, a notation will be added to their transcript to denote the 6-credit project designation. A grade of a C– or above is required in the first semester of a 6-unit project to continue the work in the final semester.

- Students in the MEng degree must complete all 6 units of CSE 7998 Master's Capstone as a single project. They are not allowed to complete two separate 3-unit projects for a total of 6 units of project work.
- As a master's project or thesis is considered to have unique content each semester, CSE 7998 Master's Capstone is not a retakeable course, and a grade from a previous semester cannot be replaced.

The Progress Report

Near the end of the first semester of a two-semester project, the student will submit a written progress report to the committee. The progress report will be used by the committee to evaluate student progress and to provide an opportunity to give feedback to the student.

Preparing and Submitting the Progress Report

The progress report should include the following:

- A copy of the original scope and duration of the work to be performed (this can be obtained from the original proposal form). Students can contact the Graduate Coordinator to receive a copy of their original proposal form.
- A discussion of any major modifications/changes to the scope of the work to be performed
- An overview of the work that has been completed during the first semester of the thesis or project
- A discussion of the work yet to be completed and a timeline for completion



The progress report should be submitted via email to all members of the committee at least one week prior to the last official day of classes for the given semester.

Outcomes

Once submitted, the committee will confer privately to discuss the student's progress made during the first semester of the project. The committee will decide on one of three possible outcomes:

1. *Project should continue without concern*, indicating the student is making consistent progress and is on track to successfully complete the project on time.
2. *Project should continue with concern*, indicating the student is making some progress, but is falling behind. Without change, the student is not likely to successfully complete the project.
3. *Project should not continue*, indicating the student is not making sufficient progress and the project should be terminated.

The outcome determined by the committee will be communicated to the student by the department's Graduate Coordinator prior to the official end of the semester. If the outcome is that the thesis or project should not continue, the student will not be enrolled in the second semester's units.

Process for Termination of the 6-Credit Project

Please note, starting for Fall 2024 onward, Master's Project/Thesis students will not be allowed to have an N grade submitted for a terminated project. Please contact the Graduate Coordinator as soon as possible regarding any questions for terminating a project/thesis.

With that in mind, please review the following scenarios:

- A two-semester project during the first semester of the project:
 - Terminated before the add/drop deadline will have no effect on the student's record.
 - Terminated after the add/drop deadline but before the Withdrawal deadline would leave a W on the student's transcript.
 - Terminated after the Withdrawal deadline could result in a failing letter grade on the student's transcript.
- A two-semester project, where the first semester has already been completed:

- If the second semester of the project is terminated before the add/drop deadline: the second semester credits of CSE 7998 Master's Capstone would be dropped.
- If the second semester is terminated after the add/drop deadline but before the Withdrawal deadline: the second semester credits of CSE 7998 Master's Capstone would leave a W on the student's transcript.
- If the second semester is terminated after the Withdrawal deadline: the termination could result in a failing letter grade on the student's transcript.
- Any CSE 7998 Master's Capstone units completed without a successful defense will not count toward the student's degree requirements.

General Degree Requirements

- Of the 30 units required for the degree, 6 units will count toward the Master's Capstone. Of the remaining 24 units, 9 units must be CSE courses at the 5000 level, and the other 15 units must be CSE courses at the 4000 level or 5000 level.
- In that section of 15 units of CSE 4000-level or 5000-level courses, students may request up to 12 units of coursework taken outside the Computer Science & Engineering Department toward their degree. To count more than 6 such units, the student and their faculty advisor must justify how the outside units contribute to a coherent, interdisciplinary plan of study, which must be reviewed and approved by the department. Increasing justification will be required as the number of outside units increases. In addition, each out-of-department course must be individually reviewed and approved by the department to ensure that it offers suitably technical graduate-level content. The student should initiate this process by submitting their request to the Graduate Coordinator.
- None of the 30 units may be taken as independent study (i.e., CSE 4000 Independent Study or CSE 5999 Independent Study).
- All 30 units required for the degree must be taken for a grade (i.e., not Pass/No Pass), and the grade received in each course must be C- or better.
- Per McKelvey School of Engineering guidelines, students must maintain a grade point average of at least 2.70.



Data Mining & Machine Learning Certificate (CSE)

The Certificate in Data Mining and Machine Learning can be awarded in conjunction with any engineering master's degree. To qualify for this certificate, students enrolled in any master's program within the McKelvey School of Engineering will need to meet the requirements listed below in addition to the standard requirements for their master's degree. All courses must be taken for a grade. Courses must be graded at a D– or better in order to count toward the certificate.

Required Courses

Code	Title	Units
CSE 4107	Introduction to Machine Learning	3
or ESE 4170	Introduction to Machine Learning and Pattern Classification	
CSE 5107	Machine Learning	3
CSE 5401	Advanced Algorithms	3
Total Units		9

Foundations Courses

Students select two of the following courses:

Code	Title	Units
CSE 4102	Introduction to Artificial Intelligence	3
CSE 5100	Deep Reinforcement Learning	3
CSE 5103	Theory of Artificial Intelligence and Machine Learning	3
CSE 5104	Data Mining	3
CSE 5105	Bayesian Methods in Machine Learning	3
CSE 5109	Advanced Machine Learning	3
CSE 5403	Algorithms for Nonlinear Optimization	3
CSE 5610	Large Language Models	3
ESE 4150	Optimization	3
SDS 4010	Probability	3
or ESE 5200	Probability and Stochastic Processes	
SDS 4020	Mathematical Statistics	3

Domain Courses

Students choose one of the following courses:

Code	Title	Units
CSE 4207	Cloud Computing With Big Data Applications	3
CSE 5106	Multi-Agent Systems	3
CSE 5108	Human-In-The-Loop Computation	3
CSE 5270	Natural Language Processing	3
CSE 5310	AI for Health	3
CSE 5370	Trustworthy Autonomy	3
CSE 5505	Adversarial AI	3
CSE 5507	Advanced Visualization	3
CSE 5509	Computer Vision	3
CSE 5804	Algorithms for Biosequence Comparison	3
CSE 5807	Algorithms for Computational Biology	3
ESE 5130	Large-Scale Optimization for Data Science	3

Additional Information

Students with previous courses in machine learning may place out of CSE 4107 Introduction to Machine Learning. These students will be required to complete an additional foundations course for a total of three foundations courses.

Cybersecurity Engineering Certificate (CSE)

The Certificate in Cybersecurity Engineering can be awarded in conjunction with any engineering master's degree. In order to qualify for this certificate, students enrolled in any master's degree program within the McKelvey School of Engineering will need to meet the requirements listed below in addition to the standard requirements for their master's degree. All courses must be taken for a grade. Courses must be graded at a D– or better in order to count toward the certificate.

Core Courses

Code	Title	Units
CSE 4303	Introduction to Computer Security	3
CSE 5203	Systems Security	3

Program Electives

Select three of the following:

Code	Title	Units
CSE 4103	Web Privacy and Security	3
CSE 4202	Operating Systems Organization	3
CSE 4304	Reverse Engineering and Malware Analysis	3



CSE 4402	Introduction to Cryptography	3
CSE 4703	Introduction to Computer Networks	3
CSE 5202	Advanced Operating Systems	3
CSE 5271	Data-Driven Privacy and Security	3
CSE 5402	Concurrency and Memory Safe System Software Development	3
CSE 5505	Adversarial AI	3
CSE 5619	Recent Advances in Computer Security and Privacy	3
CSE 5701	Network Security	3

Electrical & Systems Engineering

The Department of Electrical & Systems Engineering offers doctoral-level and master's-level degrees in Electrical Engineering and in Systems Science & Mathematics. At the doctoral level, the PhD programs typically require four to five years of full-time study leading to an original research contribution. At the master's level, the programs require 30 credit units of study and have both a course option and a thesis option.

Research activity in the department is focused in the following four areas:

Applied Physics

- Nanophotonics
- Quantum optics
- Engineered materials
- Electrodynamics

Devices & Circuits

- Computer engineering
- Integrated circuits
- Radiofrequency circuits
- Sensors

Systems Science

- Optimization
- Applied mathematics
- Control
- Financial engineering

Signals & Imaging

- Computational imaging
- Signal processing
- Optical imaging
- Data sciences

Students working in any of these areas will enjoy the benefits of programs that balance fundamental theoretical concepts with modern applications. In our department, students find ample opportunities for close interactions with faculty members working on cutting-edge research and technology development.

Prospective PhD students with previous degrees in engineering who are interested in PhD studies and research in mathematics or statistics are encouraged to apply for PhD studies in Mathematics and Statistics. For more details, visit the Graduate Programs in Mathematics and Statistics webpage.

Phone: 314-935-5565
Website: <https://ese.wustl.edu/academics/graduate-programs/index.html>

Faculty

Chair

Shinung Ching
Department Chair and Professor
PhD, University of Michigan
Engineering Neuroscience, dynamics, and control

Endowed Professors

Shantanu Chakrabartty
Clifford W. Murphy Professor
Vice Dean for Research and Graduate Education
PhD, Johns Hopkins University
Explores frontiers in analog and neuromorphic integrated circuits

Jr-Shin Li
Newton R. and Sarah Louisa Glasgow Wilson Professor of Engineering
PhD, Harvard University
Studies complex large-scale systems arising from emerging physical, biological and medical applications

Joseph A. O'Sullivan
Samuel C. Sachs Professor of Electrical Engineering
Dean, UMSL/WashU Joint Undergraduate Engineering Program
PhD, Notre Dame University
Discovers ways to improve CT imaging & optical imaging

Lan Yang

Edward H. & Florence G. Skinner Professor of Engineering
PhD, California Institute of Technology
Focuses on advanced nano/micro photonic devices with outstanding optical properties

Associate Professors

Xudong Chen

PhD, Harvard University
Develops revolutionary methods for analysis and control of large-scale multi-agent systems

Andrew Clark

PhD, University of Washington
Focused on control and security of networked and cyber-physical systems

Matthew Lew

Associate Chair for Academic Programs
PhD, Stanford University
Builds new nanoscale imaging technologies

Jung-Tsung Shen

PhD, Massachusetts Institute of Technology
Exploits the unique properties of quantum nano-photonics for applications in quantum communication, computation and biomedical imaging

Chuan Wang

Director of Graduate Programs
PhD, University of Southern California
Develops large-scale and cost-effective materials for flexible and stretchable electronic systems

Assistant Professors

Hong Hu

PhD, Harvard University
Developing theoretical foundations for high-dimensional information processing

Ioannis (Yiannis) Kantaros

PhD, Duke University
Designs safe and distributed autonomy algorithms for large-scale multi-robot systems

Mark Lawrence

PhD, University of Birmingham
Builds novel systems and devices for applications in telecommunications, computing and quantum information

Janet Sorrells

PhD, University of Illinois at Urbana-Champaign
Developing new technologies in label-free nonlinear optical microscopy to enable new applications in biology and medicine

Zhiyang Wang

PhD, University of Pennsylvania
Develops scalable and explainable machine learning for large-scale graphs and geometric data

Shen Zeng

PhD, University of Stuttgart
Develops data-integrated computational approaches for controlling complex dynamic systems

Senior Professors

Paul S. Min

PhD, University of Michigan
Routing and control of telecommunication networks, fault tolerance and reliability, software systems, network management

Robert E. Morley Jr.

DSc, Washington University in St. Louis
Computer engineering, lower-power VLSI design, computer architecture, signal processing, microprocessors systems design

Hiro Mukai

PhD, University of California, Berkeley
Theory and computational methods for optimization, optimal control, systems theory, electric power system operations, differential games

Daniel L. Rode

PhD, Case Western Reserve University
Optoelectronics and fiber optics, semiconductor materials, light-emitting diodes and lasers, semiconductor processing, electronics

Heinz Schaettler

PhD, Rutgers University
Optimal control, nonlinear systems, mathematical models in biomedicine

Barbara A. Shrauner

PhD, Harvard University (Radcliffe)
Plasma processing, semiconductor transport, symmetries of nonlinear differential equations

Barry E. Spielman

PhD, Syracuse University
High-frequency/high-speed devices, radiofrequency and microwave integrated circuits, computational electromagnetics

Tzyh Jong Tarn

DSc, Washington University
Quantum mechanical systems, bilinear and nonlinear systems, robotics and automation, life science automation

Professors of Practice

Dennis Mell

MS, University of Missouri–Rolla
Focuses on cross-disciplinary applications of robotics and automation systems

Ed Richter

MS, Washington University

Designs and develops biomedical signal processing systems including analog instrumentation, digital circuits with microcontrollers and FPGAs, and application programming; teaches electrical and computer engineering lab courses in FPGA design and development and signal processing and communications

Jason Trobaugh

DSc, Washington University

Ultrasound imaging, diffuse optical tomography, image-guided therapy, ultrasonic temperature imaging

Teaching Professors

James Feher

PhD, Missouri University of Science and Technology

Interested in the use and implementation of open source hardware and software as it is applied to engineering education

Vladimir Kurenok

PhD, Belarus State University (Minsk, Belarus)

Focuses on studying and applications of random models under low regularity assumptions

Senior Lecturers

Tsitsi Madziwa-Nussinov

PhD, University of California, Los Angeles

Teaches Introduction to Electrical and Electronic Circuits

Dorothy Wang

PhD, Virginia Tech

Fiber optic sensing, electro-optical sensors

Jinsong Zhang

PhD, University of Miami

Focused on signal, data and information processing with applications to engineering systems

Lecturers

Michael Hall

PhD, Washington University in St Louis

Teaches computer engineering, preparing students with essential skills and knowledge to achieve their professional goals and contribute to technological advancements that benefit society

Ben Wormleighton

PhD, University of California, Berkeley

Seeks to cultivate formative learning spaces and practices that develop creative and communal thinkers

Professors Emeriti

R. Martin Arthur

Newton R. and Sarah Louisa Glasgow Wilson Professor of Engineering
PhD, University of Pennsylvania
Ultrasonic imaging, electrocardiography

Arye Nehorai

The Eugene & Martha Lohman Emeritus Professor of Electrical Engineering
PhD, Stanford University
Statistical signal processing, machine learning, imaging, biomedicine

Degree Requirements

The Department of Electrical & Systems Engineering offers doctoral-level and master's-level degrees in Electrical Engineering and in Systems Science & Mathematics as well as a certificate in Imaging Science. At the doctoral level, the PhD programs typically require four to five years of full-time study leading to an original research contribution. At the master's level, the programs require a minimum of 30 units of study consistent with the residency and other applicable requirements of Washington University and McKelvey School of Engineering. The master's degrees may be pursued with a course-only option or a thesis option.

Students will enjoy the benefits of programs that balance fundamental theoretical concepts with modern applications. In our department, students will find ample opportunities for close interactions with faculty members working on cutting-edge research and technology development.

Please visit the following pages for more information about our programs:

- Electrical Engineering, PhD (p. 90)
- Systems Science & Mathematics, PhD (p. 91)
- Electrical Engineering, MSEE (p. 92)
- Systems Science & Mathematics, MSSSM (p. 93)
- Engineering Data Analytics & Statistics, MSDAS (p. 94)
- Computer Engineering, MS (p. 95)
- Robotics and Intelligent Systems, MEng (p. 97)
- Controls Certificate (p. 98)
- Financial Engineering Certificate (p. 99)
- Imaging Science & Engineering Certificate (p. 99)
- Quantum Engineering Certificate (p. 101)

Courses

ESE 5000 Research Rotation for ESE Masters Students

Masters students in Electrical and Systems Engineering may complete a rotation their first semester with research mentors acceptable to the Department. The rotations must be mutually agreeable to both the student and faculty member. The grade will be assigned

based on a written report from the rotation. The rotation allows students to sample different research projects and laboratory working environments, to enable matching masters students and research mentors with whom they will carry out thesis research.

Credit 3 units.

Typical periods offered: Fall

ESE 5010 Mathematics of Modern Engineering I

Matrix algebra: systems of linear equations, vector spaces, linear independence and orthogonality in vector spaces, eigenvectors and eigenvalues; Vector calculus: gradient, divergence, curl, line and surface integrals, theorems of Green, Stokes, and Gauss; Elements of Fourier analysis and its applications to solving some classical partial differential equations, heat, wave, and Laplace equation.

Credit 3 units.

Typical periods offered: Fall, Summer

ESE 5020 Mathematics of Modern Engineering II

This course covers Fourier series and Fourier integral transforms and their applications to solving some partial differential equations and heat and wave equations. It also presents complex analysis and its applications to solving real-valued problems, including analytic functions and their role, Laurent series representation, complex-valued line integrals and their evaluation (including the residual integration theory), and conformal mappings and their applications.

Credit 3 units.

Typical periods offered: Spring, Summer

ESE 5130 Large-Scale Optimization for Data Science

Large-scale optimization is an essential component of modern data science, artificial intelligence, and machine learning. This graduate-level course rigorously introduces optimization methods that are suitable for large-scale problems arising in these areas. Students will learn several algorithms suitable for both smooth and nonsmooth optimization, including gradient methods, proximal methods, mirror descent, Nesterov's acceleration, ADMM, quasi-Newton methods, stochastic optimization, variance reduction, and distributed optimization. Throughout the course, we will discuss the efficacy of these methods in concrete data science problems, under appropriate statistical models. Students will be required to program in Python or MATLAB.

Credit 3 units.

Typical periods offered: Fall

ESE 5200 Probability and Stochastic Processes

This course covers a review of probability theory; models for random signals and noise; calculus of random processes; noise in linear and nonlinear systems; representation of random signals by sampling and orthonormal expansions; and Poisson, Gaussian, and Markov processes as models for engineering problems.

Credit 3 units.

Typical periods offered: Fall, Spring

ESE 5230 Information Theory

Discrete source and channel model, definition of information rate and channel capacity, coding theorems for sources and channels, encoding and decoding of data for transmission over noisy channels.

Credit 3 units.

Typical periods offered: Fall

ESE 5240 Detection and Estimation Theory

Study of detection and estimation of signals in noise. Linear algebra, vector spaces, independence, projections. Data independence, factorization theorem and sufficient statistics. Neyman-Pearson and Bayes detection. Least squares, maximum-likelihood and maximum a posteriori estimation of signal parameters. Conjugate priors, recursive estimation, Wiener and Kalman filters.

Credit 3 units.

Typical periods offered: Spring

ESE 5310 Nano and Micro Photonics

This course focuses on fundamental theory, design, and applications of photonic materials and micro/nano photonic devices. It includes review and discussion of light-matter interactions in nano and micro scales, propagation of light in waveguides, nonlinear optical effect and optical properties of nano/micro structures, the device principles of waveguides, filters, photodetectors, modulators and lasers.

Credit 3 units.

Typical periods offered: Spring

ESE 5320 Introduction to Nano-Photonic Devices

Introduction to photon transport in nano-photonic devices. This course focuses on the following topics: light and photons, statistical properties of photon sources, temporal and spatial correlations, light-matter interactions, optical nonlinearity, atoms and quantum dots, single- and two-photon devices, optical devices, and applications of nano-photonic devices in quantum and classical computing and communication.

Credit 3 units.

Typical periods offered: Fall

ESE 5330 Nanophotonic Optical Media - From Metamaterials to Photonic Crystals and Beyond

The nanometer length scale holds a unique significance for optical engineering because it is home to the wavelengths of visible and infrared light. The behavior of a light wave is particularly sensitive to structural features formed at or below the scale of its wavelength and, as a consequence, nanophotonics encompasses many new and useful phenomena not found in macroscopic systems. In this course, we will explore the physics of light-matter coupling before using it as a guide to engineer new optical material properties via nanofabrication, with applications in computing, telecommunications, biomedical sensing, solar energy harvesting, robotics and more. Key topics covered in the course include Mie resonant dielectric antennas, plasmonic antennas, negative and zero refractive index metamaterials, chiral metamaterials, metasurface lenses and holograms, nonlinear and time dependent metasurfaces, Bragg mirrors, 3D photonic crystals, photonic crystal slab waveguides and cavities, guided mode resonators, photonic crystal lasers.

Credit 3 units.

Typical periods offered: Spring

ESE 5332 Hardware & Devices: RF and Microwave Component and System Design

The course aims at provide understanding of the passive and active design for modern-day RF and microwave wireless systems. The lecture-based learning in the course will be coupled with simulation in professional circuit simulators including ADS and Cadence Virtuoso, and literature review of recent advances in RFIC design. Topics in Passive Design Include Transmission Line Theory, S-parameters, Smith Chart for matching network design, Inductors, Capacitors, Power Dividers, Directional Couplers, Isolators, and Circulators. Topics in



Active Design include RF transistor modelling, Power Gain, Stability, Noise, Non-linearity, Low Noise Amplifiers, Mixers, small signal amplifiers, and Oscillators. Topics in System Design include Modern Receiver architectures and design considerations, course project. Credit 3 units.

Typical periods offered: Spring

ESE 5360 Introduction to Quantum Optics

This course covers the following topics: quantum mechanics for quantum optics, radiative transitions in atoms, lasers, photon statistics (photon counting, Sub-/Super-Poissonian photon statistics, bunching, anti-bunching, theory of photodetection, shot noise), entanglement, squeezed light, atom-photon interactions, cold atoms, atoms in cavities. If time permits, the following topics will be selectively covered: quantum computing, quantum cryptography, and teleportation.

Credit 3 units.

Typical periods offered: Fall

ESE 5430 Control Systems Design By State Space Methods

Advanced design and analysis of control systems by state-space methods: classical control review, Laplace transforms, review of linear algebra (vector space, change of basis, diagonal and Jordan forms), linear dynamic systems (modes, stability, controllability, state feedback, observability, observers, canonical forms, output feedback, separation principle and decoupling), nonlinear dynamic systems (stability, Lyapunov methods). Frequency domain analysis of multivariable control systems. State space control system design methods: state feedback, observer feedback, pole placement, linear optimal control. Design exercises with CAD (computer-aided design) packages for engineering problems.

Credit 3 units.

Typical periods offered: Fall

ESE 5440 Optimization and Optimal Control

Constrained and unconstrained optimization theory. Continuous time as well as discrete-time optimal control theory. Time-optimal control, bang-bang controls and the structure of the reachable set for linear problems. Dynamic programming, the Pontryagin maximum principle, the Hamiltonian-Jacobi-Bellman equation and the Riccati partial differential equation. Existence of classical and viscosity solutions. Application to time optimal control, regulator problems, calculus of variations, optimal filtering and specific problems of engineering interest.

Credit 3 units.

Typical periods offered: Spring

ESE 5450 Stochastic Control

Introduction to the theory of stochastic differential equations based on Wiener processes and Poisson counters, and an introduction to random fields. The formulation and solution of problems in nonlinear estimation theory. The Kalman-Bucy filter and nonlinear analogues. Identification theory. Adaptive systems. Applications. Prerequisites: ESE 520 and ESE 551

Credit 3 units.

Typical periods offered: Fall

ESE 5460 Dynamics & Control in Neuroscience & Brain Medicine

This course provides an introduction to systems engineering approaches to modeling, analysis and control of neuronal dynamics at multiple scales. A central motivation is the manipulation of neuronal activity for both scientific and medical applications using emerging neurotechnology and pharmacology. Emphasis is placed on dynamical systems and control theory, including bifurcation and stability

analysis of single neuron models and population mean-field models. Synchronization properties of neuronal networks are covered and methods for control of neuronal activity in both oscillatory and non-oscillatory dynamical regimes are developed. Statistical models for neuronal activity are also discussed. An overview of signal processing and data analysis methods for neuronal recording modalities is provided, toward the development of closed-loop neuronal control paradigms. The final evaluation is based on a project or research survey.

Credit 3 units.

Typical periods offered: Fall

ESE 5470 Robust and Adaptive Control

Graduate-level control system design methods for multi-input multi-output systems. Linear optimal based methods in robust control, nonlinear model reference adaptive control. These design methods are currently used in most industry control system design problems. These methods will be designed, analyzed, and simulated using Matlab. Linear Control Theory (review), Robustness Theory (Mu Analysis), Optimal Control and the Robust Servomechanism, H-infinity Optimal Control, Robust Output Feedback Controls, Kalman Filter Theory and Design, Linear Quadratic Gaussian with Loop Transfer Recovery, The Loop Transfer Recovery Method of Lavretsky, Mu Synthesis, Lyapunov Theory (review), LaSalle extensions, Barbalat's Lemma, Model Reference Adaptive Control, Artificial Neural Networks, On-line parameter estimation, convergence, and Persistence of Excitation.

Credit 3 units.

Typical periods offered: Spring

ESE 5510 Linear Dynamic Systems I

Input-output and state-space description of linear dynamic systems. Solution of the state equations and the transition matrix. Controllability, observability, realizations, pole-assignment, observers and decoupling of linear dynamic systems.

Credit 3 units.

Typical periods offered: Fall

ESE 5530 Nonlinear Dynamic Systems

State space and functional analysis approaches to nonlinear systems. Questions of existence, uniqueness, and stability; Lyapunov and frequency-domain criteria; w-limits and invariance, center manifold theory and applications to stability, steady state response and singular perturbations. Poincare-Bendixson theory, the van der Pol oscillator and the Hopf Bifurcation theorem.

Credit 3 units.

Typical periods offered: Spring

ESE 5582 Data-Driven Control Methods and Reinforcement Learning

Modeling and control approaches of the past decades are usually concerned with analytically described control systems with relatively mild complexity, which allows for a highly successful treatment by rigorous systems theoretic methods. Recent years, however, have witnessed a significant shift towards the consideration of far more complicated control systems in which purely analytical approaches are infeasible. This is a research-focused course that will introduce and explore systematic approaches towards augmenting the core foundations of systems and control theoretic frameworks with data-integrating and learning-based capabilities to efficiently harness the vast amounts of valuable operational data and computing resources in order to solve challenging control tasks that escape the traditional setting. The starting point for these new developments are specific macroscopic considerations of dynamical systems associated with transfer operators and Koopman operators. After reviewing these operator-theoretic frameworks, we will explore a family of sample-based approaches that emerge out of the macroscopic viewpoint.

These sample-based approaches not only mitigate drawbacks of the original operator-theoretic approaches but also facilitate more direct and efficient data-integrated paths for elucidating important features of dynamical systems with applications to control and estimation. Moreover, connections with established methods from Reinforcement Learning will be integrated into the course material.

Credit 3 units.

Typical periods offered: Spring

ESE 5620 Analog Integrated Circuits

This course focuses on fundamental and advanced topics in analog and mixed-signal VLSI techniques. The first part of the course covers graduate level materials in the area of analog circuit synthesis and analysis. The second part of the course covers applications of the fundamental techniques for designing analog signal processors and data converters. Several practical aspects of mixed-signal design, simulation and testing are covered in this course. This is a project-oriented course and it is expected that the students apply the concepts learned in the course to design, simulate and explore different circuit topologies.

Credit 3 units.

Typical periods offered: Fall

ESE 5660 Modern System-On-Chip Design

The System-on-Chip (SoC) technology is at the core of most electronic systems: smartphones, wearable devices, autonomous robots and cars, and aerospace and medical electronics. In these SoCs, billions of transistors can be integrated on a single silicon chip containing various components, such as microprocessors, DSPs, hardware accelerators, memories, and I/O interfaces. Topics include SoC architectures, design tools, and methods as well as system-level trade-offs between performance, power consumption, energy efficiency, reliability, and programmability. Students will gain an insight into the early stages of the SoC design process by performing the tasks of developing functional specifications, applying partitions and map functions to hardware and/or software, and then evaluating and validating system performance. Assignments include hands-on design projects. This course is open to both graduate and senior undergraduate students.

Credit 3 units.

Typical periods offered: Fall, Spring

ESE 5700 Coding Theory

Introduction to the algebra of finite fields. Linear block-codes, cyclic codes, BCH and related codes for error detection and correction. Encoder and decoder circuits and algorithms. Spectral descriptions of codes and decoding algorithms. Code performances.

Credit 3 units.

ESE 5820 Fundamentals and Applications of Modern Optical Imaging

Analysis, design, and application of modern optical imaging systems with emphasis on biological imaging. First part of course will focus on the physical principles underlying the operation of imaging systems and their mathematical models. Topics include ray optics (speed of light, refractive index, laws of reflection and refraction, plane surfaces, mirrors, lenses, aberrations), wave optics (amplitude and intensity, frequency and wavelength, superposition and interference, interferometry), Fourier optics (space-invariant linear systems, Huygens-Fresnel principle, angular spectrum, Fresnel diffraction, Fraunhofer diffraction, frequency analysis of imaging systems), and light-matter interaction (absorption, scattering, dispersion, fluorescence). Second part of course will compare modern quantitative imaging technologies including, but not limited to, digital holography, computational imaging, and super-resolution microscopy. Students will evaluate and critique recent optical imaging literature.

Credit 3 units.

Typical periods offered: Spring

ESE 5830 Nonlinear Optical Microscopy

This course will cover the theoretical and practical knowledge needed to design, construct, and use a nonlinear optical microscope. The course will focus on the relevant optical physics and instrumentation for different types of nonlinear optical microscopy, and additionally provide some information on applications and image processing. Topics include: ultrafast lasers, detectors, nonlinear susceptibility, nonlinear wave equation, quantum theory of nonlinear optics, harmonic generation, multiphoton fluorescence, fluorescence lifetime, optical metabolic imaging, coherent Raman scattering, and multimodal nonlinear optical microscopy.

Credit 3 units.

Typical periods offered: Fall

ESE 5860 Tomographic Systems

The study of systems for imaging the interior of an object from external measurements. Mathematical preliminaries: multidimensional linear-systems, the Poisson process, maximum-likelihood estimation. Transmission, emission, reflection, and magnetic-resonance tomography. Line integral, strip integral, weighted-integral, and divergent-ray descriptions of tomographic data. The Radon transform. Reconstruction from ideal data: filtered back-project, back-project filter, Fourier, and inverse Radon-transform methods. Reconstruction from ideal data: filtered back-project, back-project filter, Fourier, and inverse Radon-transform methods. Reconstruction from blurred and noisy data: confidence-weighting, minimum-divergence deblurring, and estimation-based methods. Techniques for treatment of mission data, attenuation, and accidentals. Application to positron-emission, single-photon emission, x-ray, and magnetic-resonance tomography and to high resolution radar-imaging. Computer architectures for producing tomographic imagery.

Credit 3 units.

Typical periods offered: Fall

ESE 5890 Biological Imaging Technology

This class will develop a fundamental understanding of the physics and mathematical methods that underlie biological imaging and critically examine case studies of seminal biological imaging technology literature. The physics section will examine how electromagnetic and acoustic waves interact with tissues and cells, how waves can be used to image the biological structure and function, image formation methods and diffraction limited imaging. The math section will examine image decomposition using basis functions (e.g. Fourier transforms), synthesis of measurement data, image analysis for feature extraction, reduction of multi-dimensional imaging datasets, multivariate regression, and statistical image analysis. Original literature on electron, confocal and two photon microscopy, ultrasound, computed tomography, functional and structural magnetic resonance imaging and other emerging imaging technology will be critiqued.

Credit 3 units.

Typical periods offered: Spring

ESE 5932 Computational Methods for Imaging Science

Inverse problems are ubiquitous in science and engineering, and they form the basis for modern imaging methods. This course will introduce students to the mathematical formulation of inverse problems and modern computational methods employed to solve them. Specific topics covered will include regularization theory, compressive sampling, variational calculus, and a survey of relevant numerical optimization methods. The application of these methods to tomographic imaging problems will be addressed in detail.

Credit 3 units.

Typical periods offered: Spring

ESE 5933 Theoretical Imaging Science

Imaging science encompasses the design and optimization of imaging systems to quantitatively measure information of interest. Imaging systems are important in many scientific and medical applications and may be designed for one specific application or for a range of applications. Performance is quantified for any given task through an understanding of the statistical model for the imaging data, the data processing algorithm used, and a measure of accuracy or error. Optimal processing is based on statistical decision theory and estimation theory; performance bounds include the receiver operating characteristic and Cramer-Rao bounds. Bayesian methods often lead to ideal observers. Extensions of methods from finite-dimensional spaces to function space are fundamental for many imaging applications. A variety of methods to assess image quality and resulting imaging system optimization are covered.

Credit 3 units.

Typical periods offered: Fall

ESE 5970 Practicum in Imaging Science

Students develop research results in computational imaging and write a conference paper on the results. This course involves the process of research project design and implementation in imaging science, participation in research teams, the development of milestones for a project, and the process of meeting expectations. The role of machine learning, computational methods, theoretical methods, datasets, and experiments in imaging science research are covered.

Credit 3 units.

Typical periods offered: Spring

ESE 5971 Practicum in Data Analytics & Statistics

In this course, students will learn through hands-on experience the application of analytics to support data-driven decisions. Through lectures and the execution of a project (to be defined at the beginning of the semester), students will learn to use descriptive, predictive, and prescriptive analytics. Lectures will focus on presenting analytic topics relevant to the execution of the project, including analytic model development, data quality and data models, review of machine learning algorithms (unsupervised, supervised, and semi-supervised approaches), model validation, insights generation and results communication, and code review and code repository. Students are expected to demonstrate the application of these concepts through the execution of a one-semester project. Students can propose their own projects or choose from a list of projects made available by the lecturer. Projects should reflect real-world problems with a clear value proposition. Progress will be evaluated and graded periodically during the semester, and the course will include a final presentation open to the academic community.

Credit 3 units.

Typical periods offered: Fall, Spring

ESE 5972 Practicum in Imaging Science and Engineering

This course provides students in the Imaging Science and Engineering program with opportunities to participate, early in their graduate studies, in projects involving image data. A list of IS&E faculty having potential projects of interest is provided. It is the student's responsibility to interview with such faculty in order to identify a project for themselves to be completed in one semester. A written report documenting the project goals, relevant literature, and results obtained is required at the end of the project. To receive credit for completing the practicum, the report must be accepted by the supervisor of the project and a committee of IS&E faculty. This course is graded Pass/Fail.

Credit 1 unit.

Typical periods offered: Fall, Spring

ESE 5980 Electrical & Systems Engineering Graduate Seminar

This pass/no pass course is required for the master's, DSc, and PhD degrees in Electrical & Systems Engineering. A satisfactory grade is required for each semester of enrollment, and this is achieved by student attendance at regularly scheduled seminars. Master's students must attend at least three seminars per semester, except for first-year master's students, who must attend four. DSc and PhD students must attend at least five seminars per semester, except for first-year PhD students who must attend six. Part-time students are exempt except during their year of residency. Any student under continuing status is also exempt.

Credit 0 units.

Typical periods offered: Fall, Spring

ESE 5981 Seminar in Imaging Science and Engineering

This seminar course consists of a series of tutorial lectures on Imaging Science and Engineering with emphasis on applications of imaging technology. Students are exposed to a variety of imaging applications that vary depending on the semester, but may include multispectral remote sensing, astronomical imaging, microscopic imaging, ultrasound imaging, and tomographic imaging. Guest lecturers come from several parts of the university. This course is required of all students in the Imaging Science and Engineering program; the only requirement is attendance. This course is graded Pass/Fail.

Credit 1 unit.

Typical periods offered: Fall

ESE 5999 Independent Study

Opportunities to acquire experience outside the classroom setting and to work closely with individual members of the faculty. A final report must be submitted to the department. Students must have the ESE Research/Independent Study Registration Form approved by the department.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ESE 7970 Masters Project

Students electing the project option for their master's degree perform their project work under this course. Consult the Masters student handbook for the requirements to successfully complete this degree option. Students must complete the ESE Project Registration Form to enroll in this course. The form requires an abstract of the work expected.

Credit 1-3 units.

Typical periods offered: Fall, Spring

ESE 7998 Masters Research

Students electing the thesis option for their master's degree perform their research under this course. Consult the Masters student handbook for the requirements to successfully complete this degree option. Students must complete the ESE Thesis Registration Form to enroll in this course. The form requires an abstract of the work expected.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ESE 8991 Research Rotation for ESE Doctoral Students

Doctoral students in Electrical and Systems Engineering are required to complete two rotations during their first year and may complete three rotations, with research mentors acceptable to the department. The rotations must be mutually agreeable to both the student and the faculty member. The grade will be assigned based on a written report from one of the rotations. The rotations allow students to sample different research projects and laboratory working environments and to enable the matching of doctoral students with the research mentors with whom they will carry out PhD dissertation research.

Credit 3 units.

Typical periods offered: Fall, Spring

ESE 8992 Introduction to the Research Process

Incoming doctoral students are introduced to the research process through a combination of training in research laboratories and professional training in classroom settings. Research laboratory training comprises the majority of the effort and is under the guidance of a faculty mentor. Students learn the methodologies, research processes, and expectations within laboratories. Professional training comprises a series of structured meetings addressing the doctoral process, goal setting, research methods, ethical conduct of research, and communication of technical ideas. The grade will be assigned based on attendance, an oral presentation on the student's research, a written research report approved by the faculty mentor, and submission of an Individual Development Plan (IDP). The course is intended to support early research engagement, establish common expectations across the program, and foster a sense of community among doctoral students. Doctoral students in Electrical & Systems Engineering and Imaging Science are required to enroll in this course during their first semester.

Credit 3 units.

Typical periods offered: Fall

ESE 8998 Doctoral Research

This course is designed for doctoral candidates to conduct advanced, original research in their field of study, leading to the completion of their dissertation. Students will engage in in-depth literature reviews, formulate research questions, develop and implement research methodologies, collect and analyze data, and write their dissertation under the guidance of their faculty advisor and dissertation committee. The course emphasizes critical thinking, scholarly integrity, and the advancement of knowledge. Regular meetings with the advisor and periodic progress reports are required. Successful completion is necessary for the awarding of the doctoral degree.

Credit 9 units.

Typical periods offered: Fall, Spring

Electrical Engineering, PhD (ESE)

Students pursuing the Doctor of Philosophy (PhD) degree in Electrical Engineering or Systems Science & Mathematics must complete a minimum of 72 units of post-baccalaureate study consistent with the residency and other applicable requirements of the McKelvey School of Engineering. These 72 units must consist of at least 36

units of coursework and at least 24 units of research, and they may include work done to satisfy the requirements of a master's degree in a related discipline. Up to 24 units for the PhD may be transferred to Washington University in St. Louis from another institution.

Below is a list of the steps needed to complete the requirements for a doctoral degree in the Department of Electrical & Systems Engineering. Each candidate for the degree must do the following:

- Complete at least 36 units of post-baccalaureate course work. Students are required to take at least five courses from the Electrical & Systems Engineering department with a course number of 4000 or higher.
- Complete the qualifying process (which includes a qualifying examination) and match with a research mentor before the second academic year of the program (PhD).
- Pass an oral preliminary research examination, to be completed within two academic years of completing the qualifying process.
- Satisfy the general residency requirement for the McKelvey School of Engineering.
- Satisfy the general teaching requirement as specified by the department.
- Write a doctoral dissertation that describes the results of original and creative research in a specialization within electrical engineering or systems science and mathematics.
- Pass a final oral examination in defense of the dissertation research.
- Take ESE 5980 Electrical & Systems Engineering Graduate Seminar each semester.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

Electrical & Systems Engineering (ESE) comprises a wide range of intellectual topics ranging from quantum and device physics to systems modeling and analysis. Courses in electrical and systems engineering cover this range of topics. The students in the PhD programs in electrical engineering and systems science and mathematics may pursue teaching opportunities in any subarea. By participating in

teaching underlying principles or system integration, the students must learn the related material in more depth than previously required. The process of communicating these ideas to others is a fundamental skill in any professional setting.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Preparatory Engagement experiences are required:

- McKelvey MTE Preparatory Trainings

Note: Students whose native language is not English must take an English communication assessment from the Engineering Communication Center and complete any recommended additional training.

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

ESE requires two AI assignments for a total of 10 MER units. Students work with their graduate supervisors on the timing and content of those assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement

EGS 8010	Take two times
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Systems Science & Mathematics, PhD (ESE)

Students pursuing the Doctor of Philosophy (PhD) degree in Electrical Engineering or Systems Science & Mathematics must complete a minimum of 72 units of post-baccalaureate study consistent with the residency and other applicable requirements of the McKelvey School of Engineering. These 72 units must consist of at least 36 units of course work and at least 24 units of research, and they may include work done to satisfy the requirements of a master's degree in a related discipline. Up to 24 units for the PhD may be transferred to Washington University in St. Louis from another institution.

Below is a list of the steps needed to complete the requirements for a doctoral degree in the Department of Electrical & Systems Engineering. Each candidate for the degree must do the following:

- Complete at least 36 units of post-baccalaureate course work. Students are required to take at least five courses from the Electrical & Systems Engineering department with a course number of 4000 or higher.
- Complete the qualifying process (which includes a qualifying examination) and match with a research mentor before the second academic year of the program.
- Pass an oral preliminary research examination, to be completed within two academic years of completing the qualifying process.
- Satisfy the general residency requirement for the McKelvey School of Engineering.
- Satisfy the general teaching requirement as specified by the department.
- Write a doctoral dissertation that describes the results of original and creative research in a specialization within electrical engineering or systems science and mathematics.
- Pass a final oral examination in defense of the dissertation research.
- Take ESE 5980 Electrical & Systems Engineering Graduate Seminar each semester.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

Electrical & Systems Engineering (ESE) comprises a wide range of intellectual topics ranging from quantum and device physics to systems modeling and analysis. Courses in electrical and systems engineering cover this range of topics. The students in the PhD programs in electrical engineering and systems science and mathematics may pursue teaching opportunities in any subarea. By participating in teaching underlying principles or system integration, the students must learn the related material in more depth than previously required. The process of communicating these ideas to others is a fundamental skill in any professional setting.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Preparatory Engagement experiences are required:

- McKelvey MTE Preparatory Trainings

Note: Students whose native language is not English must take an English communication assessment from the Engineering Communication Center and complete any recommended additional training.

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

ESE requires two AI assignments for a total of 10 MER units. Students work with their graduate supervisors on the timing and content of those assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement

EGS 8010

Take two times

Electrical Engineering, MSEE (ESE)

Either a thesis option or a course option may be selected. The special requirements for these options are as follows:

Course Option

The Master of Science in Electrical Engineering is an academic master's degree designed mainly for both full-time and part-time students interested in proceeding to the departmental full-time doctoral program and/or an industrial career. Under the course option, students may not take ESE 7998 Masters Research or ESE 7970 Masters Project. With faculty permission, they may take up to 3 units of graduate-level independent study (ESE 5999 Independent Study).

Thesis or Project Option

These options are intended for ESE students engaged in research projects. Candidates for this degree must complete a minimum of 24 units of course instruction and 6 units of ESE 7998 Masters Research or ESE 7970 Masters Project; up to 3 thesis or project units may be applied toward the 15 core electrical engineering units required for the MSEE program. Up to 6 thesis or project units may be applied as electives for the MSEE, MSSSM, and MSDAS programs. Students can take at most 3 thesis or project units in a semester. For the thesis, the student must write a master's thesis and defend it in an oral examination. For the project, the students must complete a paper documenting their work and either present their work orally or at a departmental or school wide poster session.

Degree Requirements

Students pursuing the degree Master of Science in Electrical Engineering (MSEE) must complete a minimum of 30 units of study consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering and subject to the following departmental requirements:



- At least 15 units must be taken from the following set of courses:

Code	Title	Units
ESE 4150	Optimization	3
ESE 5100-5199	Optimization category	
ESE 5200-5290	Applied probability category	
ESE 5300-5390	Applied physics and electronics category	
ESE 5400-5490	Control category	
ESE 5500-5599	Systems category	
ESE 5600-5690	Computer engineering category	
ESE 5700-5790	Communications category	
ESE 5800-5890, ESE 5910-5980, ESE 5931-5933	Signal and image processing category	
ESE 7998 or ESE 7970	Masters Research or Masters Project	1-3
BME 5700	Mathematics of Imaging Science	3
CSE 5600	Computer Systems Architecture I	3

- A maximum of 6 credits may be transferred from another institution and applied toward the master's degree. Regardless of the subject or level, all transfer courses are treated as electives and do not count toward the core requirements for the degree.
- All full-time graduate students are required to take ESE 5980 Electrical & Systems Engineering Graduate Seminar each semester. This course is taken with the Pass/No Pass grade option.
- The degree program must be consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering.
- Students must obtain a cumulative grade-point average of at least 3.0 out of a possible 4.0 overall for courses applied toward the degree. Courses that apply for the degree must be taken with the credit/letter grade option.

Degree Electives

- Any course numbered 4001 or greater in the Engineering (with the prefix of BME, CSE, EECE, ESE, or MEMS), Physics, Mathematics, or Statistics and Data Science department, excluding the exceptions listed below, are approved by the department as electives.
- Students may take either ESE 4170 Introduction to Machine Learning and Pattern Classification or CSE 4107 Introduction to Machine Learning, but they may not use both as electives for the degree.
- For students who have already taken ENGR 3180 Engineering Mathematics A, ESE 3180, ENGR 3190 Engineering Mathematics B, ESE 3190, and ESE 5010 Mathematics of Modern Engineering I may not be used as electives for graduate credit.
- Undergraduate lab course, research, independent study, senior design or capstone course are not approved as electives. Requests for an exception to this policy may be submitted to the graduate program coordinator with the approval of the student's academic advisor.

Systems Science & Mathematics, MSSSM (ESE)

Either a thesis option or a course option may be selected. The special requirements for these options are as follows:

Course Option

The Master of Science in Systems Science & Mathematics (MSSSM) is an academic master's degree that requires the completion of 30 credit units. It is designed for both full-time and part-time students interested in proceeding to the departmental full-time doctoral program and/or an industrial career. Under the course option, students may not take ESE 7998 Masters Research or ESE 7970 Masters Project. With faculty permission, they may take up to 3 units of graduate-level independent study (ESE 5999 Independent Study).

Thesis or Project Option

These options are intended for ESE students engaged in research projects. Candidates for this degree must complete a minimum of 24 units of course instruction and 6 units of ESE 7998 Masters Research or ESE 7970 Masters Project; up to 3 thesis or project units may be applied toward the 15 core electrical engineering units required for the MSEE program. Up to 6 thesis or project units may be applied as electives for the MSEE, MSSSM, and MSDAS programs. Students can take at most 3 thesis or project units in a semester. For the thesis, the student must write a master's thesis and defend it in an oral examination. For the project, the students must complete a paper documenting their work and either present their work orally or at a departmental or school wide poster session.

Degree Requirements

- Required courses (15 units) for the MS degree include the following:

Code	Title	Units
ESE 4150	Optimization	3
or ESE 5130	Large-Scale Optimization for Data Science	
ESE 5200	Probability and Stochastic Processes	3
ESE 5240	Detection and Estimation Theory	3
or ESE 5440	Optimization and Optimal Control	
or ESE 5450	Stochastic Control	
ESE 5510	Linear Dynamic Systems I	3
ESE 5530	Nonlinear Dynamic Systems	3
Total Units		15

- A maximum of 6 credits may be transferred from another institution and applied toward the master's degree. Regardless of the subject or level, all transfer courses are treated as electives and do not count toward the core requirements for the degree.
- All full-time graduate students are required to take ESE 5980 Electrical & Systems Engineering Graduate Seminar each semester. This course is taken with the Pass/No Pass grade option.
- The degree program must be consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering.
- Students must obtain a cumulative grade-point average of at least 3.0 out of a possible 4.0 overall for courses applied toward the degree. Courses that apply for the degree must be taken with the credit/letter grade option.

Degree Electives

- Any course numbered 4001 or greater in the Engineering (with the prefix of BME, CSE, EECE, ESE, or MEMS), Physics or Mathematics department, excluding the exceptions listed below, are approved by the department as electives.
- Students may take either ESE 4170 Introduction to Machine Learning and Pattern Classification or CSE 4107 Introduction to Machine Learning, but they may not use both as electives for the degree.
- For students who have already taken ENGR 3180 Engineering Mathematics A, ESE 3180, ENGR 3190 Engineering Mathematics B, ESE 3190, and ESE 5010 Mathematics of Modern Engineering I may not be used as an elective for graduate credit.
- Undergraduate lab courses, research, independent study, senior design, and capstone courses are not approved as electives. Requests for an exception to this policy may be submitted to the graduate program coordinator with the approval of the student's academic advisor.

Engineering Data Analytics & Statistics, MSDAS (ESE)

Either a thesis option or a course option may be selected. The special requirements for these options are as follows:

Course Option

The Master of Science in Engineering Data Analytics and Statistics is an academic master's degree designed mainly for both full-time and part-time students interested in proceeding to the departmental full-time doctoral program and/or an industrial career. Under the course option, students may not take ESE 7998 Masters Research or ESE 7970 Masters Project. With faculty permission, they may take up to 3 units of graduate-level independent study (ESE 5999 Independent Study).

Thesis or Project Option

These options are intended for ESE students engaged in research projects. Candidates for this degree must complete a minimum of 24 units of course instruction and 6 units of ESE 7998 Masters Research or ESE 7970 Masters Project; up to 3 thesis or project units may be applied toward the 15 core electrical engineering units required for the MSEE program. Up to 6 thesis or project units may be applied as electives for the MSEE, MSSSM, and MSDAS programs. Students can take at most 3 thesis or project units in a semester. For the thesis, the student must write a master's thesis and defend it in an oral examination. For the project, the students must complete a paper documenting their work and either present their work orally or at a departmental or school wide poster session.

Degree Requirements

Students pursuing the degree Master of Science in Data Analytics & Statistics (MSDAS) must complete a minimum of 30 units of study consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering and subject to the following departmental requirements:

- Required courses (15 units) for the MSDAS degree include the following:

Code	Title	Units
ESE 4170	Introduction to Machine Learning and Pattern Classification	3
or CSE 4107	Introduction to Machine Learning	
or CSE 5107	Machine Learning	
ESE 4150	Optimization	3
or ESE 5130	Large-Scale Optimization for Data Science	
ESE 5200	Probability and Stochastic Processes	3
ESE 5240	Detection and Estimation Theory	3
ESE 5971	Practicum in Data Analytics & Statistics	3
Total Units		15

- A maximum of 6 credits may be transferred from another institution and applied toward the master's degree. Regardless of the subject or level, all transfer courses are treated as electives and do not count toward the core requirements for the degree.



- All full-time graduate students are required to take ESE 5980 Electrical & Systems Engineering Graduate Seminar . This course is taken with the Pass/No Pass grade option.
- The degree program must be consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering.
- Students must obtain a cumulative grade-point average of at least 3.0 out of a possible 4.0 overall for courses applied toward the degree. Courses that apply for the degree must be taken with the credit/letter grade option.

Degree Electives

Code	Title	Units
Required Electives		6
CSE 4102	Introduction to Artificial Intelligence	3
CSE 4207	Cloud Computing With Big Data Applications	3
CSE 5104	Data Mining	3
CSE 5105	Bayesian Methods in Machine Learning	3
CSE 5107	Machine Learning *	3
ESE 4261	Statistical Methods for Data Analysis With Applications to Financial Engineering	3
ESE 4270	Financial Mathematics	3
ESE 5130	Large-Scale Optimization for Data Science *	3
ESE 5230	Information Theory	3
ESE 5510	Linear Dynamic Systems I	3
SDS 4020	Mathematical Statistics	3
or SDS 5020	Mathematical Statistics	
SDS 4130	Linear Statistical Models	3
or SDS 5130	Linear Statistical Models	
SDS 4155	Time Series Analysis	3
or SDS 5155	Time Series Analysis	
SDS 4210	Statistical Computation	3
or SDS 5210	Statistical Computation	
SDS 4310	Bayesian Statistics	3
or SDS 5310	Bayesian Statistics	

* This course can be taken as an elective if it is not taken to satisfy a requirement.

Free Electives (up to 6 units)

- Any course numbered 4001 or higher in the Engineering (with the prefix of BME, CSE, EECE, ESE, or MEMS), Physics, Mathematics, or Statistics and Data Science department, as electives. In addition, Finance courses FIN 5017 Quantitative Risk Management, FIN 5506 Fintech: Methods and Practice, and FIN 5370 Advanced Derivative Securities may be used as free electives.
- Students may take either ESE 4170 Introduction to Machine Learning and Pattern Classification or CSE 4107 Introduction to Machine Learning, but they may not use both as electives for the degree.
- For students who have already taken ENGR 3180 Engineering Mathematics A, ESE 3180, ENGR 3190 Engineering Mathematics B, ESE 3190, and ESE 5010 Mathematics of Modern Engineering I may not be used as electives for graduate credit.
- Undergraduate lab courses, research, independent study, senior design, and capstone courses are not approved as electives. Requests for an exception to this policy may be submitted to the graduate program coordinator with the approval of the student's academic advisor.

Computer Engineering, MS (ESE)

The Master of Science (MS) in Computer Engineering is best suited for students who are looking to focus on computer engineering (hardware) aspects. The MS in Computer Engineering program can be a pure course option program, or it can incorporate either a project or a thesis. If appropriate research experiences are included in the degree option, this can also lead toward future doctoral studies. All students in the MS in Computer Engineering program must have previously completed (as documented by their undergraduate transcript), successfully test to place out of, or complete at the start of their program the following courses: CSE 1301 Introduction to Computer Science and CSE 2600 Introduction to Digital Logic and Computer Design (or equivalent courses offered at other institutions).

The Master of Science in Computer Engineering degree is jointly administered by the Department of Computer Science and Engineering and the Department of Electrical and Systems Engineering.

Course Option

This option requires 30 units of graduate credit. Students must also follow the general degree requirements listed below.

Thesis/Project Option

Beginning in fall 2025, students seeking to take the project or thesis option in our degree programs will register for CSE 7998 Master's Capstone. CSE 7998 Master's Capstone does not count toward the student's 30 required units of coursework to complete the degree until the student has successfully defended the project or thesis. Students must also follow the general degree requirements listed below.

- Upon successful defense of a 3-unit master's project, 3 units of CSE 7998 Master's Capstone will count toward the student's degree as a 5000-level CSE departmental course.
- Upon successful defense of a 6-unit master's project, 6 units of CSE 7998 Master's Capstone will count toward the student's coursework at the 5000 level.
- Upon successful defense of a master's thesis, 6 units of CSE 7998 Master's Capstone will count toward the student's coursework at the 5000 level.

A student who successfully defends one of the three options listed above will have a notation added to their transcript to clearly indicate exactly which option (3-unit master's project, 6-unit master's project, master's thesis) was completed. Each semester, CSE 7998 Master's Capstone will be graded with a letter grade. A grade of a C– or above is required in the first semester of a 6-unit project or thesis to continue the work in the final semester. As a master's project or thesis is considered to have unique content each semester, CSE 7998 Master's Capstone is not a retakeable course, and a grade from a previous semester cannot be replaced. Students must also follow the general degree requirements listed below. Students should refer to the department's Master's Program Handbook for additional details and guidance regarding projects and theses.

The Progress Report (two-semester theses and projects only)

Near the end of the first semester of a two-semester thesis or project, the student will submit a written progress report to the committee. The progress report will be used by the committee to evaluate student progress and to provide an opportunity to give feedback to the student.

Preparing and Submitting the Progress Report

- The progress report should include the following:
 - A copy of the original scope and duration of the work to be performed (this can be obtained from the original proposal form). Students can contact the Graduate Coordinator to receive a copy of their original proposal form.
 - A discussion of any major modifications/changes to the scope of the work to be performed

- An overview of the work that has been completed during the first semester of the thesis or project
- A discussion of the work yet to be completed and a timeline for completion
- The progress report should be submitted via email to all members of the committee at least one week prior to the last official day of classes for the given semester.

Outcomes

- Once submitted, the committee will confer privately to discuss the student's progress made during the first semester of the thesis or project. The committee will decide on one of three possible outcomes:
 1. *Thesis or project should continue without concern*, indicating that the student is making consistent progress and is on track to successfully complete the thesis or project on time.
 2. *Thesis or project should continue with concern*, indicating that the student is making some progress but is falling behind. Without change, the student is not likely to successfully complete the thesis or project.
 3. *Thesis or project should not continue*, indicating that the student is not making sufficient progress and the thesis or project should be terminated.
- The outcome determined by the committee will be communicated to the student by the department's Graduate Coordinator prior to the official end of the semester. If the outcome is that the thesis or project should not continue, the student will not be enrolled in the second semester's units.

Process for Termination of a Project or Thesis

From Fall 2024 onward, master's project/thesis students will not be allowed to have an N grade submitted for a terminated project. Students should contact the Graduate Coordinator as soon as possible regarding any questions about terminating a project/thesis. With that in mind, please review the following scenarios:

- A one-semester project:
 - If the project is terminated before the add/drop deadline, it will have no effect on the student's record.
 - If the project is terminated after the add/drop deadline but before the withdrawal deadline, there will be a W on the student's transcript.
 - If the project is terminated after the withdrawal deadline, this could result in a failing letter grade on the student's transcript.
- A two-semester project or thesis, during the first semester of the project or thesis:
 - The project or thesis would follow the same timeline and have the same results as the one-semester project scenarios above.
- A two-semester project or thesis, where the first semester has already been completed:



- If the second semester of the project or thesis is terminated before the add/drop deadline, the second-semester credits of CSE 7998 Master's Capstone would be dropped.
- If the second semester is terminated after the add/drop deadline but before the withdrawal deadline, the second-semester credits of CSE 7998 Master's Capstone would be noted as a W on the student's transcript.
- If the second semester is terminated after the withdrawal deadline, the termination could result in a failing letter grade on the student's transcript.

For each of the three scenarios listed above, the student, pending advisor approval, would have the option to defend their first semester's work as a 3-credit project. (Any CSE 7998 Master's Capstone units completed without a successful defense will not count toward the student's degree requirements.)

General Degree Requirements

- 18 of the 30 units must be from the designated graduate-level Computer Engineering courses. Please visit our MS in Computer Engineering website for a comprehensive list.
- Up to 12 units may be taken from outside the two departments. In order for out-of-department courses to count toward a student's degree, they must request the course(s) be reviewed and approved by the department by contacting the Graduate Coordinator. The department will review the courses to ensure that they offer suitably technical graduate-level content. Once approved by the department, the out-of-department courses can only count toward the Electives section of the degree. To count more than 6 units from outside the CSE or ESE department, an appropriate justification for the additional increment must be provided by the advisor and student. Program approval will be evaluated with increasing stringency for each additional increment.
- Up to 12 units of 4000-level courses can count for graduate credit.
- None of the 30 units may be taken as independent study (i.e., CSE 4000 Independent Study, CSE 5999 Independent Study, ESE 4999 Independent Study, or ESE 5999 Independent Study).
- CSE courses with an N designation do not count toward the master's degree.
- All 30 units required for the degree must be taken for a grade (i.e., not Pass/No Pass), and the grade received in each course must be C– or better.
- Per McKelvey School of Engineering guidelines, students must maintain a grade point average of at least 2.70.

Robotics and Intelligent Systems, MEng

Either a thesis option or a course option may be selected. The special requirements for these options are as follows:

Course Option

The Master of Engineering in Robotics (MEngR) is an academic master's degree designed mainly for both full-time and part-time students interested in proceeding to the departmental full-time doctoral program and/or an industrial career. Under the course option, students may not take ESE 7998 Masters Research. With faculty permission, they may take up to 3 units of graduate-level independent study.

Thesis or Project Option

This option is intended for those pursuing full-time study and engaged in research projects. Candidates for this degree must complete a minimum of 24 credit units of course instruction and 6 credit units of ESE 7998 Masters Research or ESE 7970 Masters Project; up to 3 thesis or project units may be applied toward the 15 core electrical engineering units required for the MSEE program. Any of these 6 units of thesis or project research may be applied as electives for the MSEE, MSSSM, MSDAS, MCEng, and MEngR programs. Students can take at most 3 thesis or project units in a semester. For the thesis, the student must write a master's thesis and defend it in an oral examination. For the project, the students must complete a paper documenting their work and either present their work orally or at a departmental or school wide poster session.

Degree Requirements

The principal goal of the MEngR program is to prepare individuals for professional practice in robotics engineering by leveraging the technical skills developed in an undergraduate engineering or physical science program.

- Required courses (the 12 units listed below as well as 9 more units from three groups) for the MEngR degree include the following:

Required Courses (12 units)

Code	Title	Units
ESE 4170	Introduction to Machine Learning and Pattern Classification	3
or CSE 4107	Introduction to Machine Learning	
or CSE 5107	Machine Learning	
ESE 5510	Linear Dynamic Systems I	3
ESE 4450	Sensing, Planning, and Control in Robotics	3



or MEMS 5206	Modern Robotics: Mechanics, Planning, and Control	
or MEMS 5207	Robot Design	
CSE 5100	Deep Reinforcement Learning	3

- At least one course must be selected from each of the following three groups for a total of 9 units:

AI/ML & Optimization

Code	Title	Units
CSE 4102	Introduction to Artificial Intelligence	3
CSE 5105	Bayesian Methods in Machine Learning	3
CSE 5109	Advanced Machine Learning	3
CSE 5270	Natural Language Processing	3
CSE 5403	Algorithms for Nonlinear Optimization	3
CSE 5509	Computer Vision	3
CSE 5519	Advances in Computer Vision	3
CSE 5610	Large Language Models	3
ESE 4150	Optimization	3

Autonomy & Systems Science

Code	Title	Units
CSE 5106	Multi-Agent Systems	3
CSE 5370	Trustworthy Autonomy	3
ESE 4210	Decision and Estimation Theory for Discrete Stochastic Processes	3
ESE 4460	Robotics: Dynamics and Control	3
ESE 5530	Nonlinear Dynamic Systems	3
ESE 5430	Control Systems Design By State Space Methods	3

Robotics & Control Labs

Code	Title	Units
ESE 4480	Control Systems Design Laboratory	3
ESE 4481	Autonomous Aerial Vehicle Control Laboratory	3

- A maximum of 6 credits may be transferred from another institution and applied toward the master's degree. Regardless of the subject or level, all transfer courses are treated as electives and do not count toward the core requirements for the degree.
- All full-time graduate students are required to take ESE 5980 Electrical & Systems Engineering Graduate Seminar each semester. This course is taken with the Pass/No Pass grade option.
- The degree program must be consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering.

- Students must obtain a cumulative grade-point average of at least 3.0 out of a possible 4.0 overall for courses applied toward the degree. Courses that apply for the degree must be taken with the credit/letter grade option.

Degree Electives

- Any course numbered 4001 or greater in the Engineering (with the prefix of BME, CSE, EECE, ESE, or MEMS), Physics, Mathematics, or Statistics and Data Science department, excluding the exceptions listed below, are approved by the department as electives.
- Students may take either ESE 4170 Introduction to Machine Learning and Pattern Classification or CSE 4107 Introduction to Machine Learning, but they may not use both as electives for the degree.
- For students who have already taken ENGR 3180 Engineering Mathematics A, ESE 3180, ENGR 3190 Engineering Mathematics B, ESE 3190, and ESE 5010 Mathematics of Modern Engineering I may not be used as electives for graduate credit.
- The degree must include at least 15 units of 5000-level courses.
- Undergraduate lab courses, research, independent study, senior design, and capstone courses are not approved as electives. Requests for an exception to this policy may be submitted to the graduate program coordinator with the approval of the student's academic advisor.

Controls Certificate (ESE)

Requirements

The requirements for the Certificate in Controls include the following:

- Acceptance to the program
- Enrollment in a graduate program in a participating department
- Completion of at least four courses (12 units) with a minimum GPA of 3.0 out of 4.0 that are approved by the program director and completion of requirements for a graduate degree in a participating department

Courses that apply toward the degree must be taken with the credit/letter grade option. The program must be consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering.

Required Courses

Students must complete all of the following courses:



Code	Title	Units
ESE 5200	Probability and Stochastic Processes	3
ESE 5510	Linear Dynamic Systems I	3
ESE 5530	Nonlinear Dynamic Systems	3
Total Units		9

They must also complete an additional course chosen from the following list:

Code	Title	Units
ESE 4150	Optimization	3
ESE 4250	Random Processes and Kalman Filtering	3
ESE 5430	Control Systems Design By State Space Methods	3
ESE 5470	Robust and Adaptive Control	3

Financial Engineering Certificate (ESE)

The Graduate Certificate in Financial Engineering is offered by the department of Electrical & Systems Engineering with support from the Finance department of Olin School of Business.

The requirements for receiving a certificate are the following:

- Acceptance to the program
- Enrollment in a graduate program in a participating department
- Completion of at least four courses (12 units) with a minimum GPA of 3.0 out of 4.0 that are approved by the program director and completion of requirements for a graduate degree in a participating department
- Courses that apply toward the degree must be taken with the credit/letter grade option. The program must be consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering.

Required Courses

Code	Title	Units
ESE 4261	Statistical Methods for Data Analysis With Applications to Financial Engineering	3
ESE 4270	Financial Mathematics	3
FIN 5017	Quantitative Risk Management *	3
Total Units		9

* FIN 5017 Quantitative Risk Management must be taken after ESE 4270 Financial Mathematics to satisfy the prerequisites of FIN 5017 Quantitative Risk Management.

Program Electives

Students select one course from the following list:

Code	Title	Units
ESE 5130	Large-Scale Optimization for Data Science	3
ESE 5200	Probability and Stochastic Processes	3
FIN 5370	Advanced Derivative Securities	3
FIN 5506	Fintech: Methods and Practice	3

Imaging Science & Engineering Certificate (ESE)

Washington University has been a leader in imaging science research for more than four decades, with many new medical imaging modalities, advanced applications in planetary science, and fundamental theories having been developed here. The Imaging Sciences Pathway in the Division of Biology and Biological Sciences in Arts & Sciences is jointly administered with the McKelvey School of Engineering, with students pursuing degrees in departments across the university. The Imaging Science & Engineering (IS&E) certificate program complements the Imaging Sciences Pathway for students in the departments of Electrical & Systems Engineering, Biomedical Engineering, Computer Science & Engineering, Mechanical Engineering & Materials Science, Chemistry, Physics, and the Division of Biology and Biological Sciences. Each department has its own requirements, but all include the IS&E seminar. The program is flexible, so students are encouraged to appeal to the program director to identify individualized programs.

The IS&E certificate program is built on the strengths of imaging science throughout the university. This multidisciplinary program is constructed to expose students to the breadth of imaging research activities at Washington University. There has been an explosion of both increased bandwidth of existing imaging systems and new sensing modalities. The increase in bandwidth from sensors drives innovations in computing, image reconstruction and image understanding. New sensing modalities present unique opportunities for young researchers to make fundamental contributions.

Medical imaging continues to comprise the largest set of applications at Washington University. The resolution of modern whole-body imaging sensors has revolutionized medicine. The development of new portable imaging modalities broadens the impact by lowering cost. Imaging science includes understanding of the underlying physical, biological and chemical processes that yield signals of interest. Microscopes, visible/infrared cameras, magnetic resonance, X-ray, ultrasound and nuclear sensors provide the data used for imaging or inferring underlying processes. Imaging supports clinical diagnosis, radiation oncology, and molecular and neural imaging.

Imaging supports advances in earth and planetary science, enabling discovery from rovers on Mars, characterizing surface properties from satellites, and inferring internal phenomena in planetary objects. Modern understanding of materials science is driven in part by new imaging methods. New imaging systems for plant science seek better characterization of their biological systems.

Data rates from imaging systems demand efficient processing, manipulation and representation. In modern imaging systems, computing and sensing often must be jointly optimized. Inference is typically based on searching for meaningful patterns in the data, along with the relative contributions of those patterns.

For more information, please refer to the Department of Electrical & Systems Engineering website or contact the department directly.

Entering and Completing the Program

Graduate students in participating departments may apply for admission to the IS&E program. Admission requires graduate standing in a participating department, a demonstrated interest in aspects of imaging, and approval of the program director.

Upon being awarded a graduate degree by their home department and completing certain requirements of the program, students are awarded a certificate indicating their successful participation in the IS&E program in addition to having completion of the certificate program posted on their official transcript. The requirements for receiving a certificate are acceptance into the IS&E program, completion of four imaging courses approved by the program director, completion of the requirements for a graduate degree in the student's home department, and participation in the IS&E seminar required for all students in the IS&E program.

Seminars by faculty in imaging science, others at Washington University, and experts from outside the university convey new developments and directions in the field of imaging science and its applications. These seminars also provide the opportunity for interactions among those involved in the program.

Courses of Instruction

Fundamentals underlying imaging science and engineering and the application of these fundamentals to contemporary problems of importance form the theme of the program. Relevant courses come from across the university. The program is flexible, allowing students — in consultation with their advisors and the program director — to design a program that is best for them. Below are representative courses that students in the program take.

Required Seminar

Code	Title	Units
ESE 5981	Seminar in Imaging Science and Engineering	1

Courses in the Imaging Sciences Pathway in the Division of Biology & Biological Sciences

Code	Title	Units
BBS 5068	Fundamentals of Molecular Cell Biology	4
BBS 5146	Principles and Applications of Biological Imaging	3
BBS 5147	Contrast Agents for Biological Imaging	3
BME 5300	Molecular Cell Biology for Engineers	3

Courses in Electrical & Systems Engineering

Code	Title	Units
ESE 5200	Probability and Stochastic Processes	3
ESE 5240	Detection and Estimation Theory	3
ESE 4380	Applied Optics	3
ESE 5820	Fundamentals and Applications of Modern Optical Imaging	3
ESE 5890	Biological Imaging Technology	3
ESE 5932	Computational Methods for Imaging Science	3
ESE 5933	Theoretical Imaging Science	3
ESE 5970	Practicum in Imaging Science	3
ESE 5981	Seminar in Imaging Science and Engineering	1

Courses in Computer Science & Engineering

Code	Title	Units
CSE 5107	Machine Learning	3
CSE 5406	Computational Geometry	3
CSE 5504	Geometric Computing for Biomedicine	3
CSE 5509	Computer Vision	3
CSE 5515	Computational Photography	3

Courses in Biomedical Imaging

Code	Title	Units
BME 5300	Molecular Cell Biology for Engineers	3
BME 5700	Mathematics of Imaging Science	3
BME 5910	Biomedical Optics I: Principles	3
BME 5920	Biomedical Optics II: Imaging	3
BME 5940	Ultrasound Imaging	3



Courses in Chemistry and Physics

Code	Title	Units
CHEM 5035	Nuclear and Radiochemistry Lab	3
CHEM 5036	Introduction to the Atomic Nucleus	3
CHEM 5061	Magnetic Resonance	3
CHEM 5063	Electron Spin Resonance	3

Quantum Engineering Certificate (ESE)

Degree Requirements

The Certificate in Quantum Engineering requires the student to obtain a graduate degree at Washington University and the completion of the following requirements:

- Acceptance to the program
- Enrollment in a graduate program in a participating department
- Completion of at least four courses (12 units) with a minimum GPA of 3.0 out of 4.0 that are approved by the program director and completion of requirements for a graduate degree in a participating department
- Courses that apply toward the degree must be taken with the credit/letter grade option. The program must be consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering.
- At least two courses must be from the Required Course list.
- At least one of the electives needs to be a 5000-level course.

Required Courses

Code	Title	Units
CSE 4608	Introduction to Quantum Computing	3
ESE 4290	Basic Principles of Quantum Optics and Quantum Information	3
ESE 4301	Quantum Mechanics for Engineers	3
ESE 4310	Introduction to Quantum Electronics	3

Program Electives

Code	Title	Units
CHEM 4010	Physical Chemistry I	3
CHEM 5000	Independent Work	0.5-6
CHEM 5330	Time-Dependent Quantum Mechanics & Spectroscopy	3

ESE 4360	Semiconductor Devices	3
ESE 4390	Introduction to Quantum Communications	3
ESE 5320	Introduction to Nano-Photonic Devices	3
ESE 5820	Fundamentals and Applications of Modern Optical Imaging	3
MATH 5057 or MATH 4570	The Mathematics of Quantum Theory	3

Energy, Environmental & Chemical Engineering

The Department of Energy, Environmental & Chemical Engineering (EECE) provides integrated and multidisciplinary programs of scientific education in cutting-edge areas, including the **PhD in Energy, Environmental & Chemical Engineering**. The research and educational activities of the department are organized into four clusters: aerosol science and engineering; engineered aquatic processes; multiscale and electrochemical engineering; and synthetic biology and bioproduct engineering. These overlapping clusters address education and research in four thematic areas: energy; environmental engineering science; advanced materials; and sustainable technology for public health and international development. In addition to the core faculty in the department, faculty in the schools of Medicine, Arts & Sciences, Business, Law, and Social Work collaborate to provide students with a holistic education and to address topical problems of interest.

Three master's programs are offered through the department:

Master of Science in Energy, Environmental & Chemical Engineering (MS), **Master of Engineering in Energy, Environmental & Chemical Engineering (MEng)**, and **Master of Engineering in Energy, Environmental & Chemical Engineering/Master of Business Administration (MEng/MBA)**. The MS degree is a research-focused master's program for students interested in studying environmental engineering, energy systems and chemical engineering. The MEng degree provides students with critical scientific and engineering skill sets; leadership training for management, economics, and policy decision making; and the opportunity to specialize in one of five pathways. The MEng/MBA is a dual degree between the McKelvey School of Engineering and the Olin Business School that provides engineering and business approaches to issues of sustainability, energy, the environment and corporate social responsibility. Interested students must apply and be accepted to both programs before admission is provided to the MEng/MBA dual-degree program.

The department is a key participant in the university's Center for the Environment, and it supports both the International Center for Energy, Environment and Sustainability (InCEES) and the McDonnell Academy Global Energy and Environment Partnership (MAGEEP). Major externally funded research centers in the department include

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the Consortium for Clean Coal Utilization, the Nano Research Facility (NRF) and Jens Environmental Molecular and Nanoscale Analysis Laboratory (Jens Lab), the Center for Aerosol Science and Engineering (CASE), the Center for Water Innovation (CWI), and the Synthetic biology Manufacturing of Advanced materials Research Center (SMARC).

Phone: 314-935-5548
Website: <https://eece.wustl.edu/academics/graduate-programs/index.html>

Faculty

Department Chair and Professor

Joshua Yuan

Lucy & Stanley Lopata Professor
PhD, University of Tennessee
Design-based engineering to address challenges in energy, the environment and health

Endowed Professors

Richard L. Axelbaum

The Stifel & Quinette Jens Professor of Environmental Engineering Science
PhD, University of California, Davis
Combustion, advanced energy systems, clean coal, aerosols, nanoparticle synthesis, rechargeable battery materials, thermal science

Rajan Chakrabarty

Harold D. Jolley Professor of Engineering
PhD, University of Nevada, Reno
Characterizing the radiative properties of carbonaceous aerosols in the atmosphere, researching gas-phase aggregation of aerosols in cluster-dense conditions

Daniel E. Giammar

Walter E. Browne Professor of Environmental Engineering
Director, Center for the Environment
PhD, California Institute of Technology
Aquatic chemistry, environmental engineering, water quality, water treatment

Zhen (Jason) He

Laura and William Jens Professor of Energy, Environmental & Chemical Engineering
Associate Chair of Graduate Studies
PhD, Washington University
Environmental biotechnology, bioenergy production, biological wastewater treatment, resource recovery, bioelectrochemical systems, sustainable desalination technology, anaerobic digestion, forward osmosis, membrane bioreactors

Feng Jiao

Lauren and Lee Fixel Distinguished Professor
PhD, University of St. Andrews
Electrocatalysis, carbon dioxide utilization, electrochemical devices, energy storage

Young-Shin Jun

Anna McKelvey Professor
PhD, Harvard University
Aquatic processes, molecular issues in chemical kinetics, environmental chemistry, surface/physical chemistry, environmental engineering, biogeochemistry, nanotechnology

Randall Martin

Raymond R. Tucker Distinguished Professor
PhD, Harvard University
Characterizing atmospheric composition to inform effective policies surrounding major environmental and public health challenges ranging from air quality to climate change

Vijay Ramani

Senior Vice Provost for Graduate Education and International Affairs
Roma B. and Raymond H. Wittcoff Distinguished University Professor
PhD, University of Connecticut
Electrochemical engineering, energy conversion

Jay Turner

Head of the Division of Engineering Education
Vice Dean for Education
James McKelvey Professor of Engineering Education
DSc, Washington University
Air quality planning and management, aerosol science and engineering, green engineering

Fuzhong Zhang

Francis F. Ahmann Professor
PhD, University of Toronto
Metabolic engineering, protein engineering, synthetic and chemical biology

Professors

Marcus Foston

PhD, Georgia Institute of Technology
Utilization of biomass resources for fuel and chemical production, renewable synthetic polymers, development of advanced aerosol instruments

Xinhua Liang

PhD, University of Colorado Boulder
Gas-phase synthesis, surface science and catalysis, nanostructured films and devices, energy and environmental applications

Yinjie Tang

PhD, University of Washington
Metabolic modeling, fermentation engineering, algal bioprocesses

**Jian Wang**

Director of the Center for Aerosol Science and Engineering (CASE)
PhD, California Institute of Technology
Aerosol properties and processes, nucleation and new particle formation, aerosols in the marine environment, effects of aerosols on cloud microphysical properties and macrophysical structure

Gang Wu

PhD, Harbin Institute of Technology
Advanced materials, catalysis, electrochemical engineering, sustainability

Associate Professors

Peng Bai

PhD, Tsinghua University, China
Develop next-generation batteries; probe the in situ electrochemical dynamics of miniature electrodes down to nanoscales; capture the heterogeneous and stochastic nature of advanced electrodes; identify the theoretical pathways and boundaries for the rational design of materials, electrodes, and batteries through physics-based mathematical modeling and simulation

Kimberly M. Parker

PhD, Stanford University
Investigation of environmental organic chemistry in natural and engineered systems

Elijah Thimsen

PhD, Washington University in St. Louis
Gas-phase synthesis of inorganic nanomaterials for energy applications, novel plasma synthesis approaches

Assistant Professors

Christopher Cooper

PhD, Stanford University
Responsive, soft materials for applications in energy storage, environmental sustainability and human health

Jenna Ditto

PhD, Yale University
Chemical composition of indoor and outdoor air, indoor air chemistry, health impacts of air pollution exposure

Fangqiong Ling

PhD, University of Illinois at Urbana-Champaign
Microbial ecosystem analysis and modelling, process modelling, machine learning, NextGen sequencing bioinformatics, environmental microbiology, bioreactor design

Lu Xu

PhD, Georgia Institute of Technology
Air quality, climate change, atmospheric chemistry

Research Associate Professor & Senior Lecturer

Benjamin Kumfer

DSc, Washington University
Advanced coal technologies, biomass combustion, aerosol processes and health effects of combustion-generated particles

Research Assistant Professor

Chi Li

PhD, Dalhousie University
Air quality, environmental health, atmospheric chemistry, remote sensing, machine learning

Teaching Professor

Janie Brennan

Associate Chair of Undergraduate Studies
PhD, Purdue University
Chemical engineering education, biomaterials

Senior Lecturers

Trent Silbaugh

PhD, University of Washington
Chemical engineering education, catalysis, carbon capture and conversion

Kristen Wyckoff

PhD, University of Tennessee
Environmental engineering education, stormwater runoff, environmental microbiology

Lecturer

Kurt Russell

PhD, Purdue University
Chemical engineering education, catalysis

Affiliated Faculty

Gary Moore

Senior Lecturer for the Joint Engineering Program
MS, Missouri University of Science and Technology
Environmental management

Adjunct Faculty

Grigoriy Yablonsky

PhD, Boreskov Institute of Catalysis

Chemical reaction engineering and heterogeneous catalysis

Emeritus Professor

Milorad P. Dudukovic

Laura and William Jens Emeritus Professor

PhD, Illinois Institute of Technology

Chemical reaction engineering, multiphase reactors, visualization of multiphase flows, tracer methods, environmentally benign processing

Degree Requirements

Please visit the following pages for information about the degrees offered:

- Aerosol Science & Engineering, Joint MS (p. 108)
- Energy, Environmental, & Chemical Engineering, PhD (p. 108)
- Energy, Environmental, & Chemical Engineering, MS (p. 110)
- Energy, Environmental, & Chemical Engineering, MEng (p. 110)
- Combined Master of Engineering/Master of Business Administration, MEng/MBA (p. 111)

Courses

EECE 5001 Introduction to Chemical Engineering

This graduate-level course is for first-year graduate students with undergraduate majors in chemistry, physics, materials science, and other non-engineering programs. The course aims to develop students' capability and philosophy, changing from basic science and other engineering disciplines to chemical engineering science and technology by learning the fundamental principles and methods and practicing essential engineering calculations. In particular, the course allows students to explore modern chemical engineering to design and optimize processes requiring a series of operations to convert raw materials into useful products or efficiently realize desirable biological-related procedures.

Credit 3 units.

Typical periods offered: Fall

EECE 5010 Transport Phenomena in EECE

The aim of the course is for students to develop skills in applying principles of momentum, heat and mass transport in an unified manner to problems encountered in the areas of energy, environmental and chemical processes. A systems approach will be followed so that the general principles can be grasped and the skills to develop mathematical models of seemingly different processes will be emphasized. This provides the students with a general tool which they can apply later in their chosen field of research.

Credit 3 units.

Typical periods offered: Spring

EECE 5011 Advanced Transport Phenomena

Analytical tools in transport phenomena: Scaling, perturbation and stability analysis. Numerical computations of common transport problem with MATLAB tools. Low Reynolds number flows and applications to microhydrodynamics. Turbulent flow analysis and review of recent advances in numerical modeling of turbulent flows. Convective heat and mass transfer in laminar and turbulent flow systems. Introduction to two phase flow and multiphase reactors. Pressure-driven transport and transport in membranes, electrochemical systems, double layer effects and flow in microfluid devices.

Credit 3 units.

Typical periods offered: Spring

EECE 5020 Advanced Thermodynamics in EECE

The objective of this course is to understand classical thermodynamics at a deeper level than is reached during typical undergraduate work. Emphasis will be placed on solving problems relevant to chemical engineering materials science.

Credit 3 units.

Typical periods offered: Fall

EECE 5030 Mathematical Methods in EECE

The course will introduce students to mathematical principles essential for graduate study in any engineering discipline. Applied mathematical concepts will be demonstrated by applications to various areas in energy, environmental, biomedical, chemical, mechanical, aerospace, electrical and civil engineering.

Credit 3 units.

Typical periods offered: Fall

EECE 5040 Aerosol Science and Technology

Fundamental properties of particulate systems - physics of aerosols, size distributions, mechanics and transport of particles: diffusion, inertia, external force fields. Visibility and light scattering. Aerosol dynamics - coagulation, nucleation, condensation. Applications to engineered systems: Nanoparticle synthesis, atmospheric aerosols, combustion aerosols, pharmaceutical aerosols.

Credit 3 units.

Typical periods offered: Fall

EECE 5041 Advanced Topics in Aerosol Science & Engineering

This course will be focused on the discussion of advanced topics in aerosol science and engineering and their applications in a variety of fields, including materials science, chemical engineering, mechanical engineering, and environmental engineering.

Credit 3 units.

Typical periods offered: Fall

EECE 5050 Aquatic Chemistry

Aquatic chemistry governs aspects of the biogeochemical cycling of trace metals and nutrients, contaminant fate and transport, and the performance of water and wastewater treatment processes. This course examines chemical reactions relevant to natural and engineered aquatic systems. A quantitative approach emphasizes the solution of chemical equilibrium and kinetics problems. Topics covered include chemical equilibrium and kinetics, acid-base equilibria and alkalinity, dissolution and precipitation of solids, complexation of metals, oxidation-reduction processes, and reactions on solid surfaces. A primary objective of the course is to be able to formulate and solve chemical equilibrium problems for complex environmental systems. In addition to solving problems manually to develop chemical intuition regarding aquatic systems, software applications for solving chemical equilibrium problems are also introduced.

Credit 3 units.

Typical periods offered: Fall

EECE 5060 Bioprocess Engineering I: Fundamentals & Applications

The course covers the fundamentals and provides the basic knowledge needed to understand and analyze processes in biotechnology in order to design, develop and operate them efficiently and economically. This knowledge is applied to understand various applications and bioprocesses, such as formation of desirable bio and chemical materials and products, production of bioenergy, food processing and waste treatment. The main objective of the course is to introduce the essential concepts and applications of bioprocessing to students of diverse backgrounds. An additional project is required to obtain graduate credit.

Credit 3 units.

Typical periods offered: Spring

EECE 5070 Kinetics and Reaction Engineering Principles

The course is aimed at a modern multiscale treatment of kinetics of chemical and biochemical reactions and application of these fundamentals to analyze and design reactors. Application of reaction engineering principles in the areas related to energy generation, pollution prevention, chemical and biochemical processes will be studied and illustrated with case studies and computer models. Description of the role of mass and heat transport in reacting systems is also provided with numerous examples.

Credit 3 units.

Typical periods offered: Spring

EECE 5080 Combustion Phenomena

This course provides an introduction to fundamental aspects of combustion phenomena, including relevant thermochemistry, fluid mechanics, and transport processes as well as the interactions among them. Emphasis is on elucidation of the physico-chemical processes, problem formulation and analytic techniques. Topics covered include non-premixed and premixed flames, deflagrations and detonations, particle combustion, flame extinction, flame synthesis, pollutant formation and methods of remediation. Contemporary topics associated with combustion are discussed throughout.

Credit 3 units.

Typical periods offered: Fall

EECE 5090 Atmospheric Science and Climate

This course will cover current research topics in atmospheric chemistry and climate change. Topics include atmospheric composition, chemistry, transport, dynamics, radiation, greenhouse gases, natural and anthropogenic primary pollution sources and secondary aerosol production, and measurement techniques. Focus will be placed on how our atmosphere and climate are altered in a world of changing energy production and land use.

Credit 3 units.

Typical periods offered: Spring

EECE 5100 Air Quality Measurement Techniques

Aerosol particles in the atmosphere play an important role in determining air quality and in impacting climate. This course aims to introduce students to the techniques and fundamental operating principles of a variety of aerosol particle measurement instruments, as well as tools used to monitor air quality more broadly. The course will focus on aerosol particle count measurements, particle size distribution measurements, and particle chemical composition measurements. We will also cover tools used to measure greenhouse gases and volatile organic compounds in the atmosphere. We will explore measurement techniques from well-established tools to the

latest novel instrumentation, including those used for air quality regulatory assessments and in research studies. We will discuss examples of air quality measurement technology applications, including outdoor air pollution monitoring, indoor air filtration, biological aerosol measurements, satellite-based observations, and more.

Credit 3 units.

Typical periods offered: Fall

EECE 5110 Aerosol Summer School

Aerosol science and engineering encompasses the basic principles that describe the formation, growth, and evolution of a system of particles suspended in a gaseous medium, and the measurement, characterization, and modeling of their properties. Advances in this cross-disciplinary area of research are pivotal for improving our understanding and estimation of climate change; ensuring air quality protection; assessment of health impacts; and enablement of advanced material synthesis. This course will review the current knowledge on measurement, modeling, and characterization techniques for aerosols. In addition to the lead instructor, this course will facilitate the involvement and participation of leading scholars with expertise in aerosol science and engineering. This is a broad, introductory course for beginning graduate students and senior undergraduates.

Credit 3 units.

Typical periods offered: Summer

EECE 5120 Environmental Organic Chemistry

This course covers the fundamental physical-chemical examination of organic molecules (focused on anthropogenic pollutants) in aquatic (environmental) systems. Students learn to calculate and predict the chemical properties that are influencing the partitioning of organic chemicals within air, water, sediments and biological systems. This knowledge will be based on understanding intermolecular interactions and thermodynamic principles. Mechanisms of important thermochemical, hydrolytic, redox, and biochemical transformation reactions are also investigated, leading to the development of techniques (e.g., structure-reactivity relationships) for assessing environmental fate or human exposure potential.

Credit 3 units.

Typical periods offered: Fall

EECE 5130 Physical and Chemical Processes for Water Treatment

Water treatment is examined from the perspective of the physical and chemical unit processes used in treatment. The theory and fundamental principles of treatment processes are covered and are followed by the operation of treatment processes. Processes covered include gas transfer, adsorption, precipitation, oxidation-reduction, flocculation, sedimentation, filtration, and membrane processes.

Credit 3 units.

Typical periods offered: Spring

EECE 5140 Environmental Nanochemistry

This course involves the study of nanochemistry at various environmental interfaces, focusing on colloid, nanoparticle, and surface reactions. The course would also (1) examine the thermodynamics and kinetics of nanoscale reactions at solid-water interfaces in the presence of inorganic or organic compounds and microorganisms; (2) investigate how nanoscale interfacial reactions affect the fate and transport of contaminants; (3) introduce multidisciplinary techniques for obtaining fundamental information about the structure and reactivity of nanoparticles and thin films, and the speciation or chemical form of environmental pollutants at the molecular scale; (4) explore connections between environmental nanochemistry and environmental kinetic analysis at larger scales.

This course will help students attain a better understanding of the relationship between nanoscience/technology and the environment—specifically how nanoscience could potentially lead to better water treatments, more effective contaminated-site remediation, or new energy alternatives. Students enrolling in this course should have a knowledge of general chemistry.

Credit 3 units.

Typical periods offered: Spring

EECE 5150 Environmental Data Science

Many of the grand challenges that we face today require understanding and manipulation of processes at the interface of natural and manmade environments. Oftentimes, such knowledge is acquired through data. Skills to effectively visualize and analyze data and build predictive models are valued across different sectors of the society. This is an application-driven course.

Credit 3 units.

Typical periods offered: Spring

EECE 5160 Environmental Resource Recovery

This course will focus on key concepts of resource recovery from wastes. Topics include energy, water, nutrient, and value-added compounds. The course will discuss technological advancements, environmental impacts, and techno-economic assessment of environmental resource recovery. The cutting-edge recovery technologies in full-scale applications or laboratory studies will be introduced. Students will be trained for critical thinking and review of literature information, practice technical analysis and writing, and conduct a concept design of recovery systems using the data from local wastewater treatment facilities. The course is valuable as a prerequisite to more advanced research in environmental engineering, as a technical education to stimulate graduate students' interest in environmental sustainability, and as an introduction to environmental constraints that are increasingly important to other engineering disciplines.

Credit 3 units.

Typical periods offered: Fall

EECE 5170 Metabolic Engineering and Synthetic Biology

Synthetic Biology is a transformative view of biology from observation approach to synthesis approach. It is new engineering discipline and aims to make the engineering of new biological function predictable, safe, and quick. It will pave a wide range of applications to transform our views on production of sustainable energy and renewable chemicals, environmental problems, and human disease treatments. The field intersects with Metabolic Engineering in areas such as the design of novel pathways and genetic circuits for product generation and toxic chemical degradation. In this course, the field and its basis are introduced. First, relevant topics in biology, chemistry, physics, and engineering are covered. Second, students will participate in brainstorming and discussion on new biology-based systems. Last, students will design and present new synthetic biology systems to solve real-world problems. Both undergrad and graduate students can take this course.

Credit 3 units.

Typical periods offered: Fall

EECE 5180 Biomass Energy Systems and Engineering

This course offers background in the organic chemistry, biology and thermodynamics related to understanding the conversion of biomass. In addition includes relevant topics relating to biomass feedstock origin, harvest, transportation, storage, processing and pretreatment along with matters concerning thermo- and biochemical conversion technologies required to produce fuels, energy,

chemicals, and materials. Also, various issues with respect to biomass characterization, economics and environmental impact will be discussed. The main objective of the course is to introduce concepts central to a large-scale integrated biomass bioconversion system.

Credit 3 units.

Typical periods offered: Fall

EECE 5190 Molecular Biochemical Engineering

This course is set for junior level graduate students to bridge the gap between biochemical engineering theory and academic research in bioengineering. It will cover common molecular biotechnologies (molecular biology, microbiology, recombinant DNA technology, protein expression etc), biochemical models (enzyme catalysis, microbial growth, bioreactor etc) and bioengineering methodologies (protein engineering, expression control systems etc). These theories and technologies will be introduced in a manner closely related to daily academic research or biochemical industry. Areas of application include biofuel and chemical production, drug discovery and biosynthesis, bioremediation, and environmental applications. This course also contains a lab section (20~30%) that requires students to apply the knowledge learned to design experiments, learn basic experimental skills and solve current research problems.

Credit 3 units.

Typical periods offered: Spring

EECE 5200 Electrochemical Engineering

This course will teach the fundamentals of electrochemistry and the application of the same for analyzing various electrochemical energy sources/devices. The theoretical frameworks of current-potential distributions, electrode kinetics, porous electrode and concentrated solution theory will be presented in the context of modeling, simulation and analysis of electrochemical systems. Applications to batteries, fuel cells, capacitors, copper deposition will be explored.

Credit 3 units.

Typical periods offered: Spring

EECE 5210 Chemical Kinetics and Catalysis

This course reflects the fast, contemporary progress being made in decoding kinetic complexity of chemical reactions, in particular heterogeneous catalytic reactions. New approaches to understanding relationships between observed kinetic behaviour and reaction mechanism will be explained. Present theoretical and methodological knowledge will be illustrated by many examples taken from heterogeneous catalysis (complete and partial oxidation), combustion and enzyme processes.

Credit 3 units.

Typical periods offered: Spring

EECE 5220 Characterization Methods in Energy and Catalysis

This course provides a comprehensive overview of advanced characterization and analytical methods used in energy, catalysis, and electrochemistry research. Students will explore spectroscopic (e.g., XPS, Raman, FTIR, NMR), microscopic (e.g., TEM, SEM, AFM), and electrochemical techniques (e.g., CV, EIS) alongside common analytical methods such as HPLC and GC. Emphasis is placed on in situ and operando techniques to study material properties and reaction mechanisms under realistic conditions. Through lectures, case studies, and practical data analysis, students will learn to select and apply appropriate methods to link structure, composition, and performance in complex energy and catalytic systems.

Credit 3 units.

Typical periods offered: Spring

EECE 5230 EECE Project Management

An introduction to the theory and practice of engineering project management, with an emphasis on projects related to environmental protection and occupational health and safety. Topics include: project definition and justification; project evaluation and selection; financial analysis and cost estimation; project planning, including scheduling, resourcing, and budgeting; project oversight, auditing, and reporting; and effective project closure. Students will be introduced to commonly used project management tools and systems, such as work breakdown structures, network diagrams, Gantt charts, and project management software. Topics will also include project management in different organizational structures and philosophies; creating effective project teams; and managing projects in international settings.

Credit 3 units.

Typical periods offered: Summer

EECE 5240 Electrochemical Processes

Renewable electricity from solar and wind will be the primary energy source for our future distributed energy and mobility system. At the foundation of that energy system are the electrochemical energy devices including fuel cells, electrolyzers and batteries. The objectives of this course are to introduce basic concepts and principles of electrochemistry as well as their potential applications. The chemical engineering fundamentals from previous EECE courses (e.g., mass & energy balances, thermodynamics, and mass & heat transport) will be applied to describe in mathematical terms the catalytic and mass transport processes. A particular emphasis of the course is electrocatalysis at the electrochemical interfaces.

Credit 3 units.

Typical periods offered: Fall

EECE 5250 Energy and Environment

This course sets out to instruct the student on how to understand decision making regarding energy and the environment, and will provide a unique educational experience, wherein the challenges and potential solutions to meeting future energy needs will be clearly elucidated via lectures and experiential learning. Topics include: overview of energy and the environment and associated challenges; description of power generation from coal, natural gas, biomass, wind, solar, hydro, geothermal, and nuclear; political, environmental, and social considerations; regulations, economics, decision-making; students will gain experience with software capable of analyzing renewable energy projects worldwide, from backyard to power-plant scale systems.

Credit 3 units.

EECE 5260 Application of Generative AI in Bioprocess Engineering

This course will cover following topics on large language models (LLMs) and their application for bioprocess engineering and synthetic biology: 1) LLMs (online or local) introductions and comparison (GPT4o and Qwen); 2) Data security and API for safe LLM applications; 3) Trustworthy information collection, prompt engineering for information retrieval from synthetic biology literature; 4) Knowledge graph and RAG; 5) Feature engineering and data organization for text analysis of synthetic biology paper; 6) LLMs-driven machine learning of omics data; 7) Integrative LLMs with metabolic modeling. This class will also include research projects on the use of generative AI to assist metabolic engineering. Students will obtain essential skills to properly use LLMs (such as GPT4o) for advanced metabolic modeling, optimal experimental design, and knowledge synthesis.

Credit 3 units.

Typical periods offered: Fall

EECE 5270 Climate Change and Geoengineering

Climate change has already begun to impact life on the planet, and will continue in the coming decades. This course covers the fundamentals of how the climate system works, providing an understanding of the mechanisms behind past climate changes and projections for future climate shifts. It explores the methods and evidence that form the basis of our knowledge about climate, and the societal impacts of climate change and various strategies addressing it. The course will contain lectures/content on the associated climate science background, engineering/technological developments to combat the issue, and an exploration of the economics and the inequities that exacerbate the situation, followed by group discussion and synthesis of the different perspectives.

Credit 3 units.

Typical periods offered: Fall

EECE 5280 Electro-Bio Carbon Utilization Engineering

This course introduces chemical engineering approaches to converting captured CO₂ into fuels, chemicals, and materials by integrating electrocatalysis with biomanufacturing. Students learn the end-to-end process logic for carbon-to-products systems: CO₂ capture and purification; electrochemical CO₂ reduction (CO₂RR) and reactor design; biological carbon assimilation via fermentation and synthetic/metabolic engineering; and downstream separations and process integration. The course emphasizes process thinking and decision-making using technoeconomic analysis (TEA) and life cycle assessment (LCA), including how cost, energy intensity, scale, and supply-chain constraints shape viable pathways. A recurring case study anchors discussion (e.g., commercial bioethanol as a baseline, then redesigned to CO₂-enabled electro-bio manufacturing), and guest lectures highlight current CURB-relevant research and translation considerations, including societal adoption factors that influence deployment.

Credit 3 units.

Typical periods offered: Fall

EECE 5420 Polymers for Energy, Sustainability, and Human Health

Polymeric materials are critical to solving global challenges related to energy (e.g., batteries, membranes, and energy harvesting devices), sustainability (e.g., upcycling, compatibilizers, water purification, and bio-based plastics), and human health (e.g., wearable and implantable bioelectronics, stimuli-responsive soft robots, and hydrogels for drug delivery). This course covers how polymers are designed and processed across many length and time scales to achieve specific target properties for applications in energy, sustainability, and human health. Ideal and real chain conformations, persistence length, polymer architectures, scaling and blob theories, dispersity, networks and defects, and programmed interactions in heteropolymers will be covered. Analysis of polymer structure and dynamics will include: macroscopic and microscopic phase separation, crystallization and melting, glass transition behavior, rouse dynamics, linear viscoelasticity, processing methods, and network elasticity. Key polymer characterization methods including rheology and small- and wide-angle x-ray scattering will be introduced. The course will emphasize individual problem sets, in-class journal club participation, and team-based project work.

Credit 3 units.

Typical periods offered: Fall

EECE 5997 Seminar in Energy, Environmental, and Chemical Engineering

All graduate students in EECE should attend the departmental seminar series to gain exposure in various diverse fields of research. Students are also expected to participate in journal clubs and other discussion formats to discuss topical research areas. This course is required of all graduate students every semester of residency in the program.

Credit 1 unit.

Typical periods offered: Fall, Spring

EECE 5999 Independent Study

Independent investigation on topic of special interest. Interested students are encouraged to approach and engage faculty to develop a topic of interest. A form declaring the agreement must be filed in the departmental office. Petitions are generally considered in the semester preceding the independent study experience.

Credit 9 units.

Typical periods offered: Fall, Spring, Summer

EECE 7998 Masters Research

Independent research investigation on a topic of special interest for thesis-track students. This course is restricted to students enrolled in the Master of Science in Energy, Environmental & Chemical Engineering program. Students must complete and submit required registration forms prior to enrollment.

Credit 9 units.

Typical periods offered: Fall, Spring, Summer

EECE 8998 Doctoral Research

EECE Doctoral Research

Credit 9 units.

Typical periods offered: Fall, Spring, Summer

Aerosol Science & Engineering, Joint MS (EECE)

Program Overview

This one year master's program is open to BTech degree undergraduate students from any department at IIT Bombay who are in the first semester of Year 4.

The key objective of the joint master's degree is to conduct research in a project related to aerosol science and engineering that is jointly supervised by a faculty member at IIT Bombay and at Washington University in St. Louis. Another key objective is to demonstrate an interest in continuing for a co-advised PhD degree following completion of the joint master's degree.

The program is highly selective. Qualified students will be admitted and will receive a joint master's degree from Washington University in St. Louis and from IIT Bombay. Selected students will receive full financial support for the master's degree after completion of the BTech degree.

Program includes 30 credit hours of advanced-level aerosols engineering and air quality courses and research. 15 credit hours are to be completed in person at Washington University in St. Louis during the summer and fall semesters. The remaining 15 credits are to be completed in person at IIT Bombay. Students may also apply for admission into an accelerated PhD program after completing the joint master's degree.

Energy, Environmental, & Chemical Engineering, PhD (EECE)

The doctoral degree requires a total of 72 credits beyond the bachelor's degree. Of these, a minimum of 36 credits must be graduate course work, and a minimum of 30 credits must be doctoral thesis research units. At most, 12 graduate credits in a graduate program from another university may be counted as transfer credits toward the required 36 units of coursework. Core course credits cannot be transferred unless a student has taken the same courses in EECE during MS/MEng study. PhD students can apply for transfer credit by submitting a formal petition to the department through the Transfer Credit Request Form after passing the qualifying exam.

To be admitted to candidacy, students must have completed at least 18 credits at Washington University, have an overall grade-point average of at least 3.25, and pass the qualifying examination. To be eligible to take the qualifying exam, students must complete the core curriculum, maintain a 3.25 GPA as described in the EECE PhD handbook, and match with a permanent advisor. All students are required to enroll in the department seminar every semester. After passing the qualifying exam, students will complete the Mentored Teaching Experience (MTE) generally in their second and/or third year. Within 18 months after the qualifying exam (generally in their third year), students must form their Research Advisory Committee (RAC) and successfully defend their thesis proposal.

After a successful proposal defense, students should provide their research updates through annual meetings or reports with their thesis committee until their graduation. While conducting doctoral research, students should perform in a professional manner in their research lab and/or office setting and be in compliance with all safety and regulatory requirements for their research projects. Upon completion of their dissertation, students must present their dissertation research in a public forum and successfully defend the dissertation before their thesis committee.

Students admitted to a PhD program in McKelvey Engineering must maintain full-time continuous enrollment throughout the approved length of their programs. McKelvey PhD programs are to be completed within six years under normal conditions. For more detailed guidelines, please refer to the EECE doctoral studies handbook available on the EECE Graduate Degree Programs webpage.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

Teaching is fundamental to the skills and training that a Doctor of Philosophy degree represents. No matter the career path taken by a graduate of our program — whether it be academic, industrial, or outside of engineering entirely — the skills and perspectives gained while teaching will be invaluable. By teaching others, we gain a greater depth of understanding and appreciation of the subject matter, strengthen our written and oral communication, cultivate the ability to inclusively mentor others and understand their perspectives, and of course learn more about the world in which we live. Teaching and learning are a critical part of all careers, and all graduates of the EECE doctoral program should possess foundational skills in these areas.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Two Preparatory Engagement activities are required.

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices

in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

EECE requires either two AI assignments at 10 MER units or two AI assignments at 5 MER units and one AI assignment at 10 MER units. Students are eligible to be assigned to serve as an AI after they pass the qualifying exam (typically beginning in the second year of the program). Students work with their graduate program advisor on the timing of the assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

Pathway #1

- Preparatory Engagement

EGS 8005	Take two times
EGS 8010	Take one time

Pathway #2

- Preparatory Engagement

EGS 8010	Take two times
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Optional Activity: Teaching Intensive Pathway (TIP)

The TIP is an optional pathway for those students whose career interests lie in academia or another field that would benefit from extended teaching experiences. This immersive experience allows students to further explore the breadth and depth of teaching best practices and pedagogy related to their respective field. Students who are interested in participating in this elective experience must formally request to participate, which is subject to program approval. Due to this experience being an elective, unpaid experience, students who participate in the TIP will not receive compensation.

- Complete at least Level 3 of the Center for Teaching and Learning's Professional Development in Teaching Program
- One Mentored Independent Teaching experience in which the student will act as a co-instructor with an EECE faculty member with a record of strong teaching. The faculty member will mentor and support the student to do the following:

- Independently teach a significant fraction of the course
- Develop formative and summative assessments
- Learn about and attempt other activities related to effective, evidence-based teaching

Optional Pathway

EGS 8020

Take one time

Energy, Environmental, & Chemical Engineering, MS (EECE)

The MS degree is a research-focused master's program for students interested in studying environmental engineering, energy systems and chemical engineering. This degree is typically a two-year program that requires the completion of coursework and may include the completion of a research or thesis project under the supervision of a faculty member.

The program consists of 30 total credits that can be completed in one of three ways:

1. 30 credits of coursework;
2. 24 credits of coursework and 6 credits of independent study; or
3. 24 credits of coursework and 6 credits of thesis research.

The coursework for all options is comprised of 15 credits of core courses with remaining elective units (4000 or 5000 level) chosen with the approval of the advisor. Students must have a cumulative grade point average of 2.75 or better to receive the degree. The 6 credits of independent study or thesis work are done under the guidance of a tenured or tenure-track faculty member in the department. Research results presented in the form of a written project report must be approved by the advisor and an external reviewer. Research results presented in the form of a thesis must be approved by a three-person faculty committee formed with the approval of the advisor. The completion of the degree program must be consistent with the residency and other applicable requirements of Washington University and the McKelvey School of Engineering.

Doctoral students may also receive an MS in EECE "along the way" in their PhD program. They should have passed the PhD proposal defense, completed 30 units of required coursework, and published or submitted at least one peer-reviewed journal manuscript from their thesis research.

For more detailed information, please visit the MS in EECE webpage.

Energy, Environmental, & Chemical Engineering, MEng (EECE)

This professional graduate degree is a master's program based in coursework for students interested in state-of-the-art practice in environmental engineering, energy systems and chemical engineering. The master's degree provides students with critical scientific and engineering skill sets; leadership training for management, economics and policy decision; and the opportunity to specialize in specific pathways. The curriculum is geared to enhance skill sets for practice in industry and can be completed by a full-time student in 12 to 18 months.

The program consists of 30 units, with a total of five required core courses in four areas:

- Technical Core (6 units)
- Mathematics (3 units)
- Project Management (3 units)
- Social, Legal, and Policy Aspects (3 units)

Elective courses (4000 or 5000 level) are selected with the approval of the academic advisor. Up to 6 elective units may be in the form of an independent study project. All courses comprising the required 30 credits must be taken for a grade (i.e., they cannot be taken Pass/No Pass), and a minimum grade point average of 2.70 is required for graduation.

Pathways composed of specific elective courses can be completed to result in a certificate of specialization. Available pathways include the following:

- Advanced Energy Technologies
- Bioengineering and Biotechnology
- Environmental Engineering Science
- Energy and Environmental Nanotechnology
- Energy and Environmental Management

For more detailed information, please visit the MEng in EECE webpage.

Combined Master of Engineering/ Master of Business Administration, MEng/MBA (EECE)

In recent years, student interest has grown rapidly in the intersection between engineering and business approaches to issues of sustainability, energy, the environment and corporate social responsibility. An interdisciplinary approach is necessary to address these issues with innovative, critical thinking that will lead to practical, effective solutions. This combined program — the Master of Engineering in Energy, Environmental & Chemical Engineering/ Master of Business Administration (MEng/MBA), offered by McKelvey School of Engineering and Olin Business School — is well positioned to address this critical intersection.

The Olin MBA curriculum offers a comprehensive set of required and elective courses built upon a foundation of critical-thinking and leadership skills. Olin MBAs are able to shape the curriculum to meet their unique personal objectives and to incorporate the MEng degree requirements.

Both the MEng and the MBA degrees will be awarded simultaneously at the completion of the program.

Please visit the Olin Combined Programs webpage and the EECE MEng/MBA webpage for details.

Imaging Science

The PhD in Imaging Science program at Washington University in St. Louis is *one of only two* such programs in the United States. This program offers an interdisciplinary curriculum that focuses on the technology of imaging with applications that range from cancer diagnosis to virtual reality.

What Is Imaging Science?

Imaging science is an interdisciplinary academic discipline that broadly addresses the design and optimization of imaging systems and the extraction of information from images. It builds on contributions from traditional fields such as biomedical engineering, electrical engineering and computer science as well as from physics, applied mathematics, biology and chemistry.

What Can You Do With an Advanced Degree in Imaging Science?

The high demand for personnel with training in imaging science is reflected in government policy and funding opportunities. Many academic, industrial and national laboratory positions exist for highly qualified candidates. Graduates of the program will be prepared for careers in academic research or in industries that require expertise in the quantitative principles of imaging.

Curriculum Focus

- Mathematical and computational principles of image formation
- Image analysis
- Image understanding
- Image quality assessment

This interdisciplinary program is unique in that it brings together expert faculty from the McKelvey School of Engineering and the School of Medicine to provide students with the freedom and flexibility to learn from leading imaging experts and to engage in impactful research.

History

Washington University has been a leader in the technology and advancement of imaging science for more than 125 years. During the 1920s, Washington University researchers were the first to use X-rays to view the gallbladder. During the 1970s, research by Michel Ter-Pogossian at the university's Mallinckrodt Institute of Radiology led to the development of the PET scanner.

Website: <https://engineering.wustl.edu/academics/programs/imaging-science/index.html>

Faculty

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Co-Director

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PhD, University of Notre Dame

Electrical & Systems Engineering

Joe Culver

Co-Director

Sherwood Moore Professor of Radiology

PhD, University of Pennsylvania

Radiology; Biomedical Engineering

Hongyu An

Professor

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The Lee Hunter Distinguished Professor of Mechanical Engineering

PhD, Duke University

Mechanical Engineering & Materials Science

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PhD, Medical College of Wisconsin

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PhD, University of Washington

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Associate Professor
PhD, Physics, University of Pennsylvania
Biomedical Engineering

Quing Zhu

Professor
PhD, University of Pennsylvania
Biomedical Engineering

Fu Ziao

Assistant Professor
PhD, Columbia University
Cell Biology and Physiology

Professor Emeritus

Martin Arthur

Newton R. and Sarah Louisa Glasgow Wilson Professor of Engineering
PhD, University of Pennsylvania
Electrical & Systems Engineering

Degree Requirements

- Imaging Science, PhD (p. 114)
- Imaging Science, MS (p. 117)

Courses

For information regarding courses, please refer to the Degree Requirements (p. 114) section of this page.

Imaging Science, PhD (IS)

Requirements

To complete the PhD in Imaging Science, students must do the following:

- Maintain an average grade of B (3.0 grade point average) for all 72 units (up to 24 graduate units may be transferred with approval)
- Complete courses with no more than one grade below B–
- Become integrated with a research group
- Pass a qualifying exam
- Complete one mentored teaching experience, including training
- Successfully defend a thesis proposal
- Complete four research presentations
- Present and successfully defend a dissertation



Courses

Required Core Courses (19 units)

Code	Title	Units
BME 5700	Mathematics of Imaging Science	3
ESE 5130	Large-Scale Optimization for Data Science	3
or BME 5910	Biomedical Optics I: Principles	
ESE 5200	Probability and Stochastic Processes	3
ESE 5933	Theoretical Imaging Science	3
ESE 5981	Seminar in Imaging Science and Engineering	1
ESE 5970	Practicum in Imaging Science	3
ESE 8992	Introduction to the Research Process	3
Total Units		19

Elective Imaging Courses

Students choose electives from any of the following categories (at least 12 units):

- Computational Imaging & Theory
- Imaging Sensors & Instrumentation
- Image Formation & Imaging Physics
- Translational Biomedical Imaging
- Medical Physics

Typical Progression of Courses

Course	Fall Units	Spring Units
First Year		
Mathematics of Imaging Science (BME 5700)	3	—
Seminar in Imaging Science and Engineering (ESE 5981)	1	—
Elective	3	3
Introduction to the Research Process (ESE 8992)	3	—
Biological Imaging Technology (ESE 5890)	—	3
Machine learning elective	—	3
	10	9
Second Year		
Large-Scale Optimization for Data Science (ESE 5130)	3	—
Theoretical Imaging Science (ESE 5933)	3	—

Doctoral research	3	—
Practicum in Imaging Science (ESE 5970)	—	3
Elective and/or doctoral research	—	6
	9	9

Elective Options

Elective Courses — Computational Imaging & Theory

Code	Title	Units
CSE 4102	Introduction to Artificial Intelligence	3
CSE 5103	Theory of Artificial Intelligence and Machine Learning	3
CSE 5105	Bayesian Methods in Machine Learning	3
CSE 5107	Machine Learning	3
CSE 5109	Advanced Machine Learning	3
CSE 5403	Algorithms for Nonlinear Optimization	3
CSE 5406	Computational Geometry	3
CSE 5504	Geometric Computing for Biomedicine	3
CSE 5509	Computer Vision	3
CSE 5606	High Performance Computer Systems	3
ESE 5230	Information Theory	3
ESE 5240	Detection and Estimation Theory	3

Elective Courses — Image Formation & Imaging Physics

Code	Title	Units
BME 5910	Biomedical Optics I: Principles	3
BME 5940	Ultrasound Imaging	3
BME 5XX	Imaging in Nuclear Medicine (to be developed)	
BME 5XX	Magnetic Resonance Imaging (to be developed)	

Approved Life Science Courses

Code	Title	Units
BBS 3532	Developmental Biology	3
BBS 5053	Immunobiology I	4
BBS 5068	Fundamentals of Molecular Cell Biology	4
BBS 5146	Principles and Applications of Biological Imaging	3
BBS 5147	Contrast Agents for Biological Imaging	3
BBS 5224	Molecular, Cell and Organ Systems	3
BBS 5285	Current Topics in Human and Mammalian Genetics	3

BBS 5319	Molecular Foundations of Medicine	3
BBS 5480	Nucleic Acids & Protein Biosynthesis	3
BBS 5488	Genomics	4
BBS 5651	Neural Systems	6
BBS 5663	Neurobiology of Disease	2
BIOL 4040	Laboratory of Neurophysiology	4
BME 5300	Molecular Cell Biology for Engineers	3
BME 5380	Cell Signal Transduction	3

Approved Mathematics Courses

Any graduate-level course within the Department of Mathematics and Statistics is approved.

Qualifying Exam

The qualifying exam will be administered during the spring of the student's second year of graduate school. The examining committee, which will develop and grade the exam, will consist of three members of the Imaging Science PhD Program Committee. The director of the graduate program will approve the committee, the members of which will be suggested by the student and thesis advisor.

Finding a Thesis Research Mentor

Because the PhD is a research degree, the student is expected to become integrated within a research group. By the start of the first semester of study, students will be appointed a thesis advisor who will oversee their PhD research and assume financial responsibility for their stipend, tuition, health insurance and student fees. The thesis advisor must be a faculty member on the Imaging Science PhD Program Committee with the title of professor, associate professor or assistant professor.

Research Presentation/Thesis Proposal

Before the end of their third year, the student will give an oral presentation of their proposed PhD project — with the necessary background to support it — to the Research Advisory Committee. This committee must follow all guidelines for PhD degrees in the McKelvey School of Engineering and consists of five members (the dissertation research mentor plus four other members) with the following requirements:

- No more than three faculty members with primary appointment from any one department;
- Four of the members must be tenured or tenure-track faculty at Washington University;

- Three of the members must be imaging science program faculty members;
- If requested by the research mentor and approved by the co-directors, a sixth member may be added to the committee.

The committee will be chaired by the PhD mentor. At least two weeks prior to the presentation, the student will present a written document outlining the research background, proposed procedures, preliminary results and plans for completion. The required document will typically be between 15 and 30 pages in length, and it must contain a comprehensive bibliography.

The student will be placed on probation if they fail to pass their thesis proposal by the sixth semester. The student will be given a second opportunity to pass the exam during their seventh semester. If the student passes the second exam and meets the other program requirements (e.g., grades), they may continue the program without prejudice. If the student fails the exam a second time, they will be terminated from the PhD program.

After the thesis proposal, but prior to the dissertation defense, students must complete four additional research presentations, such as posters or talks at conferences, seminars, or other similar venues.

Dissertation

Upon completion of the dissertation, the doctoral candidate must work with the graduate program advisor to submit the PhD Dissertation Defense Committee approval and schedule the defense at least one month in advance. The candidate presents the dissertation in a public forum and successfully defends the dissertation before the Dissertation Defense Committee. The dissertation must be approved by the dissertation committee as part of the final examination. Students submit the PhD Dissertation Defense Approval form after their defense.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.



Mentored Experience Requirement (MER)

Philosophy of Teaching

Imaging science is a discipline based on key underlying physical, experimental, statistical, algorithmic, and computational principles. The students in the program may pursue teaching opportunities in any of these supporting principles or in one of the imaging science courses that integrates them. By teaching these principles or their integration that leads to the design of imaging systems, students must learn the material in more depth than previously required. The process of communicating these ideas to others is a fundamental skill in any professional setting.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Preparatory Engagement activities are required:

1. McKelvey MTE Preparatory Trainings

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

Students will complete an AI experience for one course at 10 MER units. Students work with their graduate supervisor on the timing and content of their AI assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement

EGS 8010	Take one time
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Imaging Science, MS (IS)

Requirements

The Master of Science (MS) in Imaging Science requires the completion of 30 credit units, including 13 credit units from the core list (two mathematics and physics courses, one seminar course, and one computation and one application course each selected from the list below) and the remaining credits from the electives list.

24 of the 30 credits must be at the 5000 level or above; up to 6 of the 30 credits can be taken at the 4000 level.

Candidates must accumulate a total of 30 graduate credits, have a cumulative grade point average of 2.7 or better, and satisfy the core curriculum requirements. Courses must be taken for a grade (i.e., not Pass/No Pass).

Courses

Required Core Imaging Science Courses (13 units)

Mathematics and Physics of Imaging Modalities Courses (6 units)

Students choose two of the following courses:

Code	Title	Units
BME 5700	Mathematics of Imaging Science	3
BME 5910	Biomedical Optics I: Principles	3
BME 5940	Ultrasound Imaging	3
ESE 5820	Fundamentals and Applications of Modern Optical Imaging	3
ESE 5890	Biological Imaging Technology	3

Computational Imaging Courses (3 units)

Students choose one of the following:

Code	Title	Units
CSE 4107	Introduction to Machine Learning *	3
CSE 5105	Bayesian Methods in Machine Learning	3
CSE 5107	Machine Learning	3
ESE 4150	Optimization	3
ESE 4170	Introduction to Machine Learning and Pattern Classification *	3
ESE 5932	Computational Methods for Imaging Science	3

* Due to the partial overlap between CSE 4107 Introduction to Machine Learning and ESE 4170 Introduction to Machine Learning and Pattern Classification, it is recommended that students take only one, as only one of these courses can count toward the curriculum requirements.

Imaging Applications Courses (3 units)

Students choose one of the following:

Code	Title	Units
BME 5440	Biomedical Instrumentation	3
BME 5920	Biomedical Optics II: Imaging	3
CSE 5509	Computer Vision	3

Seminar Course (1 unit)

Students must complete the following course:

Code	Title	Units
ESE 5981	Seminar in Imaging Science and Engineering	1

Additional Electives (30 units)

Students may choose from the list below and the lists above to meet the 30 units required:

Code	Title	Units
BBS 5146	Principles and Applications of Biological Imaging	3
BBS 5147	Contrast Agents for Biological Imaging	3
BME 5999	Independent Study	3
BME 7998	Masters Research	6
CLNV 5070	Ethical and Legal Issues in Clinical Research	2

ESE 4380	Applied Optics	3
ESE 5200	Probability and Stochastic Processes	3
ESE 5933	Theoretical Imaging Science	3
ESE 5970	Practicum in Imaging Science	3

Materials Science & Engineering

The Institute of Materials Science & Engineering (IMSE) at Washington University in St. Louis offers a unique, interdisciplinary PhD in Materials Science & Engineering that crosses traditional departmental and school boundaries. The field of materials science and engineering focuses on the study, development and application of new materials with desirable properties, with the goal of enabling new products and superior performance regimes. Disciplines in the physical sciences (e.g., chemistry, physics) play a central role in developing the fundamental knowledge that is needed to design materials for a variety of engineering applications (e.g., mechanical engineering, electrical engineering, biomedical engineering). Building on training that spans from fundamental to applied sciences, materials scientists and engineers integrate this fundamental knowledge to develop new materials and match them with appropriate technological needs.

The IMSE is well positioned to address the needs of a student seeking a truly interdisciplinary experience. The IMSE brings together a diverse group of faculty from departments in Arts & Sciences, the McKelvey School of Engineering, and the School of Medicine. The IMSE also oversees shared research and instrument facilities, develops partnerships with industry and national laboratories, and facilitates outreach activities.

Current focused areas of research and advanced graduate education within the IMSE include the following:

- Artificial intelligence in materials discovery and design
- Biomedical, bio-derived, and bio-inspired materials
- Materials for energy and environmental technologies
- Quantum and photonic materials and devices

Contact: Beth Gartin
 Phone: 314-935-7191
 Email: bgartin@wustl.edu
 Website: http://imse.wustl.edu

Faculty

Director

Katharine M. Flores

Christopher I. Byrnes Professor, Mechanical Engineering & Materials Science
 PhD, Stanford University

Professor Flores' primary research interest is the mechanical behavior of high-performance structural materials, with particular emphasis on understanding structure-processing-property relationships in bulk metallic glasses and their composites.

Professors

Jianjun Guan

Professor, Mechanical Engineering & Materials Science
PhD, Zhejiang University

Professor Guan's research interests are in biomimetic biomaterials synthesis and scaffold fabrication; bioinspired modification of biomaterials; injectable and highly flexible hydrogels; bioimageable polymers for MRI and EPR imaging and oxygen sensing; mathematical modeling of scaffold structural and mechanical properties; stem cell differentiation; neural stem cell transplantation for brain tissue regeneration; and bone and cardiovascular tissue engineering.

Marcus Foston

Professor, Energy, Environmental & Chemical Engineering
PhD, Georgia Institute of Technology

Professor Foston's research program seeks to develop innovative and novel routes to exploit and utilize lignocellulosic biomass by taking advantage of materials involved in industries such as agriculture, paper making, and forestry products.

Erik Henriksen

Professor, Physics
PhD, Columbia University

Professor Henriksen's lab research is centered on the properties of electrons confined to two dimensions. This remarkable system has yielded a tremendous amount of interesting and important physics over the past several decades, from the integer and fractional quantum Hall effects to the groundbreaking discoveries of graphene and other atomically thin crystals and especially to the recent realization of the topological nature of the electronic structure of a surprising number of materials both novel and familiar.

Song Hu

Professor, Biomedical Engineering
PhD, Washington University in St. Louis

Professor Hu's research focuses on the development of cutting-edge optical and photoacoustic technologies for high-resolution structural, functional, metabolic, and molecular imaging in vivo and their applications in neurovascular disorders, cardiovascular diseases, regenerative medicine, and cancer.

Vijay Ramani

Roma B. & Raymond H. Wittcoff Distinguished University Professor of Environment & Energy
PhD, University of Connecticut

Vijay Ramani's research interests lie at the confluence of electrochemical engineering, materials science and renewable and sustainable energy technologies. The National Science Foundation, Office of Naval Research, ARPA-E, and Department of Energy have funded his research, with mechanisms including an NSF CAREER award (2009) and an ONR Young Investigator Award (ONR-YIP; 2010).

Srikanth Singamaneni

The Lilyan & E. Lisle Hughes Professor, Mechanical Engineering & Materials Science
PhD, Georgia Institute of Technology

Professor Singamaneni's research interests include plasmonic engineering in nanomedicine (in vitro biosensing for point-of-care diagnostics, molecular bioimaging, nanotherapeutics); photovoltaics (plasmonically enhanced photovoltaic devices); surface-enhanced Raman scattering (SERS)-based chemical sensors, with particular emphasis on the design and fabrication of unconventional and highly efficient SERS substrates; hierarchical organic/inorganic nanohybrids as multifunctional materials; bioinspired structural and functional materials; polymer surfaces and interfaces; responsive and adaptive materials and scanning probe microscopy; and surface force spectroscopy of soft and biological materials.

Fuzhong Zhang

Professor, Energy, Environmental & Chemical Engineering
PhD, University of Toronto

Professor Zhang's research focuses on developing synthetic biology tools and systems for the sustainable production of structurally defined chemicals and high-performance materials. Current research projects include the following: (1) engineering microbial metabolic dynamics and heterogeneity; (2) engineering metabolic pathways to produce structure-defined biofuels and chemicals; and (3) developing microbial factories to produce high-performance materials.

Associate Professors

Peng Bai

Associate Professor, Energy, Environmental & Chemical Engineering
PhD, Tsinghua University, Beijing

Professor Bai's research focuses on the development of next-generation batteries. Knowledge and tools developed in the Bai Group also apply to and benefit the design of other electrochemical energy systems, like supercapacitors and fuel cells.

Mikhail Y. Berezin

Associate Professor, Radiology
PhD, Moscow Institute of Oil and Gas/Institute of Organic Chemistry

Dr. Berezin's lab focuses on the development of novel optically active probes ranging from small molecules to nanoparticles and the development of optical instrumentation for spectroscopy and imaging using knowledge of excited states. The lab's research interest lies in the investigation and application of molecular excited states and their reactions for medical imaging and clinical treatment.

Nathaniel Huebsch

Associate Professor, Biomedical Engineering
PhD, Harvard University

Professor Huebsch's research focus is in basic and translational stem cell mechanobiology, with specific focus on hydrogels to control cell-mediated tissue repair and three-dimensional, iPSC-based heart-in-a-dish models to study the influence of mechanical loading and genetics on arrhythmia and contractility.

Matthew Lew

Associate Professor, Electrical & Systems Engineering
PhD, Stanford University

Professor Lew and his students build advanced imaging systems to study biological and chemical systems at the nanoscale, leveraging innovations in applied optics, signal and image processing, design optimization, and physical chemistry. Their advanced nanoscopes (microscopes with nanometer resolution) visualize the activity of individual molecular machines inside and outside living cells. Examples of new technologies developed in the Lew Lab include (1) using tiny fluorescent molecules as sensors that can detect amyloid proteins; (2) designing new "lenses" to create imaging systems that can visualize how molecules move and tumble; and (3) new imaging software that minimizes artifacts in super-resolution images.

Xianglin Li

Associate Professor, Mechanical Engineering & Materials Science
PhD, University of Connecticut

Professor Li's research interests are in batteries and fuel cells, including direct methanol fuel cells, lithium-oxygen batteries and battery thermal management; transport phenomena in porous media; greenhouse gas emissions and full fuel cycle analysis of fossil fuels; and life cycle assessment and economic analysis of advanced energy techniques, among others.

Mark Meacham

Associate Professor, Mechanical Engineering & Materials Science
PhD, Georgia Institute of Technology

Professor Meacham's research interests include microfluidics, micro-electromechanical systems (MEMS) and associated transport phenomena, with application to design, development and testing of novel energy systems and life sciences tools, from scalable micro-/nanotechnologies for improved heat and mass exchangers to MEMS-based tools for manipulation and investigation of cellular processes. He is also interested in the behavior of jets and/or droplets of complex fluids during ejection from microscopic orifices, which is critical to applications as disparate as biological sample preparation and additive manufacturing.

Rohan Mishra

Associate Professor, Mechanical Engineering & Materials Science
PhD, Ohio State University

Professor Mishra's research interest is to develop quantitative structure-property correlations in materials starting from the atomic scale. To develop such correlations, his group synergistically combines electronic structure calculations with atomic-resolution electron microscope imaging and spectroscopy. The end goal is the rational

design of materials with properties tailored for electronic, optical, magnetic and energy applications. Current research topics include perovskite materials for photovoltaic and optoelectronic applications, novel electrocatalysts, oxidizers, and wide-bandgap semiconductors.

Jai Rudra

Associate Professor, Biomedical Engineering
PhD, Louisiana Tech University

Jai Rudra's lab is interested in the development of nanoscale biomaterials such as nanofibers, nanoparticles, virus-like particles, and hydrogels for engaging the immune system to induce protective antibody and cell-mediated immune responses against diseases such as tuberculosis, melanoma, and flavivirus infections (i.e., West Nile and Zika). He is also investigating the development of vaccines against drugs of addiction such as cocaine.

Chuan Wang

Associate Professor, Electrical & Systems Engineering
PhD, University of Southern California

Professor Wang's research focus is on two-dimensional semiconductor nanoelectronics and optoelectronics, stretchable electronics, printed electronics, and sensors and actuators.

Patricia Weisensee

Associate Professor, Mechanical Engineering & Materials Science
PhD, University of Illinois at Urbana-Champaign

Professor Weisensee's work focuses on understanding the interplay of fluid dynamics, heat transfer, and liquid-solid interactions of droplets and other multi-phase systems. Practical applications of interest are phase change heat transfer for thermal management, thermal storage, water harvesting, metallic additive manufacturing, and droplet interactions with biological and natural systems.

Assistant Professors

Sang-Hoon Bae

Assistant Professor, Mechanical Engineering & Materials Science
PhD, University of California, Los Angeles

Professor Bae's research group focuses on tackling the challenges in materials science with thermodynamics, kinetics, and solid-state physics.

Matthew Bersi**Christopher Cooper**

Assistant Professor, Energy, Environmental & Chemical Engineering
PhD, Stanford University

Christopher Cooper's research at WashU focuses on using dynamic polymers to create responsive, soft materials for applications in energy storage, environmental sustainability, and human health. Through advanced synthesis and characterization, his research group designs polymers with distinct molecular designs and reversible bonds for applications including wearable or implantable electronic devices,

recyclable underwater adhesives, soft actuators, and upcycling of industrial plastics. Cooper has published more than 15 peer-reviewed journal articles and given numerous conference presentations and invited talks.

Francisco Lagunas Vargas

Mark Lawrence

Assistant Professor, Electrical & Systems Engineering
PhD University of Birmingham

Professor Lawrence and his lab are harnessing breakthroughs in nanoscale engineering to push the limits of light-based technologies, targeting applications ranging from all-optical computing and quantum communication to metrology and biosensing.

Kelly Powderly

Assistant Professor of Chemistry
PhD, Princeton University

The Powderly Group seeks to develop and utilize new synthetic pathways to discover extended solids with magnetic, electronic, and non-trivial topological properties of interest in quantum information science and to explore new fundamental bonding in materials.

Sheng Ran

Assistant Professor, Physics
PhD, Iowa State University

Professor Ran's research aims to realize and understand exotic states of quantum materials using combined techniques of bulk crystal synthesis, electric and thermal transport measurements under extreme temperature, pressure and magnetic field conditions, and neutron and high-energy X-ray scattering.

Xi Wang

Assistant Professor, Physics
PhD, Florida State University

Xi Wang's lab utilizes cutting-edge magneto optical and optoelectronic microscopy and spectroscopy to probe and control excitons, electrons, phonons, magnons, and so on in quantum materials for applications in quantum simulation and quantum communication.

Chong Zu

Assistant Professor, Physics
PhD, Tsinghua University

Professor Zu's research interests lie at the interface between atomic, molecular, and optical physics; condensed matter physics; and quantum information.

Degree Requirements

- Materials Science & Engineering, Interdisciplinary PhD (p. 121)

Materials Science & Engineering, Interdisciplinary PhD (MSE)

Degree Requirements

The Materials Science and Engineering (IMSE) doctoral degree requires a minimum of 72 credits beyond the bachelor's degree, with a minimum of 36 credits being graduate coursework (including the IMSE curriculum requirements as outlined in the IMSE Doctoral Handbook) and 18 to 36 credits of doctoral thesis research. To be admitted to candidacy, students must have an overall GPA greater than 3.0, have no more than one grade of B- or below in a core course or IMSE elective, and pass the qualifying examination. All students are required to enroll in the department seminar every semester.

At most, 12 credits of 4000-level courses may be applied toward the required 36 academic credit. Graduate courses may be transferred in (up to 24 credits) but must be evaluated and approved by the IMSE Graduate Studies Committee.

Students enroll in two to three courses each semester, as outlined in the Doctoral Handbook. They complete their qualifying examination in late summer following their first academic year. During their second and third years, students complete their remaining courses and complete their thesis proposal in their fifth semester of study.

After a successful proposal defense, students should provide their research updates through annual meetings with their thesis committee. Upon completion of their dissertation, students must successfully defend the dissertation before their thesis committee.

For more detailed guidelines, please refer to the IMSE Doctoral Handbook available on the IMSE PhD program webpage.

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as *MERs*.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

Materials scientists and engineers work at the interface between the fundamental physical sciences and application-oriented disciplines. As such, they often need to translate between underlying physical principles governing the performance of a material and the design requirements of a system or device. This translation is inherently two-way; the emergent properties of novel materials enable new, potentially transformative applications, and new devices often require materials with unique (and challenging) property profiles. To facilitate this two-way translation, our PhD graduates must be able to communicate both fundamental and applied concepts to a variety of audiences, including supervisors, subordinates, clients, and co-workers, whose familiarity with the MSE field may range from novice to expert. Moreover, mentored teaching experiences instill a sense of responsibility, professionalism, and ethical conduct, preparing students to navigate the complex landscape of academia, industry, government, or other research-oriented sectors with confidence and integrity.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Two preparatory workshops are required:

1. McKelvey Teaching Orientation (Canvas Course)
2. McKelvey Teaching Workshop (Canvas Course)

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

Students will AI two times at 10 MER units for a total of 20 units. Students work with their graduate supervisor on the timing and content of those assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement

EGS 8010	Take two times
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Mechanical Engineering & Materials Science

The Department of Mechanical Engineering & Materials Science offers a **PhD in Mechanical Engineering**. The department's research strengths include biomechanics and biotechnology, energy and sustainability, advanced materials, and aerospace systems. The doctoral student works in conjunction with their advisor to design the program of study and the research project. The dissertation is defended at the end of the research effort. A typical time to PhD after the completion of the undergraduate engineering degree is four to five years, but the length of the program may vary, depending on the individual and the area of study.

The Department of Mechanical Engineering & Materials Science offers a **Master of Science (MS)** degree in **Mechanical Engineering**, **Aerospace Engineering**, or **Materials Science and Engineering**. The department also offers a **Master of Engineering in Mechanical**



Engineering for those coming from fields closely related to mechanical engineering. The MS degrees can be completed using a course option, a project option, or a thesis option. For the thesis option, the student will work closely with a faculty advisor on the thesis. For the project option, the student will work closely with a faculty advisor on the project. A typical time for the completion of an MS or MEng degree is one and one half to two years, with the thesis option usually taking longer than the project and course options.

Faculty contact for the PhD program: Patricia Weisensee

Faculty contact for the MS programs: Xianglin Li

Website: <https://mems.wustl.edu/academics/graduate/index.html>

Faculty

Department Chair

James Friend

Stephen F. and Camilla T. Brauer Distinguished Professor of Mechanical Engineering
PhD, Missouri University of Science and Technology
Small-scale acoustic phenomena

Associate Chair of Education

Emily J. Boyd

PhD, University of Texas at Austin
Thermofluids

Associate Chair of Research

Spencer P. Lake

PhD, University of Pennsylvania
Soft-tissue biomechanics

Endowed Professors

Ramesh K. Agarwal

William Palm Professor of Engineering
PhD, Stanford University
Computational fluid dynamics, computational physics

Philip V. Bayly

The Lee Hunter Distinguished Professor of Mechanical Engineering
PhD, Duke University
Nonlinear dynamics, vibrations, biomechanics

Katharine M. Flores

Christopher I. Byrnes Professor of Engineering
PhD, Stanford University
Mechanical behavior of structural materials

Guy M. Genin

Harold & Kathleen Faught Professor of Mechanical Engineering
PhD, Harvard University
Solid mechanics, fracture mechanics

Jianjun Guan

Earl E. & Myrtle E. Walker Professor of Engineering
PhD, Zhejiang University
Biomimetic biomaterials synthesis, scaffold fabrication

David A. Peters

McDonnell Douglas Professor of Engineering
PhD, Stanford University
Aeroelasticity, vibrations, helicopter dynamics, aerodynamics

Srikanth Singamaneni

Lilyan and E. Lisle Hughes Professor of Mechanical Engineering
PhD, Georgia Institute of Technology
Microstructures of cross-linked polymers

Professors

Spencer P. Lake

PhD, University of Pennsylvania
Soft-tissue biomechanics

Amit Pathak

PhD, University of California, Santa Barbara
Cellular biomechanics

Jessica E. Wagenseil

DSc, Washington University
Arterial biomechanics

Associate Professors

Xianglin Li

PhD, University of Connecticut
Multiphase heat and mass transfer in energy systems; computational fluid dynamics

J. Mark Meacham

PhD, Georgia Institute of Technology
Micro-/nanotechnologies for thermal systems and the life sciences

Rohan Mishra

PhD, The Ohio State University
Computational materials science

Sara Roccabianca

PhD, University of Trento
Biomechanics of the urinary tract and cardiovascular systems

Patricia B. Weisensee

PhD, University of Illinois at Urbana-Champaign
Thermal fluids

Assistant Professors

Sang-Hoon Bae

PhD, University of California, Los Angeles
Materials growth, optoelectronics, renewable energy

Matthew R. Bersi

PhD, Yale University
Biomedical engineering

Christopher Cooper

PhD, Stanford University
Responsive, soft materials for application in energy storage

Fanwei Kong

PhD, University of California, Berkeley
Develop machine learning and computational methods

Francisco Lagunas Vargas

PhD, University of Illinois Chicago
Developing structure-property relationships in functional materials

Professors of Practice

Swami Karunamoorthy

DSc, Washington University
Helicopter dynamics, engineering education

Ed Whalen

PhD, University of Illinois Urbana-Champaign
Aerospace engineering

Louis G. Woodhams

BS, University of Missouri–St. Louis
Computational biomechanics

Teaching Professors

Emily J. Boyd

PhD, University of Texas at Austin
Thermofluids

Ruth J. Okamoto

DSc, Washington University
Biomechanics, solid mechanics

Research Professor

Anders E. Carlsson

PhD, Harvard University
Biophysical Modeling, Mechanobiology

Joint Faculty

Richard L. Axelbaum (Energy, Environmental & Chemical Engineering)

Stifel & Quinette Jens Professor of Environmental Engineering Science
PhD, University of California, Davis
Combustion, nanomaterials

Christopher Cooper (Energy, Environmental & Chemical Engineering)

PhD, Stanford University
Responsive, soft materials for applications in energy storage, environmental sustainability and human health

Elliot L. Elson (Biochemistry & Molecular Biophysics)

Professor Emeritus of Biochemistry & Molecular Biophysics
PhD, Stanford University
Biochemistry, molecular biophysics

Michael D. Harris (Physical Therapy, Orthopaedic Surgery, and Mechanical Engineering & Materials Science)

PhD, University of Utah
Whole body and joint-level orthopaedic biomechanics

Kenneth F. Kelton (Physics)

Arthur Holly Compton Professor of Arts & Sciences
PhD, Harvard University
Study and production of titanium-based quasicrystals and related phases

Eric C. Leuthardt (Neurological Surgery and Biomedical Engineering)

MD, University of Pennsylvania School of Medicine
Neurological surgery

Lori Setton (Biomedical Engineering)

Lucy and Stanley Lopata Distinguished Professor of Biomedical Engineering
PhD, Columbia University
Biomechanics for local drug delivery, tissue regeneration specific to the knee joints and spine

Matthew J. Silva (Orthopaedic Surgery)

Julia and Walter R. Peterson Orthopaedic Research Professor
PhD, Massachusetts Institute of Technology
Biomechanics of age-related fractures and osteoporosis

Simon Tang (Orthopaedic Surgery and Biomedical Engineering)

PhD, Rensselaer Polytechnic Institute
Biological mechanisms

Senior Professors

Phillip L. Gould

PhD, Northwestern University
Structural analysis and design, shell analysis and design, biomechanical engineering

Mark J. Jakiela

PhD, University of Michigan
Mechanical design, design for manufacturing, optimization, evolutionary computation

Kenneth L. Jerina

DSc, Washington University
Materials, design, solid mechanics, fatigue, fracture

Shankar M.L. Sastry

PhD, University of Toronto
Materials science, physical metallurgy

Barna A. Szabo

PhD, State University of New York at Buffalo
Numerical simulation of mechanical systems, finite-element methods

Senior Lecturers

Afaqque Manzoor

PhD, Jeju National University
Soft robotics and flexible electronics

J. Jackson Potter

PhD, Georgia Institute of Technology
Senior design

Lecturers

Chiamaka Asinugo

MS, Washington University
Mechanical engineering design

Sharniece Holland

PhD, University of Alabama
Additive manufacturing, mathematics

Jeffery Krampf

MS, Washington University
Fluid mechanics, modeling, design

H. Shaun Sellers

PhD, Johns Hopkins University
Mechanics, materials

Adjunct Instructors

Derek Barkey

MS, University of Southern California
Structures, numerical methods and simulation

Robert G. Becnel

MS, Washington University
FE review

Andrew W. Cary

PhD, University of Michigan
Computational fluid dynamics

Keith Coleman

MS, Missouri University of Science and Technology
Aerospace defense and project management

Joshua Dustin

PhD, Purdue University
Structures and materials

Richard S. Dyer

PhD, Washington University
Propulsion, thermodynamics, fluids

Richard R. Janis

MS, Washington University
Building environmental systems

Krishnan K. Sankaran

PhD, Massachusetts Institute of Technology
Metallic materials

Michael C. Wendl

DSc, Washington University
Mathematical theory, computational methods in biology and engineering

Degree Requirements

Please visit the following pages for more information about Mechanical Engineering & Materials Science graduate programs:

- Mechanical Engineering, PhD (p. 133)
- Materials Science & Engineering, PhD (p. 134)
- Mechanical Engineering, MSME (p. 135)
- Aerospace Engineering, MSAE (p. 136)
- Materials Science & Engineering, MS (p. 136)
- Mechanical Engineering, MEng (p. 137)

Courses

MEMS 5000 Graduate Seminar

This is a required pass/no pass course for masters and doctoral degrees. A passing grade is required for each semester of full-time enrollment. A passing grade is received by attendance at the weekly seminars.

Credit 0 units.

Typical periods offered: Fall, Spring

MEMS 5104 CAE-Driven Mechanical Design

An introduction to the use of computer-aided engineering (CAE) tools in the mechanical design process. Topics include: integrating engineering analysis throughout the process; multi-disciplinary optimization; and computer-aided design directed toward new manufacturing processes. Students will work with commercial and research software systems to complete several projects. Students should have experience and familiarity with a CAD tool, optimization and the finite element method.

Credit 3 units.

Typical periods offered: Fall

MEMS 5205 Machine Learning Applications in Mechanical Engineering

This course explores the fundamentals of machine learning and deep learning, and their engineering applications. Key topics include classification, regression, dimensionality reduction, optimization methods, and uncertainty quantification. Advanced concepts such as physics-informed neural networks and operators, graph neural networks, normalizing flows, and neural differential equations will also

be covered. Applications of these methods will be discussed, including reduced-order models for computational fluid dynamics simulations, automated segmentation and object detection in image data, and constitutive relations modeling of materials.

Credit 3 units.

Typical periods offered: Spring

MEMS 5206 Modern Robotics: Mechanics, Planning, and Control

This course provides a comprehensive foundation in modern robotics, focusing on kinematics, dynamics, motion planning, and control for mobile robots and robot arms. Modules include: 1. Foundations of Robot Motion 2. Robot Kinematics 3. Robot Dynamics 4. Robot Motion Planning and Control 5. Robot Manipulation and Wheeled Mobile Robots

Credit 3 units.

Typical periods offered: Fall, Summer

MEMS 5207 Robot Design

This hands-on, project-based course focuses on ROS 2 (Robot Operating System 2) and its application in real-world industrial scenarios. Students will gain practical experience in designing, simulating, and implementing robotic systems using ROS 2. Through engaging projects, students will learn key concepts of robotics development, including control and trajectory planning, while preparing for industrial challenges. Modules include 1) Fundamentals of Robotics and ROS 2 2) Robot Modeling and Simulation (project 1) 3) Control Systems and Digital Twin (project 2) 4) Trajectory Planning, Integration, and Capstone Project.

Credit 3 units.

Typical periods offered: Summer

MEMS 5301 Nonlinear Vibrations

In this course students are introduced to concepts in nonlinear dynamics and vibration and application of these concepts to nonlinear engineering problems. Specific topics include: modeling of lumped and continuous nonlinear systems (strings, beams, and plates); vibrations of buckled structures; perturbation and other approximate analytical methods; the use and limitations of local linearization; properties of nonlinear behavior, such as dimension and Lyapunov exponents; stability of limit cycles; bifurcations; chaos and chaotic vibrations; experimental methods and data analysis for nonlinear systems. Concepts will be reinforced with a number of examples from recently published research. Applications will include aeroelastic flutter, impact dynamics, machine-tool vibrations, cardiac arrhythmias, and control of chaotic behavior.

Credit 3 units.

Typical periods offered: Fall, Spring

MEMS 5302 Theory of Vibrations

Analytical methods in vibrations. Topics include: Duhamel's integral, Laplace and Fourier transforms, and Fourier series with applications to transient response, forced response, and vibration isolation, Lagrange's equations for linear systems, discrete systems, degrees of freedom, reducible coordinates, holonomic constraints, and virtual work, matrix methods and state variable approach with applications to frequencies and modes, stability, and dynamic response in terms of real and complex modal expansions, dynamic response of continuous systems by theory of partial differential equations, Rayleigh-Ritz and Galerkin energy methods, finite difference and finite element algorithms.

Credit 3 units.

Typical periods offered: Spring

MEMS 5401 General Thermodynamics

General foundations of thermodynamics valid for small and large systems, and for equilibrium and non-equilibrium states. Topics include: definitions of state, work, energy, entropy, temperature, heat interaction, and energy interaction. Applications to simple systems, phase rule, perfect and semi-perfect gas, bulk-flow systems, combustion, energy and entropy balances, availability analysis for thermo-mechanical power generation, and innovative energy-conversion schemes.

Credit 3 units.

Typical periods offered: Spring

MEMS 5402 Radiation Heat Transfer

Formulation of the governing equations of radiation heat transfer. Topics include: electromagnetic theory of radiation, properties of ideal and real surfaces, techniques for solutions of heat transfer between gray surfaces, radiation in absorbing, emitting and scattering media.

Credit 3 units.

Typical periods offered: Fall

MEMS 5403 Conduction and Convection Heat Transfer

This course examines heat conduction and convection through various fundamental problems that are constructed from the traditional conservation laws for mass, momentum, and energy. Problems include the variable-area fin, the unsteady Dirichlet, Robbins, and Rayleigh problems, multi-dimensional steady conduction, the Couette flow problem, duct convection, and boundary layer convection. Though some numerics are discussed, emphasis is on mathematical technique and includes the extended power series method, similarity reduction, separation of variables, integral transforms, and approximate integral methods.

Credit 3 units.

Typical periods offered: Spring

MEMS 5410 Fluid Dynamics I

This course covers the fundamentals of incompressible fluid flow. Topics include: fundamental equations (continuity and Navier-Stokes Equations), basic solutions for steady and unsteady flows; laminar and turbulent boundary layer analysis; free shear flows; integral analysis, similarity solutions; turbulent flow on plates, pipes, and channels; computational fluid dynamics software

Credit 3 units.

Typical periods offered: Fall

MEMS 5411 Fluid Dynamics II

Governing equations and thermodynamics relations for compressible flow. Topics include: kinetic theory of gases, steady, one-dimensional flows with friction and heat transfer, shock waves, Rankine-Hugoniot relations, oblique shocks, reflections from walls and flow interfaces, expansion waves, Prandtl-Meyer flow, flow in nozzles, diffusers and inlets, two-and three dimensional flows, perturbation methods, similarity rules, compressible laminar and turbulent boundary layers, acoustic phenomena. Emphasis is relevant to air vehicles.

Credit 3 units.

Typical periods offered: Spring

MEMS 5412 Computational Fluid Dynamics

Computational fluid dynamics relevant to engineering analysis and design. Topics include: fundamentals of finite-difference, finite-volume, and finite-element methods, numerical algorithms for parabolic, elliptic, and hyperbolic equations, convergence, stability, and consistency of numerical algorithms, application of numerical algorithms to selected model equations relevant to fluid flow, grid-generation techniques, and convergence acceleration schemes.

Credit 3 units.

Typical periods offered: Fall

MEMS 5413 Advanced Computational Fluid Dynamics

Scope and impact of computational fluid dynamics. Governing equations of fluid mechanics and heat transfer. Three-dimensional grid-generation methods based on differential systems. Numerical methods for Euler and compressible Navier-Stokes equation. Numerical methods for incompressible Navier-Stokes equations. Computation of transonic inviscid and viscous flow past airfoils and wings. Analogy between the equations of computational fluid dynamics, computational electromagnetics, computational aeroacoustics, and other equations of computational physics. Non-aerospace applications - Bio-fluid mechanics, fluid mechanics of buildings, wind and water turbines, and other energy and environment applications.

Credit 3 units.

Typical periods offered: Fall

MEMS 5414 Aeroelasticity & Flow-Induced Vibrations

This course deals with the interactions between aerodynamics, dynamics and structures in aerospace systems. Topics covered will include unsteady aerodynamics, finite-state aerodynamic models, classical fixed-wing flutter, rotary-wing aeroelasticity and experimental methods in aeroelasticity. Emphasis will be given to the prediction of flutter and limit cycles in aeroelastic systems

Credit 3 units.

Typical periods offered: Fall, Spring

MEMS 5416 Turbulence

Hydrodynamic instabilities and the origin of turbulence. Mixing length and vorticity transport theories. Statistical theories of turbulence. Phenomenological considerations of turbulence growth, amplification and damping, turbulent boundary layer behavior, and internal turbulent flow. Turbulent jets and wakes.

Credit 3 units.

MEMS 5417 Physical Acoustics

The primary focus of this course is on plane waves as an introduction to acoustical concepts of propagation, reflection and transmission, refraction, normal modes, horn theory, and absorption and dispersion. The course also includes more complicated problems (e.g., those involving spherical and cylindrical waves) and selected topics in applied acoustics including materials/damping, imaging, nondestructive evaluation, and acoustic microfluidics.

Credit 3 units.

Typical periods offered: Fall

MEMS 5422 Solar Thermal Energy Systems

Fundamentals of radiation heat transfers and solar radiation, including basic terminology, atmospheric scattering and absorption, radiation interactions with surfaces, and selective surfaces. Components, cycles, and materials of concentrating solar power plants, including parabolic trough and solar towers. Overview over thermal storage, other solar thermal technologies and photovoltaics. This course includes a final project.

Credit 3 units.

Typical periods offered: Fall

MEMS 5423 Sustainable Environmental Building Systems

Sustainable design of building lighting and HVAC systems considering performance, life-cycle cost and downstream environmental impact. Criteria, codes and standards for comfort, air quality, noise/vibration and illumination. Life cycle and other investment methods to integrate energy consumption/conservation, utility rates, initial cost, system/component longevity, maintenance cost and building productivity. Direct and secondary contributions to acid rain, global warming and ozone depletion.

Credit 3 units.

Typical periods offered: Fall, Spring

MEMS 5424 Thermo-Fluid Modeling of Renewable Energy Systems

Overview of sustainable energy systems. Fundamentals of energy conversion. Renewable energy sources and energy conversion from wind, biomass, solar-thermal, geothermal, and ocean/waves. Applications to energy storage, fuel cells, green air and ground transportation, energy - efficient buildings. Energy-economics modeling, emissions modeling, global warming and climate change.

Credit 3 units.

Typical periods offered: Fall

MEMS 5427 Fundamentals of Fuel Cells

This course is intended for the graduate and senior undergraduate Mechanical Engineering/ Materials Science/Chemical Engineering students interested in obtaining a fundamental background in fuel cell systems. Several types of fuel cells will be discussed, and the fundamental thermodynamics, kinetics of electrochemistry processes, and charge and mass transfer of fuel cells will be introduced. The primary focus will be placed on low temperature fuel cells based on polymer based electrolytes. The design, operation, performance, and reliability/durability of fuel cell systems will be discussed in detail. Specific interests to mechanical engineers, including water management and thermal management, will be a main focus of this course. Furthermore, the state of art research and development of fuel cell technologies may be presented through reading assignments from current literature.

Credit 3 units.

Typical periods offered: Spring

MEMS 5428 Structure and Rheology of Complex Fluids

Complex fluids are a broad class of materials that have a microstructure that is much smaller than the macroscopic scale but much larger than molecular size. These materials are central to a wide range of industrial, environmental, and biomedical applications. This course will cover basic rheological and structural measurements and data interpretation of complex fluids. We will study structure, dynamics, and flow properties of polymers, colloids, liquid crystals, and other substances with both liquid and solid-like characteristics. Selected topics include: Rheology of polymer solutions, colloidal suspensions, constitutive equations, self-assembling fluids such as surfactants, liquid crystals, block copolymers, and their roles in nanotechnology; geophysical flows (granular flow, lava flow, etc); microfluidics (blood flow, cells in microchannels).

Credit 3 units.

Typical periods offered: Spring

MEMS 5500 Elasticity

Elastic constitutive relations for isotropic and anisotropic materials. Formulation of boundary-value problems. Application to torsion, flexure, plane stress, plane strain, and generalized plane stress problems. Solution of three-dimensional problems in terms of displacement potentials and stress functions. Solution of two-dimensional problems using complex variables and conformal mapping techniques. Variational and minimum theorems.

Credit 3 units.

Typical periods offered: Spring, Summer

MEMS 5501 Mechanics of Continua

A broad survey of the general principles governing the mechanics of continuous media. Topics include: general vector and tensor analysis, rigid body motions, deformation, stress and strain rate, large deformation theory, conservation laws of physics, constitutive relations, principles of continuum mechanics and thermodynamics, two-dimensional continua.

Credit 3 units.

Typical periods offered: Fall

MEMS 5502 Plates and Shells

Introduction to the linear theory of thin elastic plates and shells. The emphasis is on application and the development of physical intuition. The first part of the course focuses on the analysis of plates under various loading and support conditions. The remainder of the course deals mainly with axisymmetric deformation of shells of revolution. Asymptotic methods are used to solve the governing equations. Applications to pressure vessels, tanks, and domes.

Credit 3 units.

Typical periods offered: Fall

MEMS 5506 Experimental Methods in Solid Mechanics

Current experimental methods to measure mechanical properties of materials will be covered. Lectures include theoretical principles, measurement considerations, data acquisition and analysis techniques. Lectures are complemented by laboratory sections using research equipment such as biaxial testing machines, pressure myographs, indentation devices for different scales, and viscometers.

Credit 3 units.

Typical periods offered: Spring

MEMS 5507 Fatigue and Fracture Analysis

The course objective is to demonstrate practical methods for computing fatigue life of metallic structural components. The course covers the three major phases of metal fatigue progression: fatigue crack initiation, crack propagation and fracture. Topics include: stress vs. fatigue life analysis, cumulative fatigue damage, linear elastic fracture mechanics, stress intensity factors, damage tolerance analysis, fracture toughness, critical crack size computation and load history development. The course focus is on application of this technology to design against metal fatigue and to prevent structural failure.

Credit 3 units.

Typical periods offered: Fall

MEMS 5508 Image-Based Measurement of Shape, Motion, and Deformation

Many engineering analysis and design applications require the knowledge of how materials respond to applied loads. This course will provide an overview of various imaging and computer vision techniques to measure full-field object characteristics including shape, motion, and deformation. Selected topics will include basic geometrical optics, lenses and mirrors, single camera models and calibration, image processing, digital image correlation (in multiple dimensions), stereo vision, photogrammetry, strain calculations, and inverse methods. This course is intended for graduate and upper-level students interested in experimental solid mechanics and practical applications of image processing and analysis.

Credit 3 units.

Typical periods offered: Spring

MEMS 5510 Finite Element Analysis

This course covers the theory and application of the finite element method. Topics include basic concepts, generalized formulations, construction of finite element spaces, extensions, shape functions, parametric mappings, numerical integration, mass matrices, stiffness matrices and load vectors, boundary conditions, modeling techniques, computation of stresses, stress resultants and natural frequencies, and control of the errors of approximation.

Credit 3 units.

Typical periods offered: Spring

MEMS 5562 Cardiovascular Mechanics

This course focuses on solid and fluid mechanics in the cardiac and cardiovascular system. Cardiac and cardiovascular physiology and anatomy. Solid mechanics of the heart, heart valves, arteries, veins, and microcirculation. Flow through the heart chambers and blood vessels.

Credit 3 units.

Typical periods offered: Spring

MEMS 5564 Orthopaedic Biomechanics-Cartilage/Tendon

Basic and advanced viscoelasticity and finite strain analysis applied to the musculoskeletal system, with a primary focus on soft orthopaedic tissues (cartilage, tendon, and ligament). Topics include: mechanical properties of cartilage, tendon, and ligament; applied viscoelasticity theory for cartilage, tendon, and ligament; cartilage, tendon, and ligament biology; tendon and ligament wound healing; osteoarthritis. This class is geared to graduate students and upper level undergraduates familiar with statics and mechanics of deformable bodies.

Credit 3 units.

Typical periods offered: Spring

MEMS 5565 Mechanobiology of Cells and Matrices

At the interface of the cell and the extracellular matrix, mechanical forces regulate key cellular and molecular events that profoundly affect aspects of human health and disease. This course offers a detailed review of biomechanical inputs that drive cell behavior in physically diverse matrices. In particular, cytoskeletal force-generation machineries, mechanical roles of cell-cell and cell-matrix adhesions, and regulation of matrix deformations are discussed. Also covered are key methods for mechanical measurements and mathematical modeling of cellular response. Implications of matrix-dependent cell motility in cancer metastasis and embryonic development are discussed.

Credit 3 units.

Typical periods offered: Fall

MEMS 5566 Engineering Mechanobiology

Engineering Mechanobiology is a new paradigm for understanding and manipulating the biological function of plants, animals, and their cells. Mechanical force has emerged as a critical component of all biological systems, providing mechanisms to sculpt plants and animals during morphogenesis, to enable cell migration, polarization, proliferation, and differentiation in response to physical changes in the environment, and to modulate the function of single molecules. This course provides a foundation for understanding these factors across plant and animal cells. The course begins with an introduction to plant and animal cell biology and principles of signaling, then progresses to an overview of the cell wall and ECM and an introduction to the mechanics and statistical mechanics of solid, viscoelastic, and fibrous continua. The course then focuses on the questions of how do cells feel, how do cells converse with the ECM and wall, and how do cells remember? Knowledge of undergraduate calculus and physics is expected.

Credit 3 units.

Typical periods offered: Fall

MEMS 5601 Mechanical Behavior of Materials

A materials science based study of mechanical behavior of materials with emphasis on mechanical behavior as affected by processes taking place at the microscopic and/or atomic level. The response of solids to external or internal forces as influenced by inter atomic bonding, crystal/molecular structure, crystalline/non crystalline defects, and material microstructure will be studied. The similarities and differences in the response of different kinds of materials viz., metals and alloys, ceramics, polymers, and composites will be discussed. Topics covered include physical basis of elastic, visco elastic, and plastic deformation of solids; strengthening of crystalline materials; visco elastic deformation of polymers as influenced by molecular structure and morphology of amorphous, crystalline, and fibrous polymers; deformation and fracture of composite materials; mechanisms of creep, fracture and fatigue; high strain-rate deformation of crystalline materials; and deformation of non crystalline materials.

Credit 3 units.

Typical periods offered: Fall

MEMS 5602 Non-Metallics

Structure, mechanical, and physical properties of ceramics and cermets, with particular emphasis on the use of these materials for space, missile, rocket, high-speed aircraft, nuclear, and solid-state applications.

Credit 3 units.

Typical periods offered: Fall

MEMS 5603 Materials Characterization Techniques I

An introduction to the basic theory and instrumentation used in transmission electron, scanning electron, and optical microscopy. Practical laboratory experience in equipment operations, experimental procedures, and material characterization. Fundamentals, applications, and hands-on laboratory experience in transmission electron microscopy (TEM), scanning transmission electron microscopy (STEM), and scanning electron microscopy (SEM). Topics include wave optics of electrons, electron lenses and aberrations, electron-specimen interactions, electron diffraction theory, and quantitative elemental analysis using X-ray energy dispersive spectroscopy (XEDS) and electron energy loss spectroscopy (EELS).

Credit 3 units.

Typical periods offered: Fall, Spring

MEMS 5604 Materials Characterization Techniques II

Introduction to crystallography and elements of X-ray physics. Diffraction theory and application to materials science including following topics: reciprocal lattice concept, crystal-structure analysis, Laue methods, rotating crystal methods, powder method, and laboratory methods of crystal analysis.

Credit 3 units.

Typical periods offered: Fall, Spring

MEMS 5605 Mechanical Behavior of Composites

Analysis and mechanics of composite materials. Topics include micromechanics, laminated plate theory, hydrothermal behavior, creep, strength, failure modes, fracture toughness, fatigue, structural response, mechanics of processing, nondestructive evaluation, and test methods.

Credit 3 units.

Typical periods offered: Fall, Spring

MEMS 5606 Soft Nanomaterials

Soft nanomaterials, which range from self-assembled monolayers (SAMs) to complex 3D polymer structures, are gaining increased attention owing to their broad range applications. The course intends to introduce the fundamental aspects of nanotechnology pertained to soft matter. Various aspects related to the design, fabrication, characterization and application of soft nanomaterials will be discussed. Topics that will be covered include but not limited to SAMs, polymer brushes, Layer-by-Layer assembly, responsive polymers structures (films, capsules), polymer nanocomposites, biomolecules as nanomaterials and soft lithography.

Credit 3 units.

Typical periods offered: Spring

MEMS 5607 Introduction to Polymer Blends and Composites

The course covers topics in multicomponent polymer systems (polymer blends and polymer composites) such as: phase separation and miscibility of polymer blends, surfaces and interfaces in composites, microstructure and mechanical behavior, rubber toughened plastics, thermoplastic elastomers, block copolymers, fiber reinforced and laminated composites, techniques of polymer processing with an emphasis on composites processing, melt processing methods such as injection molding and extrusion, solution processing of thin films, selection of suitable processing methods and materials selection criteria for specific applications. Advanced topics include: nanocomposites such as polymer/CNT composites, bioinspired nanocomposites, and current research challenges.

Credit 3 units.

Typical periods offered: Spring

MEMS 5608 Introduction to Polymer Science and Engineering

Topics covered in this course are: the concept of long-chain or macromolecules, polymer chain structure and configuration, microstructure and mechanical (rheological) behavior, polymer phase transitions (glass transition, melting, crystallization), physical chemistry of polymer solutions (Flory-Huggins theory, solubility parameter, thermodynamics of mixing and phase separation), polymer surfaces and interfaces, overview of polymer processing (extrusion, injection molding, film formation, fiber spinning) and modern applications of synthetic and bio-polymers.

Credit 3 units.

Typical periods offered: Fall

MEMS 5610 Quantitative Materials Science & Engineering

This course will cover the mathematical foundation of primary concepts in materials science and engineering. Topics covered include mathematical techniques in materials science and engineering; Fourier series; ordinary and partial differential equations; special functions; matrix algebra; and vector calculus. Each topic will be followed by its application to concepts in thermodynamics; kinetics and phase transformations; structure and properties of hard and soft matter; and characterization techniques. This course is intended especially for students pursuing graduate study in materials science.

Credit 3 units.

Typical periods offered: Fall

MEMS 5611 Principles and Methods of Micro and Nanofabrication

A hands-on introduction to the fundamentals of micro- and nanofabrication processes with emphasis on cleanroom practices. The physical principles of oxidation, optical lithography, thin film deposition, etching and metrology methods will be discussed, demonstrated and practiced. Students will be trained in cleanroom

concepts and safety protocols. Sequential micro-fabrication processes involved in the manufacture of microelectronic and photonic devices will be shown. Training in imaging and characterization of micro- and nano-structures will be provided.

Credit 3 units.

Typical periods offered: Spring

MEMS 5612 Atomistic Modeling of Materials

This course will provide a hands-on experience using atomic scale computational methods to model, understand and predict the properties of real materials. It will cover modeling using classical force-fields, quantum-mechanical electronic structure methods such as density functional theory, molecular dynamics simulations, and Monte Carlo methods. The basic background of these methods along with examples of their use for calculating properties of real materials will be covered in the lectures. Atomistic materials modeling codes will be used to calculate various material properties.

Credit 3 units.

Typical periods offered: Spring

MEMS 5613 Biomaterials Processing

Biomaterials with 3D structures are important for tissue regeneration. The goal of this class is to introduce various types of biomaterials and fabrication approaches to create 3D structures. The relationship between material properties, processing methods, and design will be the primary focus. The topics include degradable biomaterials for scaffold fabrication, processing of tissue engineering scaffolds, processing of tissue engineering hydrogels, processing of drug delivery systems, and scaffold surface modification.

Credit 3 units.

Typical periods offered: Fall

MEMS 5614 Polymeric Materials Synthesis and Modification

Polymer is a class of widely used material. Polymer performance is highly dependent on its chemical properties. The goal of this class is to introduce methods for synthesis and modification of polymers with different chemical properties. The topics include free radical polymerization, reversible addition-fragmentation chain transfer polymerization, atom transfer radical polymerization, step growth polymerization, cationic polymerization, anionic polymerization, ring-opening polymerization, and bulk and surface modification of polymers.

Credit 3 units.

Typical periods offered: Spring

MEMS 5615 Metallurgy and Design of Alloys

The design of materials used in critical structures such as in airplanes entails optimizing and balancing multiple properties (e.g., strength, fracture toughness, corrosion resistance) to satisfy often conflicting requirements (e.g., better fuel efficiency, lower cost, operation in extreme conditions). Properties of metallic materials are determined by their microstructure, which in turn is determined by their compositions and processing paths. An understanding of the multivariate relationships among compositions, processing parameters, microstructures, and properties is therefore essential to designing alloys and predicting their behavior in service. This course will discuss these relationships, with emphasis on the hierarchy of microstructural features, how they are achieved by processing, and how they interact to provide desirable property combinations -- essentially the physical metallurgy of alloys. The discussion will be based on examples from alloys used in airframes, engines, and automobiles and on their design for state-of-the-art processes such as additive manufacturing.

Credit 3 units.

Typical periods offered: Spring

MEMS 5616 Defects in Materials

Defects in materials play a critical role in controlling the properties of solids, which makes them interesting and necessary to study. The objective of this course is to provide a broad overview of defects in crystalline solids, their effect on properties, and methods of characterizing them. Course topics include crystal structures, defect classification, defect interactions, the role of defects in controlling properties of materials, and characterization techniques.

Credit 3 units.

Typical periods offered: Spring

MEMS 5617 Advanced Study of Solid-State Electronics

This course is designed for students who want to pursue advanced study in solid-state materials and electronic applications. It will provide fundamentals of 1) basic solid-state physics 2) phase equilibria and fabrication of emerging solid-state materials: 3D thin films (III-V, III-N, complex oxide) and low dimensional materials (0D, 1D, 2D) 3) electrical and photonic properties and 4) property manipulation: doping and strain engineering. Students will learn various emerging solid-state electronic devices such as HEMT, nano-materials based TFT, QD LEDs, nanogenerators, advanced solar cells and more. The goal of this course is to help students understand fundamentals to design new solid-state device architectures. The course is particularly beneficial for students who have an interest in the emerging semiconductor field.

Credit 3 units.

Typical periods offered: Fall

MEMS 5618 Electronic Behavior of Materials

This course is designed for students who want to understand electronic behavior of materials which is related to electronic/semiconductor research and industry. It will provide fundamentals of 1) crystal structures and bonding of electronic materials, 2) electronic movement in various materials, 3) electronic behavior in junctions, 4) electronic, optic, and magnetic properties correlation, 5) various electronic applications such as solar cells, light-emitting diodes, and transistors. The goal of the course is to help students understand basic knowledge and fundamental about electronic behavior in materials. The course is particularly beneficial for students who have an interest in the semiconductor research and industry.

Credit 3 units.

Typical periods offered: Fall

MEMS 5619 Thermodynamics of Materials

Thermodynamics of mixtures and phase equilibria in materials systems. The course will review the laws of thermodynamics and introduce the principles of statistical mechanics along with thermodynamic variables and the relationships between them. It will cover thermodynamic equilibria in unary and multicomponent systems along with the construction of phase diagrams. The use of thermodynamics for understanding surfaces and interfaces, defects, chemical reactions, and other technical applications will be emphasized.

Credit 3 units.

Typical periods offered: Fall

MEMS 5620 Kinetics of Materials

This course offers an in-depth exploration of phase formation and transformation in solids and liquids. Key topics include equilibrium and non-equilibrium thermodynamics, equilibrium and metastable phase diagrams, nucleation and growth, diffusion and interface-limited processes, shear-type transformations, and order/disorder transformations. Additionally, the course will examine essential



deposition tools, such as physical vapor deposition (PVD) and chemical vapor deposition (CVD), applying fundamental kinetic principles to materials growth. Discussions will encompass a range of materials, from conventional to emerging.

Credit 3 units.

Typical periods offered: Spring

MEMS 5621 Materials Selection in Design

Analysis of the scientific bases of material behavior in the light of research contributions of the last 20 years. Development of a rational approach to the selection of materials to meet a wide range of design requirements for conventional and advanced applications. Although emphasis will be placed on mechanical properties, acoustical, optical, thermal and other properties of interest in design will be discussed.

Credit 3 units.

Typical periods offered: Fall

MEMS 5700 Aerodynamics

This course introduces fundamental concepts of aerodynamics, equations of compressible flows, irrotational flows and potential flow theory, singularity solutions, circulation and vorticity, the Kutta-Joukowski theorem, thin airfoil theory, finite wing theory, slender body theory, subsonic compressible flow and the Prandtl-Glauert rule, supersonic thin airfoil theory, an introduction to performance, and basic concepts of airfoil design.

Credit 3 units.

Typical periods offered: Spring

MEMS 5701 Aerospace Propulsion

Propeller, jet, ramjet and rocket propulsion. Topics include: fundamentals of propulsion systems, gas turbine engines, thermodynamics and compressible flow, one-dimensional gas dynamics, analysis of engine performance, air breathing propulsion system, the analysis and design of engine components, and the fundamentals of ramjet and rocket propulsion.

Credit 3 units.

Typical periods offered: Spring

MEMS 5703 Analysis of Rotary-Wing Systems

This course introduces the basic physical principles that govern the dynamics and aerodynamics of helicopters, fans and wind turbines. Simplified equations are developed to illustrate these principles, and the student is introduced to the fundamental analysis tools required for their solution. Topics include: harmonic balance, Floquet theory and perturbation methods.

Credit 3 units.

Typical periods offered: Fall

MEMS 5704 Aircraft Structures

Basic elements of the theory of elasticity; application to torsion of prismatic bars with open and closed thin-wall sections; the membrane analogy; the principle of virtual work applied to 2D elasticity problems. Bending, shear and torsion of open and closed thin-wall section beams; principles of stressed skin construction, structural idealization for the stress analysis of wings, ribs and fuselage structures. Margin of safety of fastened connections and fittings. Stability of plates, thin-wall section columns and stiffened panels. Application of the finite element method for the analysis of fastened connections, structural fittings and problems of local stability of aircraft structural components.

Credit 3 units.

Typical periods offered: Fall

MEMS 5705 Wind Energy Systems

A comprehensive introduction to wind energy systems, a practical means of extracting green and sustainable energy. Topics include: a historical perspective of wind turbines; horizontal axis and vertical axis wind turbines; the basic parameters such as power rating and efficiency; the structural components ranging from blade and hub to nacelle and tower; wind turbine aerodynamics, aeroelasticity and control systems; blade fatigue; statistical wind modeling; unsteady airfoil aerodynamics and downstream wake; and environmental considerations such as noise and aesthetics.

Credit 3 units.

Typical periods offered: Spring

MEMS 5706 Aircraft Performance

This course introduces the principles and applications of aerodynamics to determine the performance of typical jet engine and propeller airplanes. The performance calculations include flight conditions of takeoff, climb, level flight, and landing. The topics covered also include range and endurance computation, turning flight, flight envelope, constraint analysis and design process. The knowledge and skill gained in this course can be readily applied in the preliminary design of an airplane.

Credit 3 units.

Typical periods offered: Spring

MEMS 5707 Flight Dynamics

The course objective is to introduce methods for analyzing and simulating flight vehicle dynamics and to assess performance characteristics. Topics will include: aerodynamics, structural dynamics, vehicle forces and moments, vehicle equations of motion, rigid body and flexible body considerations, model linearization, longitudinal and lateral stability, stability and control augmentation, and aircraft handling qualities. The course focus is on the application of flight dynamics principles and MATLAB will be used extensively for modeling and simulation assignments and demonstrations.

Credit 3 units.

Typical periods offered: Fall

MEMS 5708 Aircraft Design

This course is a survey of the Roskam method of aircraft design. Students will learn how to balance aerodynamics, structures, propulsion, and stability and control to develop an aircraft suited to perform a given mission profile while conforming to given set of requirements. Also covered are weight estimation and manufacturability and how to utilize historical aircraft data to guide the design of future aircraft. The course is intended to prepare students to better compete in design and design, build and fly competitions in addition to being better prepared to work in any aspect of the aerospace industry.

Credit 3 units.

Typical periods offered: Fall

MEMS 5801 Micro-Electro-Mechanical Systems I

Introduction to MEMS: Microelectromechanical systems (MEMS) are ubiquitous in chemical, biomedical, and industrial (e.g., automotive, aerospace, printing) applications. This course will cover important topics in MEMS design, micro-/nanofabrication, and their implementation in real-world devices. The course will include discussion of fabrication and measurement technologies (e.g., physical/chemical deposition, lithography, wet/dry etching, and packaging), as well as application of MEMS theory to design/fabrication of devices in a cleanroom. Lectures will cover specific processes and how those processes enable the structures needed

for accelerometers, gyros, FR filters, digital mirrors, microfluidics, micro total-analysis systems, biomedical implants, etc. The laboratory component will allow students to investigate those processes first-hand by fabricating simple MEMS devices.

Credit 3 units.

Typical periods offered: Fall

MEMS 5802 Micro-Electro-Mechanical Systems II

A second course in MEMS. Topics include: physical microsystems, pressure sensors, accelerometers, microfluids and micro-scale thermal phenomena, electroosmotic flows, microvalves, micropumps, optical MEMS, active flow control, system and constraints on microsystem design, compliant mechanisms, microfabricated electrochemical sensors, bio-MEMS and case studies.

Credit 3 units.

Typical periods offered: Fall

MEMS 5803 Nanotechnology Concepts and Applications

The aim of this course is to introduce to students the general meaning, terminology and ideas behind nanotechnology and its potential application in various industries. The topics covered will include nanoparticles - properties, synthesis and applications, carbon nanotubes - properties, synthesis and applications, ordered and disordered nanostructured materials and their applications, quantum wells, wires and dots, catalysis and self-assembly, polymers and biological materials, nanoelectronics and nanophotonics, nanomanufacturing and functional nano-devices, health effects and nanotoxicity etc. Students with background in general physics, chemistry and biology should be able to comprehend the material.

Credit 3 units.

Typical periods offered: Summer

MEMS 5910 Biomechanics Journal Club

This journal club is intended for graduate students and advanced undergraduates with an interest in biomechanics. We will review landmark and recent publications in areas such as brain, cardiovascular and orthopedic biomechanics, discussing both experimental and modeling approaches. This course will meet once weekly at a time to be arranged.

Credit 1 unit.

Typical periods offered: Fall

MEMS 5999 Independent Study

Independent investigation on topic of special interest. Students must complete the Independent Study Approval Form available in the department office.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

MEMS 6998 Masters Project

This course entails an independent research investigation on a topic of special interest to project-track students. It is restricted to students enrolled in the Master of Science in Mechanical Engineering, Master of Science in Aerospace Engineering, or Master of Science in Materials Science and Engineering programs. Students must have a faculty supervisor and complete and submit the required registration forms prior to enrollment.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

MEMS 6999 Energy Analysis and Design Project

The Energy Analysis and Design Project is designed to provide mechanical engineering skills in energy applications, renewable energy, and technologies related to energy which can involve heat transfer, thermodynamics, and fluid mechanics. The project topic can be chosen by the student or can be developed by both the student and faculty sponsor. The subsequent research and analysis, conducted under the guidance and direction of the faculty sponsor, results in a final project report that is approved by the faculty sponsor. The course is normally completed over one or two semesters. Recent projects have included: Energy Modeling and Efficiency Improvements: A Comparison of TRACE 700 and eQuest, Analysis of Hydroelectric Power, Optimization of Residential Solar Thermal Heating in the United States, Analysis of Ocean Thermal Energy Conversion Systems, Laboratory Plug Load Analysis and Case Study, Modeling and Optimizing Hydronic Radiant Heating and Cooling Systems using Comsol Multiphysics, CFD Analysis in HVAC Applications, Energy Analysis of Waste Disposal Methods, CFD Analysis of Containment Solutions for Data Center Cooling, Energy Recovery Ventilation, Comparative Study of Green Building Rating Systems, Grid Energy Storage, Protection of Permafrost Under the Qinghai-Tibet Railway by Heat Pipe Technology, Investing in Residential Solar Photovoltaic Systems, How Piping Layout Effects Energy Usage, and Comparison of Building Energy Savings Between China and the United States.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

MEMS 7998 Masters Research

Independent research investigation on a topic of special interest for thesis-track students. This course is restricted to students enrolled in the Master of Science in Mechanical Engineering, Master of Science in Aerospace Engineering, or Master of Science in Materials Science and Engineering. Students must complete and submit required registration forms prior to enrollment.

Credit 6 units.

Typical periods offered: Fall, Spring, Summer

MEMS 8000 MEMS Research Experience for First-Year PhD Students

Independent research project that will be determined jointly by the doctoral student and the instructor. Assignments may include background reading, presentations, experiments, theoretical, and/or modeling work. The goal of the course is for the doctoral student to learn the background, principles, and techniques associated with research topics of interest and to determine a mutual fit for the student's eventual doctoral thesis laboratory.

Credit 3 units.

Typical periods offered: Fall, Spring

MEMS 8998 Doctoral Research

This course is designed for doctoral candidates to conduct advanced, original research in their field of study, leading to the completion of their dissertation. Students will engage in in-depth literature reviews, formulate research questions, develop and implement research methodologies, collect and analyze data, and write their dissertation under the guidance of their faculty advisor and dissertation committee. The course emphasizes critical thinking, scholarly integrity, and the advancement of knowledge. Regular meetings with the advisor and periodic progress reports are required. Successful completion is necessary for the awarding of the doctoral degree.

Credit 9 units.

Typical periods offered: Fall, Spring, Summer

Mechanical Engineering, PhD (MEMS)

Degree Requirements

The Mechanical Engineering doctoral degree requires a minimum of 72 credits beyond the bachelor's degree, with a minimum of 36 credits being graduate coursework (including the MEMS curriculum requirements as outlined in the MEMS Doctoral Handbook) and a minimum of 24 credits of doctoral thesis research. To be admitted to candidacy, students must have an overall GPA of 3.0 or higher and pass the qualifying examination. All students are required to enroll in the department seminar every semester.

At most, 6 units of coursework may be taken as graduate independent study, and a maximum of 6 units of 4000-level courses are allowed (these must be from courses not required for the BS degree). Please refer to the MEMS Doctoral Handbook for more guidance on course requirements. Graduate courses may be transferred in (up to 24 credits) but must be evaluated and approved by the Director of Graduate Studies.

Students enroll in two to three courses each semester and participate in a First Year Research Experience during the first two semesters of their program. They must complete their qualifying examination no later than May 31 (December 16 for Spring admissions) of their first year. During their second year, students complete their remaining courses and must complete their thesis proposal prior to the start of their fifth semester.

After a successful proposal defense, students provide their research updates through annual meetings with their thesis committee. Upon completion of their dissertation, typically in year 5, students must present their dissertation research in a public forum and successfully defend the dissertation before their thesis committee. At least one published article is required at the time of defense.

For more detailed guidelines, please refer to the MEMS Doctoral Handbook available on the MEMS PhD program webpage.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

Over the course of their PhD program, doctoral students in MEMS are expected to make novel advances in an area or topic in mechanical engineering through innovative and impactful research. Simultaneously, our goal is to prepare MEMS PhD graduates to thrive in various careers in academia, industry, government, or other research-oriented sectors. To maximize their impact in such careers, our students must also learn to communicate both fundamental concepts and novel research findings to a variety of audiences: co-workers, clients and trainees of divergent backgrounds. These careers also require the ability to assess the accuracy and value of others' technical work. Our MTE program seeks to instill these skills through the MTE program requirements described below.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Two McKelvey instructional trainings are required:

1. McKelvey Teaching Orientation
2. McKelvey Teaching Workshop

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

MEMS requires one AI assignment at 10 MER units to be completed during the student's third year of residency. Students work with their advisors and the Director of Undergraduate Studies on the timing and content of their MTE assignment.

Required Pathways for Completion

- Preparatory Engagement

EGS 8010

Take once

Materials Science & Engineering, PhD (IMSE)

The Materials Science and Engineering doctoral degree requires a minimum of 72 credits beyond the bachelor's degree, with a minimum of 36 credits being graduate coursework (including the IMSE curriculum requirements as outlined in the IMSE Doctoral Handbook) and 18 to 36 credits of doctoral thesis research. To be admitted to candidacy, students must have an overall GPA greater than 3.0, have no more than one grade of B- or below in a core course or IMSE elective, and pass the qualifying examination. All students are required to enroll in the department seminar every semester.

At most, 12 credits of 4000-level courses may be applied toward the required 36 academic credit. Graduate courses may be transferred in (up to 24 credits) but must be evaluated and approved by the IMSE Graduate Studies Committee.

In their first year, students enroll in two to three courses each semester and participate in two semesters of a First Year Research Experience course, as outlined in the Doctoral Handbook. They complete their qualifying examination in summer following their first academic year. During their second and third years, students complete their remaining courses and complete their thesis proposal in their fifth semester of study.

After a successful proposal defense, students should provide their research updates through annual meetings with their Research Advisory Committee. Upon completion of their dissertation, students must successfully defend the dissertation before their Dissertation Committee.

For more detailed guidelines, please refer to the IMSE Doctoral Handbook available on the IMSE PhD program webpage.

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as MERs.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

Materials scientists and engineers work at the interface between the fundamental physical sciences and application-oriented disciplines. As such, they often need to translate between underlying physical principles governing the performance of a material and the design requirements of a system or device. This translation is inherently two-way; the emergent properties of novel materials enable new, potentially transformative applications, and new devices often require materials with unique (and challenging) property profiles. To facilitate this two-way translation, our PhD graduates must be able to communicate both fundamental and applied concepts to a variety of audiences, including supervisors, subordinates, clients, and co-workers, whose familiarity with the MSE field may range from novice to expert. Moreover, mentored teaching experiences instill a sense of responsibility, professionalism, and ethical conduct, preparing students to navigate the complex landscape of academia, industry, government, or other research-oriented sectors with confidence and integrity.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Two preparatory workshops are required:

1. McKelvey Teaching Orientation (Canvas Course)
2. McKelvey Teaching Workshop (Canvas Course)

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

Students will AI for two semesters at 10 MER units for a total of 20 units. Students work with their faculty mentor on the timing and content of those assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement

EGS 8010

Take two times

Mechanical Engineering, MSME (MEMS)

Thesis Option

The quantitative requirement for the degree is 30 credit units. A minimum of 24 of these units must be coursework, and a minimum of 6 units must be MEMS 7998 Masters Research.

The overall grade point average must be 2.70 or better.

Courses may be chosen from 4000- and 5000-level offerings with the following restrictions:

- No more than 3 units total of Independent Study (MEMS 4999 Independent Study or MEMS 5999 Independent Study) are allowed.
- A maximum of 6 units of 4000-level courses are allowed, and these must be from courses not required for the BSME degree (if counted for the MSAE) or not required for the BSAE degree (if counted for the MSME degree), with the exception of MEMS 4320 Modeling, Simulation and Control, which can count toward the MS.
- Each course must be approved by the candidate's thesis advisor.
- A maximum of 6 units of transfer credit with a grade of B or better are allowed for courses taken at other graduate institutions.
- A minimum of 15 units of the total 30 units must be in MEMS courses.
- Courses offered outside of the McKelvey School of Engineering and courses offered by the Sever Institute (with the course prefixes CNST, CYBER, ETEM, and INFO) are not permitted, unless they are approved in advance and in writing by the MS program advisor.

The student must also write a satisfactory thesis and successfully defend it in an oral examination before a faculty committee consisting of at least three members, at least two of which are from the Department of Mechanical Engineering & Materials Science.

Full-time MS students in any area are required every semester to take MEMS 5000 Graduate Seminar, which is a 0-unit, Pass/No Pass course.

Course Option

The quantitative requirement for the degree is 30 credit units (normally 10 courses) completed with a grade point average of 2.70 or better.

Course credits must conform to the following distribution:

Applied Mathematics	6 credits
Area of Specialization	15 credits
Electives	9 credits

Elective courses may be chosen in any area of engineering or mathematics at the 4000 level or higher. Of the 30 units, a minimum of 24 must be in 5000-level courses. No more than 6 units may be in 4000-level courses; core requirements for the ME undergraduate degree are not allowed, with the exception of MEMS 4320 Modeling, Simulation and Control, which is allowed. No more than 3 units total of Independent Study (MEMS 4999 Independent Study or MEMS 5999 Independent Study) may be used as an elective. A minimum of 15 units must be in MEMS. Courses offered outside of the McKelvey School of Engineering and courses offered by the Sever Institute (with the course prefixes CNST, CYBER, ETEM, and INFO) are not permitted, unless they are approved in advance and in writing by the MS program advisor.

Full-time MS students in any area are required every semester to take MEMS 5000 Graduate Seminar, which is a 0-unit, Pass/No Pass course.



Degree candidates will plan their course programs with the help of a departmental advisor. Use the link below to find courses in the areas of specialization.

Engineering Areas of Specialization for the MS in Mechanical Engineering

- Applied Mechanics
- Dynamics/Mechanical Design
- Solid Mechanics/Materials Science
- Fluid/Thermal Sciences
- Energy Conversion and Efficiency

Refer to the MS Degree Course Options [PDF] for additional information.

Aerospace Engineering, MSAE (MEMS)

Thesis Option

The quantitative requirement for the degree is 30 credit units. A minimum of 24 of these units must be coursework, and a minimum of 6 units must be Masters Research (MEMS 7998 Masters Research).

The overall grade point average must be 2.70 or better.

Courses may be chosen from 4000- and 5000-level offerings. All must be engineering, math- or science courses with the following restrictions:

- No more than 3 units total of Independent Study (MEMS 4999 Independent Study or MEMS 5999 Independent Study) are allowed.
- A maximum of 6 units of 4000-level courses are allowed, and these must be from courses not required for the BSME degree (if counted for the MSAE) or not required for the BSAE degree (if counted for the MSME degree), with the exception of MEMS 4320 Modeling, Simulation and Control, which is allowed.
- Each course must be approved by the candidate's thesis advisor.
- A maximum of 6 units of transfer credit with a grade of B or better are allowed for courses taken at other graduate institutions.
- A minimum of 15 units of the total 30 units must be in MEMS courses.

The student must also write a satisfactory thesis and successfully defend it in an oral examination before a faculty committee consisting of at least three members, at least two of which are from the Department of Mechanical Engineering & Materials Science.

Full-time MS students in any area are required every semester to take MEMS 5000 Graduate Seminar, which is a 0-unit, Pass/No Pass course.

Course Option

The quantitative requirement for the degree is 30 credit units (normally 10 courses) completed with a grade point average of 2.70 or better.

Course programs must be focused in the area of aerospace engineering. They must conform to the following distribution:

Applied Mathematics	6 credits
Aerospace	15 credits
Electives	9 credits

Elective courses may be used to accumulate additional credits in other areas of engineering or in mathematics. No more than 3 units total of Independent Study (MEMS 4999 Independent Study or MEMS 5999 Independent Study) may be included as an elective course. A maximum of 6 units of 4000-level courses are allowed for the MSME or MSAE degree, and these must be from courses not required for the BSME degree (with the exception of MEMS 4320 Modeling, Simulation and Control, which is allowed). Non-engineering courses (e.g., T-courses, finance or entrepreneurship courses) cannot be counted as engineering electives. A minimum of 15 units must be in MEMS.

Full-time MS students are required to take MEMS 5000 Graduate Seminar, which is a 0-unit, Pass/No Pass course.

Degree candidates will plan their course programs with the help of a departmental advisor.

Materials Science & Engineering, MS (MEMS)

Thesis Option

The quantitative requirement for the degree is 30 credit units. A minimum of 24 of these units must be course credit, and a minimum of 6 units must be MEMS 7998 Masters Research. A minimum of 15 units of the total 30 units must be in MEMS courses.

The overall grade point average must be 2.70 or better.

Every semester, full-time MS students in Materials Science and Engineering (MSE) are required to take either the department's Graduate Seminar (MEMS 5000 Graduate Seminar) or the Graduate Seminar offered by the Institute of Materials Science & Engineering (IMSE 8997 IMSE Graduate Seminar). These are 0-unit, Pass/No Pass courses.

Degree candidates will plan their programs with the help of their thesis advisor. Courses are to be Engineering courses at the 5000 level or above, or they may be Chemistry; Earth, Environmental, and Planetary Science; or Physics courses at the 4000 level or above. Course credit must include at least 12 units (four courses) from a list of approved materials-focused courses (PDF) as well as 3 units (one course) of mathematics at the graduate level. The following restrictions apply:

- A maximum of 3 units of MEMS 5999 Independent Study are allowed.
- A maximum of 6 units of 4000-level courses are allowed.
- Each course must be approved by the candidate's thesis advisor.
- A maximum of 6 units of transfer credit with a grade of B or higher are allowed for courses taken at other graduate institutions.
- For the combined bachelor's/master's program, up to 6 units can count for both the BS and the MS, as long as the program of study satisfies the criteria above.

The student must also write a satisfactory thesis and successfully defend it in an oral examination before a faculty committee consisting of at least three members, at least two of which are from the Department of Mechanical Engineering & Materials Science.

Course Option

The quantitative requirement for the degree is 30 credit units (normally 10 courses). A minimum of 15 units of the total 30 must be in MEMS courses.

The overall grade point average must be 2.70 or better.

Every semester, full-time MSE students are required to take either the department's Graduate Seminar (MEMS 5000 Graduate Seminar) or the Graduate Seminar offered by the Institute of Materials Science & Engineering (IMSE 8997 IMSE Graduate Seminar). These are 0-unit, Pass/No Pass courses.

Degree candidates will plan their programs with the help of their faculty advisor. Courses are to be engineering, math, or science courses at the 4000 level or above (with the restrictions described below) or Chemistry; Earth, Environmental, and Planetary Science; or Physics courses at the 4000 level or above. Course credit must include at least 18 units (six courses) from a list of approved materials-focused courses (PDF) as well as 3 units (one course) of mathematics at the graduate level. The following restrictions apply:

- A maximum of 3 units of MEMS 5999 Independent Study are allowed.
- A maximum of 6 units of 4000-level courses are allowed. The 4000-level courses cannot be required courses for the student's undergraduate degree.

- A maximum of 6 units of transfer credit with a grade of B or better are allowed for courses taken at other graduate institutions.
- For the combined bachelor's/master's program, up to 6 units can count for both the BS and the MS, as long as the program of study satisfies the criteria above.

The remaining courses (electives) may be chosen according to the general criteria above, as long as they contribute to a coherent program of study in materials science.

Mechanical Engineering, MEng (MEMS)

The Master of Engineering in Mechanical Engineering (MEng in ME) is a one- to two-year program offered by the Department of Mechanical Engineering & Materials Science of Washington University in St. Louis. The program is especially tailored for 1) individuals without an ME or AE degree who plan to change careers and enter the ME profession; 2) international students seeking to establish U.S. credentials in the ME profession; and 3) current professionals working in ME who wish to advance their skills and education. A distinctive feature of the program is the ability to customize the course content to meet specific individual needs.

Degree Requirements

Candidates for admission should have an undergraduate degree in engineering, the physical sciences or mathematics, with a grade point average of 2.75 or better.

Note: It should be emphasized that, in many states, the MEng in ME will not be sufficient to qualify the degree recipient to sit for a professional engineering exam.

- 30 units of credit in engineering or mathematics courses are required, and these must be at the 4000 level or higher. Courses from the other engineering departments (CSE, EECE, ESE, and BME) are encouraged, but at least 15 of the 30 units must be in MEMS. Courses offered outside of the McKelvey School of Engineering and courses offered by the Sever Institute (with the course prefixes CNST, CYBER, ETEM, and INFO) are not permitted unless they are approved in advance and in writing by the MS program advisor.
- All courses must be taken for a grade, with an overall GPA of 2.70 or higher required.
- At least 9 of the 30 units must be in MEMS courses at the 5000 level.
- All 4000-level courses must be either 1) approved for the Master of Science in Mechanical Engineering (ME) or Aerospace Engineering (AE); or 2) approved by the MEMS faculty for application toward the MEng degree.
- No more than 6 units of independent study are allowed.



- No more than 6 units may be transferred from another university. These units must be in engineering or math courses at the 4000 level or above with a grade of B or better, and the courses must not be required for the candidate's BS degree.

Full-time MS students in any area are required to take MEMS 5000 Graduate Seminar every semester. This is a 0-unit, Pass/No Pass course.

Henry Edwin Sever Institute

With the Sever Institute's flexible schedules, both new and experienced professionals can keep their careers moving forward while developing the knowledge and credentials that will set them apart. Our graduate students seek to lead the way in making an impact on the wide range of organizational and technical opportunities and challenges in engineering, information technology, cybersecurity, construction, and complex operational environments. The experientially-driven curriculum and course work will increase students' knowledge and expertise. Those who complete our programs are prepared to step into leadership roles and make a real difference in both their organizations and the world.

Degree Programs

- Master of Construction Management (p. 138)
- Master of Cybersecurity Management (p. 141)
- Master of Engineering Management (p. 144)
- Master of Information Systems Management (p. 148)

Online Degree Programs

- Online Master of Cybersecurity Management (p. 151)
- Online Master of Engineering Management (p. 154)

Graduate Certificates

- Graduate Certificate in Construction Management (p. 157)
- Graduate Certificate in Cybersecurity Management (p. 159)
- Graduate Certificate in Engineering Management (p. 162)
- Online Graduate Certificate in Cybersecurity Management (p. 165)

Email: sever@wustl.edu
Website: <https://sever.wustl.edu>

Degree Programs

Master of Construction Management

The Master of Construction Management (MCM) is a 30-unit part-time program designed to enhance leadership, management, and technical capabilities while providing experience to relevant best practices and technologies for professionals in the built environment. The curriculum augments project-based learning with interdisciplinary teamwork for an authentic experiential learning experience.

Washington University students pursue the MCM to augment their primary area of study, including students from the Sam Fox College of Architecture (Master of Architecture + Master of Construction Management [MArch/MCM] dual degree program); the McKelvey School of Engineering (Engineering BS/MCM); and the Sever Institute (MEM/MCM dual degree).

- **Part-time Master's Degree:** 30 units

The Master of Architecture + Master of Construction Management (MArch/MCM) dual degree program is an interdisciplinary collaboration between Washington University's College of Architecture and McKelvey Engineering's Construction Management Program. The program prepares architectural students for diverse roles within today's multidisciplinary design and construction process.

Throughout the program, students learn theories in combination with real-world applications, thus strengthening their management acumen, collaborative problem-solving, interpersonal communication, and leadership competencies. Graduates become leaders and integrators capable of facing the challenges and opportunities in today's built environment.

In this program, the School of Architecture accepts 9 credit units earned in McKelvey's MCM program toward the MArch degree. In the same way, McKelvey Engineering accepts 9 credit units earned in the College of Architecture toward the MCM degree, so long as the MCM degree is finished at the same time or immediately following the completion of the MArch degree.

More information can be found on the Master of Architecture + Master of Construction Management Dual Degree Program page of the Sever Institute website.

Email: sever@wustl.edu
Website: <https://sever.wustl.edu/degree-programs/construction/index.html>

Faculty

Program Director

Steve W. Bannes

Director of Graduate Studies, Construction Management

Professor of Practice

MS, Education, Southwest Baptist University

BS, Construction Engineering & Management, Southern Illinois University Edwardsville

For a list of our program faculty, please visit our website.

Requirements

- Master of Construction Management (p. 140)
- Master of Construction Management/Master of Architecture (p. 140)

Courses

CNST 5532 Specialized Topics in Construction Estimating

This course explores the application of cost estimating principles and estimating within a project management framework in conjunction with scope definition, quality control, planning and scheduling, risk management and loss prevention techniques, local conditions, information and communication, and working relations with stakeholders. Using a single building project, the course introduces the application of basic quantity surveying and estimating principles using a methodical approach with suggested check lists and techniques for arriving at a reliable cost estimate including direct, indirect, and contingency costs and profits. Student's estimating efforts culminate with a competitive bid day scenario.

Credit 3 units.

Typical periods offered: Fall, Spring

CNST 5550 Site Infrastructure Construction Strategies

This course provides a broad perspective of the means, methods, and procedures associated with managing civil engineering and heavy construction projects. Topics include strategic bidding and estimating, heavy equipment, marine construction heavy civil operations and bridge building. Integration of scheduling, estimating, and construction contracts with a project based approach. *There will be a \$60 fee for use of the required licensed software used in this class.*

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5572 Legal Aspects of Construction

A survey of the legal problems of the construction manager, including but not limited to liability in the areas of contracts, agency, torts, insurance, bad judgment and oversight.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5573 Fundamentals in Construction Management

In this course, students will be exposed to the overall construction process from initial concept through startup of the completed facility. The focus is to provide familiarization of the construction and contracting process and potential involvements by construction

managers in the planning, design, construction, and post construction phases. Additional topics are introduced to provide a foundation which will prepare students for future construction management coursework. Case studies and industry examples are used throughout the course to authenticate the lectures and assignments.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5574 Construction Project Planning and Scheduling

Project planning and scheduling process utilizing current techniques including critical path analysis for effective and logical scheduling of construction projects. Identification of project activities and their relationships; schedule development, analysis, and updating; relationship of project costs and resources to the schedule; legal implications; effective communication of schedule information; development of procedures to monitor actual field progress; computer application in project scheduling.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5579 Advanced Construction Management

A comprehensive study of the operations encountered in the management of a construction firm. Topics include estimating, scheduling, forms of contracts, risk analysis and management, extra work orders, claims and disputes, construction safety, and contract close-out.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5580 Digital Construction Technology: Principles and Practices

This course focuses on BIM's philosophy of integration between designers, construction professional, and owners, in order to overcome both technological and implementation changes using Virtual Design and Construction (VDC) and Integrated Project Delivery (IPD). VDC is a methodology that relies on a multidisciplinary collaboration of the digital simulation of design & construction. IPD, on the other hand, integrates people, systems, business structures and practices into a process to optimize efficiency and productivity. In this course, students will learn about BIM's application by exploring 3D, 4D aspects of BIM including geometry, spatial relationships, quantity take off, estimation and scheduling. Along with that, students also will learn about Virtual Design and Construction (VDC) and Integrated Project Delivery (IPD) system that are integral component of a successful BIM projects.

Credit 3 units.

Typical periods offered: Fall, Spring

CNST 5981 MCM - M.Arch Capstone Project Phase 1

In the capstone course sequence (CNST 5981 and CNST 5982), M.Arch + MCM dual degree program students apply constructability principles to their ARCH 7520: Degree Project and successfully demonstrate their application. Constructability principles include analysis of construction methods and procedures, as well as project cost, time, value, quality, and safety. Phase 1 students will develop a Constructability Review, Analysis, and Plan (CAAP) for their project. The CAAP is a plan to focus and guide the work in CNST 5982 – Phase 2. It includes: · Identification of the specific constructability issue(s) you will evaluate (assess/analyze). · Methodology to be used in gathering information and conducting the analysis · Identification of the Phase 2 deliverables After completing CNST 5981, students will enroll and complete CNST 5982.

Credit 1 unit.

Typical periods offered: Fall, Spring, Summer



CNST 5982 MCM - M.Arch Capstone Project Phase 2

In the capstone course sequence (CNST 5981 and CNST 5982), M.Arch + MCM dual degree program students apply constructability principles to their ARCH 7520: Degree Project and successfully demonstrate their application. Constructability principles include analysis of construction methods and procedures, as well as project cost, time, value, quality, and safety. Students will enroll and complete CNST 5982 – Phase 2 in the semester following ARCH 7520: Degree Project and completion of CNST 5981. CNST 5982 – Phase 2 students will execute the Constructability Review, Analysis, and Plan (CAAP) developed in CNST 5981 – Phase 1. This work will be incorporated into the final report, the Constructability Review and Analysis (CRA) Report. It will include: · The Constructability Review and Analysis, and · Results/Conclusions – Lessons learned
Credit 2 units.

Typical periods offered: Fall, Spring, Summer

CNST 5998 Applied Research Study

Applied Research Study (ARS) is an advanced, project-based course designed to allow students to develop in-depth knowledge and further their education building on the education offered in the Programs. Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education, and society. Students collaborate with an adjunct faculty advisor to collect data. Findings are applicable and may be implemented upon completion of a study. Applied research focuses on answering one specific applied research question for a client or sponsor. Applied Research Study must have prior approval of a faculty sponsor and the Program Director.
Credit 3 units.

Typical periods offered: Fall, Spring, Summer

Master of Construction Management (Sever)

Total units required: 30

In order to earn the degree, all courses must be passed with a C– or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the degree.

Code	Title	Units
Required: 18 units		
CNST 5532	Specialized Topics in Construction Estimating	3
CNST 5572	Legal Aspects of Construction	3
CNST 5573	Fundamentals in Construction Management	3
CNST 5574	Construction Project Planning and Scheduling	3
CNST 5579	Advanced Construction Management (Capstone)	3

ETEM 5587	Communication Excellence for Influential Leadership	3
Electives: Choose 12 units		
Technology		
CNST 5580	Digital Construction Technology: Principles and Practices	3
CYBER 5559	Introduction to Cybersecurity	3
INFO 5509	Fundamentals of Information Technology	3
INFO 5575	Enterprise Data Management	3
Project Management		
ARCH 4340	Structures I	3
ARCH 4350	Structures II	3
CNST 5550	Site Infrastructure Construction Strategies	3
ETEM 5510	Understanding Emerging & Disruptive Technologies	3
ETEM 5531	Introduction to Agile Project Management	3
ETEM 5532	The Art & Science of Risk Management	3
Leadership		
ETEM 5581	Leading in a Technology-Rich World	3
ETEM 5582	Human Performance in the Organization	3
ETEM 5586	Cross-Cultural Negotiation	3
ETEM 5600	Supply Chain for Engineering Managers	3

Master of Construction Management/ Master of Architecture (Sever)

Total units required: 30 (21 McKelvey School of Engineering units and 9 units of Architecture courses)

In order to earn the degree, all courses must be passed with a C– or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the degree.

Code	Title	Units
Required: 9 units MCM-MArch shared		
CNST 5532	Specialized Topics in Construction Estimating	3
CNST 5573	Fundamentals in Construction Management	3
CNST 5574	Construction Project Planning and Scheduling	3



+12 Required MCM units		
CNST 5572	Legal Aspects of Construction	3
CNST 5981 & CNST 5982	MCM - M.Arch Capstone Project Phase 1 and MCM - M.Arch Capstone Project Phase 2	3
or CNST 5998	Applied Research Study	
ETEM 5587	Communication Excellence for Influential Leadership	3
Elective: 3 units, choose from list below		3
Elective: Choose one course for 3 units		
Technology		
CNST 5580	Digital Construction Technology: Principles and Practices	3
CYBER 5559	Introduction to Cybersecurity	3
ETEM 5510	Understanding Emerging & Disruptive Technologies	3
INFO 5509	Fundamentals of Information Technology	3
INFO 5575	Enterprise Data Management	3
Project Management		
CNST 5550	Site Infrastructure Construction Strategies	3
ETEM 5531	Introduction to Agile Project Management	3
ETEM 5532	The Art & Science of Risk Management	3
Leadership		
CNST 5579	Advanced Construction Management	3
ETEM 5581	Leading in a Technology-Rich World	3
ETEM 5582	Human Performance in the Organization	3
ETEM 5586	Cross-Cultural Negotiation	3
Plus 9 units from Master of Architecture		9
MArch waived courses cannot be applied.		

* These courses are covered by College of Architecture funding and should be taken earlier in the dual degree program.

Master of Cybersecurity Management

As technology and cybersecurity threats continue to grow and evolve, so does the need for highly skilled cybersecurity leaders who can direct and protect critical information infrastructures. Securing an organization's data requires a refined combination of technical skills, managerial acumen, and leadership expertise.

The Master of Cybersecurity Management at Washington University is a 30-unit part-time program designed for working professionals. This program was developed with one critical goal: to educate mid- and senior career professionals in the management of the people, technology, and resources necessary to lead cybersecurity organizations.

The curriculum provides students with the knowledge needed to protect from, defend against, respond to, and recover after cyber threats and to manage the organization's risk exposure. Graduates of this program will be equipped to solve complex cybersecurity problems and ensure the enterprise's ongoing vitality and prosperity.

Email: sever@wustl.edu
 Website: <https://sever.wustl.edu/degree-programs/cybersecurity/index.html>

Faculty

For a list of our program faculty, please visit our website.

Requirements

- Master of Cybersecurity Management (p. 144)

Courses

CYBER 5559 Introduction to Cybersecurity

This course is intended as a comprehensive introduction to the cybersecurity field. It covers a broad range of cyber security terms, definitions, historical perspectives, concepts, processes, technologies, and trends with a focus on managing risk and the employment of cybersecurity as an organizational enabler. This course is largely asynchronous with some mandatory synchronous meetings. Details will be noted in the syllabus.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5560 Cybersecurity Technologies and Threats

This course presents a comprehensive survey of cybersecurity technology, including basic theory and concepts. Students will gain hands-on familiarity with cybersecurity technology through lab exercises, in-class studios, and scenarios. Topics covered include security considerations surrounding operating systems, the web, email, databases, wireless technology, the cloud, and the Internet of Things. Also addressed are cryptography, secure software design, physical security, and human factors in cybersecurity.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5561 Oversight for Excellence: Cybersecurity Management and Governance

This course takes a comprehensive approach to the management of the organizational cybersecurity function. It also explores the principles of information technology governance. Course work provides a deeper understanding of best practices for managing cybersecurity processes and meeting multiple needs of enterprise management by balancing business risks and operational and technical imperatives. Toward this end, the course addresses a range of topics

necessary for success, including the elements of and how to establish a governance program, cybersecurity management frameworks, developing and implementing a cybersecurity strategy, deploying cybersecurity policy and controls, ensuring standards and regulatory compliance, functional and budgetary advocacy, interfacing with the C-suite and board, and talent acquisition and development.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5562 Efficient and Effective Cybersecurity Operations

In this course, students will gain understanding of what it takes to manage the people, process, and technology for effective and efficient day-to-day cybersecurity operations. Using the Cybersecurity Operations Center (CSOC) as the fundamental exemplar, students will learn the functions and processes that comprise a typical CSOC with an underlying focus on continually optimizing operations and processes to ensure agility and performance. Students will examine options for structuring the CSOC and core CSOC functions and processes such as threat intelligence; monitoring, detection, and threat assessment; vulnerability management; incident response; prevention, including awareness training; partner and third-party coordination; analytics, metrics, and reporting; training; and CSOC technologies and instrumentation.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5563 Enterprise Network Security

This course presents a detailed and comprehensive study of the architecture and defensive approaches to protect enterprise network environments against cyber threats. Students will gain practical experience in secure network architectures and design approaches. Using a building-block approach along with case studies and design exercises, the course will establish the value of applied foundational security frameworks and system models. Specific topics include defensive network design, advanced treatment of appropriate security implementation tools and techniques, boundary defense, secure wireless and mobility solutions, remote and business partner access, and third-party and vendor interactions to ensure appropriate enterprise network solutions are implemented.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5564 Access Control and Identity Management

Business advancements due to technologies such as cloud, mobility, and the need to access information from anywhere using any device have made identity management and access control a critical component of cybersecurity. In this course, students will gain understanding of organizational and technical identity management and access control frameworks. They will also learn central concepts such as least privileged access, authentication, and authorization, which protect applications and systems from unapproved access. Topics covered include single sign-on, privileged account management, provisioning, role management, and directory services. Students will complete a real-world identity management and access control business case to identify risks and controls, and they will also create a strategy and roadmap to address challenges and propose solutions.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5565 Cybersecurity Analytics

This course provides an introduction to use of data analytics in support of an organization's cybersecurity function. The course is designed to increase student understanding of how data analytics can be used to manage security and how data analytics can be deployed in support of risk-based assessment and decision making. Students who complete

this course successfully will be able to apply data analytics techniques and tools to help organizations discover anomalies pertaining to cyber threats; to implement, assess and monitor basic security functions; to respond to emerging threats or prioritized requests as defined by organizational stakeholders; to depict cybersecurity risk posture within the context of compliance and regulatory requirements; and to construct a comprehensive cybersecurity analytics framework.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5566 Cybersecurity Risk Management

In this course, students will gain deeper appreciation of the challenges faced by enterprises when addressing cybersecurity risks. The course will cover the evolution of cyber threats, including attacker methods and their targets across different industries. Students will be able to understand the differences between enterprise, operational and cybersecurity risk management and the role that each play (or should play) in managing risks to an organization. Students will gain technical understanding of industry-leading frameworks (COSO, ISO, NIST, FAIR) and become conversant with their strengths and weaknesses as well as the applicability and practicality of their implementation.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5567 The Hacker Mindset: Cyber Attack Fundamentals

This course is designed to provide an introductory understanding of how offensive security techniques practically operate. During this course, students will use hacking techniques to compromise systems, collect data, and perform other tasks that fall under the generally understood use of the term hacker. These techniques will be related to risk-based defensive security practices, with a view toward enhancing the student's understanding of what it takes to be a successful defender. By the conclusion of the course, students will have a baseline technical understanding of hacking techniques; they will have executed offensive security operations and increased their technical understanding of what it takes to deal with cyber threats.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5568 Emerging Issues and Technology in Cybersecurity

Each new technology advancement brings with it promises and challenges. Will it be used for good or lead to disaster? This course examines contemporary and near-future cybersecurity threats and the potential security impact of new technologies. Topics include new forms of computing and communications and their implications for cybersecurity practitioners as well as incipient threat vectors. Historical security incidents will also be used to provide context and insight into the relationship of technology and security. Throughout the course, students will be challenged to develop strategies and responses to deal with emerging technologies and threats in the ever-evolving cybersecurity domain.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5569 Incident Response and Business Continuity

This course focuses on the end-to-end process and methods to deal with cybersecurity incidents. Using recent examples of cyber breaches and incidents, students explore how CISOs react and respond to these incidents and learn best practices for doing so. Topics include developing an incident response plan, organizing an incident response team, leveraging cyber intelligence and external partners to aid in response, handling public and private communications about the incident, and post-breach restoration. Particular attention will be paid to establishing a strong understanding of cybersecurity indicators and motives for espionage activities from both an external and

rogue insider's perspective. Students will learn about host-based and network incident response tools and digital forensic tools, including techniques and tactics for their effective use. This section of the course includes key hands-on activities that are typically used in post-breach analysis and investigations, such as the forensic analysis of network storage, hard drives, and memory. Students will also become familiar with post-breach report construction and examine the proper drafting and use of such reports for submission to legal counsel, the courts, and organizational leaders.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5570 Leadership Seminar for Technology Professionals

This seminar is designed to develop the leadership capacity of professionals working in the information technology and cybersecurity fields. Although domain expertise plays an important role in the success of a technology professional, it's when this expertise is integrated with the ability to lead people that transforms the merely competent into multi-dimensional force multipliers for the organization. In this course, students will participate in an immersive, seminar-based learning experience targeted toward professional and personal development on a range of essential leadership skills. Students will benefit from interaction with industry experts in the IT and cybersecurity fields and receive coaching support to achieve professional and personal goals. Each student will complete a series of self- and multi-rater assessments as well as a personal leadership development plan to gain insight and build competencies critical to effective leadership. Topics include creating a shared vision, strategy development, building and sustaining a healthy culture, essentials of finance and budgeting, driving results, energizing people for performance, innovation, emotional intelligence, navigating organizational politics, managing up, negotiations, stress resilience, talent coaching and development, effective communication, and time management.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5587 Cloud Security

Today's organizations are more and more focused on delivering faster results and better products and services and doing this securely in an ever-evolving technological landscape. Cloud-based technologies have enabled the critical capabilities, functionality and innovations necessary to transform the way organizations survive and thrive in this competitive environment. As such, the cloud requires cybersecurity practitioners to think differently about managing risk, producing resilient solutions, and dealing with third-party providers. In this course, students will learn best practices for cloud security to include methods for architecting and applying security-related features in a cloud platform. Through case studies, standards, best practices, and studio exercises, students will develop the necessary skills to identify the security challenges of a cloud environment in support of the ongoing operations of the enterprise.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5588 Managerial AI in Cybersecurity

This course bridges the gap between strategic leadership and technical execution, preparing cybersecurity managers to govern the rapid transition from traditional Machine Learning to autonomous Agentic AI. Students will move beyond high-level theory to master the "business of AI," aligning AI initiatives with organizational objectives while managing the complex lifecycle of autonomous systems. The curriculum focuses on Security by Design, teaching managers how to architect governance using a Separation of Duties (SoD) framework. This approach divides responsibility between the "Agent Plane" (DevOps/Operations) and the "Guard Plane" (Cybersecurity),

ensuring rigorous oversight of autonomous reasoning and actions. Students will evaluate unique AI threat landscapes—including prompt injection, jailbreaking, and hallucination—and implement Guard Model Architectures to mitigate these risks. Weaving technical validation with ethical responsibility, the course covers the NIST AI Risk Management Framework and the EU AI Act, preparing leaders to navigate the legal and compliance challenges of enterprise AI.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5589 Cybersecurity Risk and Governance of Third-Party**Ecosystems**

This graduate-level course examines cybersecurity risk as an enterprise management problem, emphasizing how security weaknesses, control gaps, and governance failures manifest in real-world incidents—particularly across third-party and supply-chain relationships. Using case studies drawn from notable breaches, outages, fraud events, and regulatory actions, students learn to translate technical risk into business impact and actionable executive oversight. The course is designed for current or aspiring CISO-level leaders and focuses on establishing and governing a comprehensive Third-Party Risk Management (TPRM) program. Students will develop the ability to set risk appetite and minimum security requirements for vendors, evaluate and prioritize third-party exposure, oversee due diligence and continuous monitoring, and ensure contract language, assurance mechanisms, and escalation paths align with organizational objectives. Topics include vendor segmentation and criticality, security questionnaires and evidence-based validation, audit and attestation frameworks, incident notification and response coordination, cloud/SaaS and managed service provider risk, fourth-party dependencies, data protection and privacy obligations, and reporting metrics suitable for senior leadership and boards. By the end of the course, students will be able to design and communicate an oversight model that balances security, speed, cost, and compliance—enabling resilient operations in a highly interconnected vendor ecosystem.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5998 Applied Research Study

Applied Research Study (ARS) is an advanced, project-based course designed to allow students to develop in-depth knowledge and further their education building on the education offered in the Programs. Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education, and society. Students collaborate with an adjunct faculty advisor to collect data. Findings are applicable and may be implemented upon completion of a study. Applied research focuses on answering one specific applied research question for a client or sponsor. Applied Research Study must have prior approval of a faculty sponsor and the Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5999 Independent Study

Submission of the Independent Study Proposal with Approval of the Faculty Sponsor and Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

Master of Cybersecurity Management (Sever)

Total units required: 30

In order to earn the degree/certificate, all courses must be passed with a C– or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the degree/certificate.

Code	Title	Units
Required: 18 units		
CYBER 5560	Cybersecurity Technologies and Threats	3
CYBER 5561	Oversight for Excellence: Cybersecurity Management and Governance	3
CYBER 5566	Cybersecurity Risk Management	3
CYBER 5567	The Hacker Mindset: Cyber Attack Fundamentals	3
CYBER 5588	Managerial AI in Cybersecurity	3
CYBER 5589	Cybersecurity Risk and Governance of Third-Party Ecosystems	3
Electives: Choose 12 units		
Cybersecurity Management Emphasis		
CYBER 5562	Efficient and Effective Cybersecurity Operations	3
CYBER 5568	Emerging Issues and Technology in Cybersecurity	3
ETEM 5581	Leading in a Technology-Rich World	3
ETEM 5587	Communication Excellence for Influential Leadership	3
Applied Data Analytics & Machine Learning Emphasis		
INFO 5558	Applications of Deep Neural Networks	3
INFO 5559	Applications of Generative AI and Large Language Models	3
INFO 5574	Foundations of Analytics	3
INFO 5576	Analytics Applications	3
Cybersecurity Design & Engineering Emphasis		
CSE 5203	Systems Security	3
CYBER 5563	Enterprise Network Security	3
CYBER 5564	Access Control and Identity Management	3
CYBER 5569	Incident Response and Business Continuity	3
Bridge Course*		
CYBER 5559	Introduction to Cybersecurity	3

* The bridge course is offered for students with limited to no cybersecurity background. The successfully completed course will count toward the 9 required elective units.

Master of Engineering Management

The competitive Master of Engineering Management program bridges the gap between technology and business by providing students with the technical expertise and leadership skills needed to advance their careers. The 30-unit Master of Engineering Management is available for full-time or part-time students.

This program brings together Washington University faculty and industry-leading experts to help students learn to strategize, lead, make informed decisions, manage financials, and leverage both existing and emerging technology. The courses prepare individuals to utilize common management tactics across all of the engineering disciplines.

- *Full-time Master's Degree:* 30 units, 1-1.5 years to complete
- *Part-time Master's Degree:* 30 units, 2.5 years+ to complete

Email: sever@wustl.edu

Website: <https://sever.wustl.edu/degree-programs/engineering/index.html>

Faculty

Program Director

John Bade

Director of Graduate Studies, Engineering Management
PhD, Missouri University of Science & Technology
MBA, Saint Louis University
ME, Missouri University of Science & Technology

For a list of our program faculty, please visit our website.

Requirements

- Master of Engineering Management (p. 147)

Courses

ETEM 5504 Engineering Management & Financial Intelligence

Discover the full picture of how business works within the organization. This course walks the student through the complete business cycle -- the roles the various functions play in a business operation as well as how information is used to make business



decisions (e.g. financial data, marketing data, production data, economic data). To bring these learnings to life, this course also uses management simulation games and classroom competitions. Includes strategy, product planning and management, sales and support, research and development, manufacturing and supply chain, with particular emphasis on accounting, finance and the use of financial statements.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5505 Decision Analysis & Optimization

Expand the ability to analyze and optimize complex business situations by leveraging the key data. Decision-making in today's complex world requires advanced analytical methods and tools, including mathematical modeling and quantitative techniques. Powerful tools for forecasting, finance, operations, production and logistics. Emerging technologies such as the Industrial Internet of Things (IIoT) and Block Chain are enabling a whole new set of possibilities!

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5507 Strategic Engineering Management

Learn the frameworks and process for developing a strategy focused on technology acquisition and value return. This course will cover the entire lifecycle of strategy development, from discovery and business case development, to evaluation and selection, and finally deployment and realization (value return). The tools in this course will help students determine direction when faced with a technology / automation investment decision. These strategies are built on so much more than just functional capabilities of a given technology and in turn, this course is structured to introduce students to all facets that go into a successful Technology Strategy.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5508 Marketing Innovation

Explore the intersection of marketing strategies and engineering processes as a way to enhance product development and market competitiveness. This course equips future engineering leaders with an understanding of essential marketing principles and the rationale behind effective strategy and implementation. Students will acquire the skills to critically evaluate a marketing plan, identify opportunities to align marketing activities to achieve their business goals, and segment/target customers.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5510 Understanding Emerging & Disruptive Technologies

The current era of rapid technology innovation is causing significant disruption to markets and societies. Blockbuster was the darling of Wall Street in 2004 and filed for bankruptcy in 2010. Blockbuster CEO in 2008: Neither Redbox nor Netflix are even on the radar screen in terms of competition. Blockbuster is not alone in their blindness. Microsoft laughed off the first iPhone, and laughed off Google. IBM laughed off the first personal computer. These should be a warning to all business leaders. Numerous technologies are threatening disruption today. Understanding what they are and how they might disrupt will make or break countless companies in the coming years.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5520 Introduction to Innovation & Entrepreneurship

What exactly is innovation, and what is entrepreneurship? How do they drive business and society? Where do good ideas come from? Can anyone learn to be innovative or be an entrepreneur, and does thinking like an engineer help or hinder this process? What does an innovative organization look and act like? What barriers exist to innovation/entrepreneurship, and can they be overcome? This course introduces important frameworks and concepts, offers the student hands-on individual and team learning, includes numerous guest lecturers, and cultivates essential communication skills, all with the goal of fostering an understanding of, and confidence in, innovation and entrepreneurship - both for the individual as well as for the organization.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5521 Human Performance in the Organization

Gain insights and practice in the art and science of leadership. This course addresses the leadership and management capabilities required to move into positions of greater responsibility, with a focus on technology-based organizations. Topics include leadership, goals, motivation and performance, management of change, conflict and effectiveness, organizational development and work design. Because when a leader gets better, everyone gets better.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5525 Innovating for Defense

This interdisciplinary entrepreneurial course gives students the unique opportunity to solve real problems facing the U.S. Department of Defense (DoD) and the U.S. Intelligence Community (IC). This course is open to all students who want to solve real problems for real stakeholders in real time. In consultation with course instructors, students will form their own interdisciplinary teams to explore a challenge experienced by a dedicated DoD problem sponsor who will be regularly engaged with the team. Student teams learn and use the Lean Startup methodology and the Mission Model Canvas made famous by Stanford University to iteratively cut through the complexity of the problem. Note: This course is sponsored by the U.S. DoD. It was originally developed at Stanford University and is now taught at 30+ U.S. universities. A student does NOT have to be a citizen of the United States to take this course; none of the DoD problems are classified.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5527 Entrepreneurship: Challenges & Opportunities

In a world with endless entrepreneurial opportunities, what is the skillset needed to understand the stages from idea to market? This course covers how to quantify the size of the potential market for any entrepreneurial idea, to assess the technical feasibility and financial viability of the idea, to prioritize an initial market for the idea, and to develop a strategy for pursuing the initial market for the idea, whether at a startup or an existing business.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5528 Legal Concepts for Engineering and Technical Managers

With emerging technologies developing at a non-linear rate, the law must adapt just as quickly. As engineering managers, you will be an integral collaborator with your legal team as these laws evolve. Whether it is determining who owns a patent for an invention developed by artificial intelligence, working through smart contracts,

or even run-of-the-mill product liability issues, having a strong understanding of legal concepts will help you interact with attorneys and provide recommendations to guide your team through potential legal crossroads.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5530 Project Planning Methodologies

Build expertise with today's critical project management methodologies in our fast-paced world. Variations of waterfall are widely used in industry, but new uses of agile are being discovered every day, both inside and outside of software-based organizations. This course exposes the student to the fundamental and emerging techniques and tools used to manage successful projects of various sizes and complexity -- managing cost, schedule, quality, risk, solution and requirements -- while adapting to today's fast-paced and uncertain business environment. This course has a Connect fee associated with it. Please check the course materials for the updated amount.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5531 Introduction to Agile Project Management

SCRUM, XP, Kanban, ScrumBan, SAFe - these are some of the key frameworks and processes covered in this course. Agile as a mindset, a skillset, and a toolset are all critical in our fast-paced world. Today's businesses have either started or will soon begin their Agile journey. This course will use books from industry recognized experts in the field of Agile development as well as case studies and varying practical assignments. Students will come away with a solid understanding of the core agile concepts, processes, frameworks, roles, and practices that are shown to deliver leading Market and Business value.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5532 The Art & Science of Risk Management

This course focuses on why many project managers miss requirements for schedule, budget or even both. The course concentrates on key risk management techniques practiced by leading project and program managers and taught through fact-filled lectures, case work and project execution as applied to information systems, engineering, financial, product/process and design projects/programs in today's fast-moving environment. Students will take away key value propositions, including risk identification, risk quantification, risk monitoring, risk control and risk mitigation. This course will enable the student to address common scope, schedule, quality and cost risk events that occur on complex projects. Project risk management examines the types of risk, with a focus on understanding the process of risk identification, assessment, prevention, mitigation, and recovery; governance, auditing, and control of confidentiality; integrity; and availability of data. Using common operational, strategic, tactical, and technological scenarios, the course work provides a comprehensive approach to the challenges faced by managers when global data is readily available, risk is pervasive, regulations are ever-increasing, and the threat of disruption from potential crises is real.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5581 Leading in a Technology-Rich World

Leadership has fundamentally changed from top-down, autocratic and task-focused to collaborative and people-focused in just a few generations. Great senior leaders now get their people to do the greatest things. They must constantly learn, think innovatively, move

and adapt very quickly, and collaborate over short and long distances. Students will learn new leadership skills, explore their individual leadership styles, and discuss the senior leadership challenges in an evolving tech-rich world.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5582 Human Performance in the Organization

Why do some careers soar and others stall? Why it is easy to build relationships with some people - but not others? Why some teams function well and consistently outperform others? Curious about what kind of managers are leaders, or will be? Want to know more about how organizations decide who to hire and who to promote? Human Performance in the Organization is designed to help answer these questions. The content is a mix of relevant theory, personal reflection, and practical application. Our goal is to understand human performance at all levels of the organization. Topics include performance and career management; negotiation and influence; power and politics; mentoring and coaching; high-performance teams; conflict management; talent development and succession planning; and change management.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5586 Cross-Cultural Negotiation

This course introduces students to and gives them practice with principle-based tools and techniques to reach agreements across varied cultures. Best practices from the most famous negotiators of ancient history (i.e., the Phoenicians) are studied and used as a methodology that includes the role of a third party in resolving conflict. The cross-cultural elements are based on multicultural experiences, research studies and the real-life experiences of the instructor. The course is highly interactive (about 70% of the course work). Participants learn through role plays and simulation as well as through readings and case-study analysis.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5587 Communication Excellence for Influential Leadership

Exceptional communicators become extraordinary leaders. This course will guide students to learn to exceptionally communicate their message by applying refined nuances that inspire and transform those with whom they converse. Through a proven communicative process, students will acquire skills necessary to differentiate them as leaders. Students will learn how to communicate across a variety of settings using strategies that result in clear, vivid, and engaging exchanges. Students will practice: storytelling; creating and using clear visuals; engaging listeners; demonstrating passion when speaking; responding to questions with clarity and brevity, and, using their distinctive voice as a leadership asset. Each student will learn how to assess his or her own communication capabilities, adjust to different listeners, and how to evaluate speaker effectiveness and provide valuable feedback to others. Video recordings will be used to demonstrate incremental communicative changes throughout the course, and to show how these strategies bring about outstanding leadership.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5600 Supply Chain for Engineering Managers

This course provides a comprehensive introduction to the fundamentals of supply chain management by applying theoretical concepts to actual quantitative and qualitative problem sets across various economic sectors. Through a case-based approach, students explore both the mechanics and the business context of strategic



and tactical decisions across the end-to-end supply chain. Special emphasis is given to the intersections of supply chain and engineering, including product lifecycle management, strategic sourcing, and high-tech manufacturing.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5602 Systems Engineering

This course focuses on leadership involvement and the strategies essential for designing and implementing successful systems. It highlights the importance of asking the right questions, identifying problems early, leveraging data, aligning with key requirements, and crafting holistic solutions that address the entire system

Credit 3 units.

Typical periods offered: Summer 4, Summer 3, Summer 2, Summer 1, Summer Half B, Summer Half A, Summer, Spring, Summer Intersession, Fall

ETEM 5985 Master of Engineering Management Capstone

As the integrative finale of the MEM program, this course transitions students from theory to professional practice. Functioning as a graduate-level consulting team, students partner with industry sponsors to tackle a real-world challenge. The students will work closely with the sponsor throughout the semester. The capstone requires the synthesis of technical and business acumen to define project scope, execute rigorous data-driven analysis, and develop viable solutions. The semester concludes with a formal delivery of strategic recommendations to organizational stakeholders and a comprehensive technical paper. This course validates the student's ability to lead complex projects and deliver measurable value in a professional environment.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5998 Applied Research Study

Applied Research Study (ARS) is an advanced, project-based course designed to allow students to develop in-depth knowledge and further their education building on the education offered in the Programs. Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education, and society. Students collaborate with an adjunct faculty advisor to collect data. Findings are applicable and may be implemented upon completion of a study. Applied research focuses on answering one specific applied research question for a client or sponsor. Applied Research Study must have prior approval of a faculty sponsor and the Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

Master of Engineering Management (Sever)

Total units required: 30

In order to earn the degree, all courses must be passed with a C– or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the degree.

Code	Title	Units
Required: 18 units		
ETEM 5504	Engineering Management & Financial Intelligence	3
ETEM 5507 or ETEM 5508	Strategic Engineering Management Marketing Innovation	3
ETEM 5510	Understanding Emerging & Disruptive Technologies	3
ETEM 5530	Project Planning Methodologies	3
ETEM 5581 or ETEM 5582	Leading in a Technology-Rich World Human Performance in the Organization	3
ETEM 5985	Master of Engineering Management Capstone	3
Electives: Choose 12 units		
Applied Data Analytics Emphasis		
INFO 5509	Fundamentals of Information Technology	3
INFO 5574	Foundations of Analytics	3
INFO 5575	Enterprise Data Management	3
INFO 5576	Analytics Applications	3
Computer Science & Security Emphasis		
CSE 1301	Introduction to Computer Science	3
CSE 2407	Data Structures and Algorithms	3
CYBER 5559	Introduction to Cybersecurity	3
CYBER 5560	Cybersecurity Technologies and Threats	3
CYBER 5567	The Hacker Mindset: Cyber Attack Fundamentals	3
CYBER 5568	Emerging Issues and Technology in Cybersecurity	3
ETEM 5505	Decision Analysis & Optimization	3
Managing, Leading & Innovating Emphasis		
ETEM 5507	Strategic Engineering Management	3
ETEM 5508	Marketing Innovation	3
ETEM 5520	Introduction to Innovation & Entrepreneurship	3
ETEM 5528	Legal Concepts for Engineering and Technical Managers	3
ETEM 5581	Leading in a Technology-Rich World	3
ETEM 5582	Human Performance in the Organization	3
ETEM 5586	Cross-Cultural Negotiation	3
ETEM 5587	Communication Excellence for Influential Leadership	3
ETEM 5600	Supply Chain for Engineering Managers	3
MGT 5101	Startup Practicum (STL)	3
Project Management & Operational Excellence Emphasis		
CNST 5532	Specialized Topics in Construction Estimating	3

CNST 5572	Legal Aspects of Construction	3
CNST 5573	Fundamentals in Construction Management	3
ETEM 5531	Introduction to Agile Project Management	3
ETEM 5532	The Art & Science of Risk Management	3

Master of Information Systems Management

Building on more than three decades of innovative graduate education and professional development programs in information technology, the McKelvey School of Engineering at Washington University in St. Louis offers a 30-unit Master of Information Systems Management. This program is a key component of Washington University's strategy to prepare the next generation of technology leaders. The 30-unit Master of Information Systems Management brings together candidates with interests and backgrounds in technology and management into a blend of outstanding courses led by Washington University faculty and industry leaders in information, systems, technology, management, and leadership.

- *Full-time and Part-time Master's Degree:* 30 units

Email: sever@wustl.edu
 Website: <https://sever.wustl.edu/degree-programs/information-systems/index.html>

Faculty

Program Director

Saeed Akbani

Director of Graduate Studies, Information Systems Management
 MBA, Washington University in St. Louis
 MS, Electrical Engineering, University of Michigan
 BS, Electrical Engineering, Washington University in St. Louis

For a list of our program faculty, please visit our website.

Requirements

- Master of Information Systems Management (p. 150)

Courses

INFO 5509 Fundamentals of Information Technology

This course is designed to provide a comprehensive survey of the information technology field. The enterprise relies heavily on information technology to generate value, efficiency, and effectiveness. As such, organizational leaders must ensure that the enterprise transforms to keep pace in the competitive environment. Globalization, mergers and acquisitions, and the proliferation of new business and operating models require management to continuously reconsider technology infrastructures, organizational structures, process re-engineering, outsourcing, innovation, technology effectiveness, and the creation and management of data and knowledge. Given these challenges and opportunities, the IT professional has never been more crucial to organizational success. In this context, students will become familiar with core IT concepts, processes, and technology and gain an increased understanding of the crucial role of IT in the modern enterprise.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

INFO 5517 Operational Excellence & Service Delivery

This course examines needed management skills and processes for the efficient and effective functioning of IT infrastructure and operational environments to deliver the right set of services, at the right quality, and at the right costs for internal and external users and customers. Specific emphasis is placed on understanding the roles of IT operations including system administration, network administration, help desk services, asset management, DevOps, and reporting. Students will study the application of industry best practice frameworks for the management of information technology infrastructure, operations, and development. Frameworks covered include the Information Technology Infrastructure Library (ITIL) and Control Objectives for Information and related Technology (COBIT). Through the application of continuous service improvement, students will understand the IT service lifecycle and will be able to assess the effectiveness of processes and services.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

INFO 5521 Principles of Software Design & Architecture

Software applications harness the power of IT infrastructure to deliver powerful capabilities to users enabling them to transact with accuracy and efficiency. Software applications take on many forms such as web applications, mobile apps, and eCommerce sites, which are taken for granted by the users, business and consumers. However, developing, deploying, and maintaining secure and scalable commercial software applications is a complicated task, which if not managed correctly, can result in significant financial losses and waste of time. In this class students learn how to architect and design software taking into account business drivers and important attributes such as availability, performance, scalability, reliability, and security, and trade-offs between different design objectives. We discuss various topics from software lifecycle management to integration of applications. Contemporary topics like CI/CD pipelines, application containerization, serverless architecture are also discussed in detail. Through class lectures, discussions, assignments, case studies, and group projects, students will build a solid understanding of application architectures and frameworks. Given the depth of topics covered, some level of prior programming experience is helpful but is not a requirement for this course.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

INFO 5540 IT Architecture & Infrastructure

This course will demonstrate the importance of understanding organizational strategy and goals, then designing and deploying an IT infrastructure that supports that strategy and those goals. The course will showcase how fundamental IT building blocks are integrated in meaningful ways in order to support IT services that drive core business outcomes. Through a hands-on enterprise architecture design project, students will learn to design IT infrastructure in a rational, innovative, and cost-effective manner. We will cover a range of enterprise architecture design considerations commonly faced by organizations as they enhance their services, launch new products, or expand to new markets. There is a \$15/student fee that covers the cost of transportation for the Washington University's Medical School data center tour. Students are also required to use their own method of payment for the Azure course materials (\$150-\$200).

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

INFO 5552 Block Chain

This graduate-level course delves into the intersection of blockchain technology and artificial intelligence (AI), exploring their combined applications across business, finance, and digital asset innovation. Students will gain insights into foundational concepts such as distributed consensus, cryptographic hashing, smart contracts, tokenization, DAOs, and decentralized finance, while examining the trust layer blockchain adds to AI applications. Through hands-on projects, students will design and propose solutions leveraging both blockchain and AI to address contemporary organizational and societal challenges, as well as evaluate real-world use cases and regulatory implications.

Credit 3 units.

Typical periods offered: Fall, Spring

INFO 5558 Applications of Deep Neural Networks

Deep learning is a group of exciting new technologies for neural networks. It is now possible to create neural networks of much greater complexity through a combination of advanced training techniques and neural network architectural components. Deep learning allows a neural network to learn hierarchies of information in a way that is like the function of the human brain. This course will introduce the student to computer vision with Convolution Neural Networks (CNN), time series analysis with Long Short-Term Memory (LSTM), transformers, large language models (LLMs), and classic neural network structures. The focus is primarily on applying deep learning to problems, with some introduction to mathematical foundations. High-Performance Computing (HPC) aspects demonstrate how one can leverage deep learning on graphical processing units (GPUs). Students will use Python to implement deep learning using PyTorch and other libraries. It is unnecessary to know Python before this course; however, familiarity with at least one programming language is assumed. We deliver this course in a hybrid format, including classroom and online instruction.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

INFO 5559 Applications of Generative AI and Large Language Models

This course covers the dynamic world of Generative Artificial Intelligence providing hands-on practical applications of Large Language Models (LLMs) and advanced text-to-image networks. Using Python as the primary tool, students will interact with OpenAI's models for both text and images. The course begins with a solid foundation in generative AI principles, moving swiftly into the utilization of LangChain for model-agnostic access and the management of prompts, indexes, chains, and agents. A significant focus is placed on the integration of the Retrieval-Augmented Generation (RAG) model with graph databases, unlocking new possibilities in AI applications. As the course progresses, students

will delve into sophisticated image generation and augmentation techniques, including LoRA (Low-Rank Adaptation), and learn the art of fine-tuning generative neural networks for specific needs. The final part of the course is dedicated to mastering prompt engineering, a critical skill for optimizing the efficiency and creativity of AI outputs. Ideal for students, researchers, and professionals in computer science or related fields, this course offers a transformative learning experience where technology meets creativity, paving the way for innovative applications in the realm of Generative AI. Note: This course will require the purchase of up to \$100 in OpenAI API credits to complete the course.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

INFO 5563 IT Strategy, Governance, and Risk Management

Firms with superior IT governance designed to support the organization's strategy achieve better performance and higher profits than firms with poor (or no) governance. Just as corporate governance aims to ensure quality decisions about all corporate assets, IT governance links IT decisions with company objectives and monitors performance and accountability. We will start with developing an understanding of IT governance and go over the decision-rights and decision-making processes associated with it. We will study various enterprise operating models and strategies and see how they in turn determine the IT strategy and operating model. We will also review practices to provide business oversight and transparency into IT investments and go over how IT leaders can proactively partner with other business leaders to drive top-line growth and/or operational cost savings. We will also review how to classify initiatives into projects and programs and group them into portfolios. Furthermore, we will discuss different project implementation approaches, ranging from waterfall to agile methodologies. We will also cover how many IT departments are transitioning towards a more productized delivery model. Finally, we will also review technology selection processes, architectural governance, procurement of products and services, as well as service and vendor management. Throughout this process, we will be reviewing decision-making from the perspective of both leveraging business opportunities and managing risk. Risk management is an essential component of an IT leader's role. We will cover the risk management process and use it to identify and manage & control some of the common risks that contemporary IT organizations face. This includes guarding against cyber threats, protecting data, and managing vendor, business continuity, regulatory, project, and operational risks etc.

Credit 3 units.

Typical periods offered: Fall, Spring

INFO 5574 Foundations of Analytics

The steeply decreasing costs of gathering, storing, and processing data have created a strong motivation for organizations to move toward data-driven approaches to problem solving. As such, data analytics continues to grow rapidly in importance across industry, government, and nonprofit organizations. This course seeks to equip students with a wide range of data analytics techniques that serve as the foundation for a broad range of applications, including descriptive, inferential, predictive, and prescriptive analytics. Students will learn the process of building a data model as well as a variety of analytics techniques and under what situations they are best employed. Through lectures and practical exercises, students will become familiar with the computational mathematics that underpin analytics; the elements of statistical modeling and machine learning; model interpretation and assessment; and structured and unstructured data analysis. Students will also undertake a project to build an analytical model using a real-world dataset.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

INFO 5575 Enterprise Data Management

In the 4th Industrial Revolution of Digital Transformation, Data is a key and necessary foundational element. Enterprise Data Management is the responsibility and opportunity to effectively utilize data and make it useful to achieve organizational goals. Organizations have begun generating, collecting, and accumulating more data at a faster pace than ever before. The advent of Big Data has proven to be both an opportunity and challenge for organizations who are awash, even drowning-in data, but starved for knowledge. Unfortunately, many organizations have not developed comprehensive enterprise data management (EDM) practices that treat data as a true organizational asset. EDM is a comprehensive approach to defining, governing, securing, and maintaining the access & quality of the right data involved in the business processes of an organization. This course will cover many aspects of building an enterprise data management program, including areas such as data governance, data security, data architecture, data quality, data ownership, metadata management, data strategy, and others.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

INFO 5576 Analytics Applications

This course builds on the content taught in Enterprise Data Management and Foundations of Data Analytics. It focuses on the strategic, operational, tactical, and practical use of data analytics to inform decisions within an organization across a range of industry and government sectors as well as within organizational functions. Students will be introduced to specific analytics techniques that are used currently by practitioners in areas of diagnostic, descriptive, predictive, and prescriptive analytics. Students will learn the critical phases of analytics including data preparation, model development, evaluation, validation, selection, and deployment. In so doing, students will learn to apply data analytics in order to optimize organizational processes, improve performance, and inform decision-making.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

INFO 5985 MISM Capstone

The capstone course is the culmination of the Masters of Information Systems Management program. The capstone project provides the opportunity for students to employ the knowledge and skills they have gained from their coursework in a rigorous and systematic manner. Projects are sponsored by external corporate, government, and non-profit organizations and provide the opportunity to deliver meaningful research and recommendations for "real-world" IT challenges and problems. In order to protect sponsoring company's interests, students may be required to sign an NDA (non-disclosure agreement) to participate in this course. Students may be required to purchase a subscription to Project Management software. Estimated cost = \$50.00

Credit 3 units.

Typical periods offered: Fall, Spring

Master of Information Systems Management (Sever)

Total Units Required: 30

Students must complete five out of the six required courses as well as the mandatory Capstone. In addition, they need to choose four electives. In order to earn the degree, all courses must be passed with a C– or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the degree.

Code	Title	Units
CYBER 5559	Introduction to Cybersecurity	3
INFO 5517	Operational Excellence & Service Delivery	3
INFO 5521	Principles of Software Design & Architecture	3
INFO 5540	IT Architecture & Infrastructure	3
INFO 5563	IT Strategy, Governance, and Risk Management	3
INFO 5575	Enterprise Data Management	3
INFO 5985	MISM Capstone (mandatory; should be completed in the final semester)	3
Required: 18 units		
Electives: Choose 12 units		
Cybersecurity Emphasis		
CYBER 5560	Cybersecurity Technologies and Threats	3
CYBER 5561	Oversight for Excellence: Cybersecurity Management and Governance	3
CYBER 5562	Efficient and Effective Cybersecurity Operations	3
CYBER 5563	Enterprise Network Security	3
CYBER 5566	Cybersecurity Risk Management	3
CYBER 5567	The Hacker Mindset: Cyber Attack Fundamentals	3
Management Emphasis		
ETEM 5504	Engineering Management & Financial Intelligence	3
ETEM 5505	Decision Analysis & Optimization	3
ETEM 5582	Human Performance in the Organization	3
ETEM 5587	Communication Excellence for Influential Leadership	3
ETEM 5600	Supply Chain for Engineering Managers	3
Applied Data Analytics & Machine Learning Emphasis		



INFO 5552	Block Chain	3
INFO 5558	Applications of Deep Neural Networks	3
INFO 5559	Applications of Generative AI and Large Language Models	3
INFO 5574	Foundations of Analytics	3
INFO 5576	Analytics Applications (prior completion of INFO 5574 recommended)	3
Mathematical Data Analytics Emphasis		
CSE 4102	Introduction to Artificial Intelligence	3
CSE 4107	Introduction to Machine Learning	3
CSE 5104	Data Mining	3
CSE 5107	Machine Learning	3
ESE 4150	Optimization	3
ESE 5200	Probability and Stochastic Processes	3
AI & Machine Learning Emphasis		
CSE 4102	Introduction to Artificial Intelligence	3
CSE 4107	Introduction to Machine Learning	3
CSE 5104	Data Mining	3
CSE 5107	Machine Learning	3
CSE 5109	Advanced Machine Learning	3
Bridge Course*		
INFO 5509	Fundamentals of Information Technology	3

* The bridge course is offered for students with limited to no information systems background. The successfully completed course will count toward the 12 required elective units.

Online Degree Programs

Online Master of Cybersecurity Management

This exclusively online, part-time program was developed for cybersecurity working professionals seeking to advance their leadership skills and to deepen the managerial acumen required to establish, maintain, and develop an effective and efficient cybersecurity enterprise. Students in this 30-unit program will acquire the expertise needed to successfully execute a range of core cybersecurity functions, including leadership, governance, risk management, operations, and incident response. The program places particular emphasis on business-related skills such as communicating with non-technical line-of-business leaders and peers,

speaking the language of business, and strategy formulation and development. Graduates of this program will be well prepared to step into positions of greater responsibility and to make larger and more consequential contributions to their organizations.

Email: sever@wustl.edu

Website: <https://sever.wustl.edu/degree-programs/cybersecurity/index.html>

Faculty

For a list of our program faculty, please visit our website.

Requirements

- Online Master of Cybersecurity Management (p. 153)

Courses

CYBER 5559 Introduction to Cybersecurity

This course is intended as a comprehensive introduction to the cybersecurity field. It covers a broad range of cyber security terms, definitions, historical perspectives, concepts, processes, technologies, and trends with a focus on managing risk and the employment of cybersecurity as an organizational enabler. This course is largely asynchronous with some mandatory synchronous meetings. Details will be noted in the syllabus.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5560 Cybersecurity Technologies and Threats

This course presents a comprehensive survey of cybersecurity technology, including basic theory and concepts. Students will gain hands-on familiarity with cybersecurity technology through lab exercises, in-class studios, and scenarios. Topics covered include security considerations surrounding operating systems, the web, email, databases, wireless technology, the cloud, and the Internet of Things. Also addressed are cryptography, secure software design, physical security, and human factors in cybersecurity.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5561 Oversight for Excellence: Cybersecurity Management and Governance

This course takes a comprehensive approach to the management of the organizational cybersecurity function. It also explores the principles of information technology governance. Course work provides a deeper understanding of best practices for managing cybersecurity processes and meeting multiple needs of enterprise management by balancing business risks and operational and technical imperatives. Toward this end, the course addresses a range of topics necessary for success, including the elements of and how to establish a governance program, cybersecurity management frameworks, developing and implementing a cybersecurity strategy, deploying cybersecurity policy and controls, ensuring standards and regulatory compliance, functional and budgetary advocacy, interfacing with the C-suite and board, and talent acquisition and development.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5562 Efficient and Effective Cybersecurity Operations

In this course, students will gain understanding of what it takes to manage the people, process, and technology for effective and efficient day-to-day cybersecurity operations. Using the Cybersecurity Operations Center (CSOC) as the fundamental exemplar, students will learn the functions and processes that comprise a typical CSOC with an underlying focus on continually optimizing operations and processes to ensure agility and performance. Students will examine options for structuring the CSOC and core CSOC functions and processes such as threat intelligence; monitoring, detection, and threat assessment; vulnerability management; incident response; prevention, including awareness training; partner and third-party coordination; analytics, metrics, and reporting; training; and CSOC technologies and instrumentation.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5563 Enterprise Network Security

This course presents a detailed and comprehensive study of the architecture and defensive approaches to protect enterprise network environments against cyber threats. Students will gain practical experience in secure network architectures and design approaches. Using a building-block approach along with case studies and design exercises, the course will establish the value of applied foundational security frameworks and system models. Specific topics include defensive network design, advanced treatment of appropriate security implementation tools and techniques, boundary defense, secure wireless and mobility solutions, remote and business partner access, and third-party and vendor interactions to ensure appropriate enterprise network solutions are implemented.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5564 Access Control and Identity Management

Business advancements due to technologies such as cloud, mobility, and the need to access information from anywhere using any device have made identity management and access control a critical component of cybersecurity. In this course, students will gain understanding of organizational and technical identity management and access control frameworks. They will also learn central concepts such as least privileged access, authentication, and authorization, which protect applications and systems from unapproved access. Topics covered include single sign-on, privileged account management, provisioning, role management, and directory services. Students will complete a real-world identity management and access control business case to identify risks and controls, and they will also create a strategy and roadmap to address challenges and propose solutions.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5565 Cybersecurity Analytics

This course provides an introduction to use of data analytics in support of an organization's cybersecurity function. The course is designed to increase student understanding of how data analytics can be used to manage security and how data analytics can be deployed in support of risk-based assessment and decision making. Students who complete this course successfully will be able to apply data analytics techniques and tools to help organizations discover anomalies pertaining to cyber threats; to implement, assess and monitor basic security functions; to respond to emerging threats or prioritized requests as defined by organizational stakeholders; to depict cybersecurity risk posture within the context of compliance and regulatory requirements; and to construct a comprehensive cybersecurity analytics framework.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5566 Cybersecurity Risk Management

In this course, students will gain deeper appreciation of the challenges faced by enterprises when addressing cybersecurity risks. The course will cover the evolution of cyber threats, including attacker methods and their targets across different industries. Students will be able to understand the differences between enterprise, operational and cybersecurity risk management and the role that each play (or should play) in managing risks to an organization. Students will gain technical understanding of industry-leading frameworks (COSO, ISO, NIST, FAIR) and become conversant with their strengths and weaknesses as well as the applicability and practicality of their implementation.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5567 The Hacker Mindset: Cyber Attack Fundamentals

This course is designed to provide an introductory understanding of how offensive security techniques practically operate. During this course, students will use hacking techniques to compromise systems, collect data, and perform other tasks that fall under the generally understood use of the term hacker. These techniques will be related to risk-based defensive security practices, with a view toward enhancing the student's understanding of what it takes to be a successful defender. By the conclusion of the course, students will have a baseline technical understanding of hacking techniques; they will have executed offensive security operations and increased their technical understanding of what it takes to deal with cyber threats.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5568 Emerging Issues and Technology in Cybersecurity

Each new technology advancement brings with it promises and challenges. Will it be used for good or lead to disaster? This course examines contemporary and near-future cybersecurity threats and the potential security impact of new technologies. Topics include new forms of computing and communications and their implications for cybersecurity practitioners as well as incipient threat vectors. Historical security incidents will also be used to provide context and insight into the relationship of technology and security. Throughout the course, students will be challenged to develop strategies and responses to deal with emerging technologies and threats in the ever-evolving cybersecurity domain.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5569 Incident Response and Business Continuity

This course focuses on the end-to-end process and methods to deal with cybersecurity incidents. Using recent examples of cyber breaches and incidents, students explore how CISOs react and respond to these incidents and learn best practices for doing so. Topics include developing an incident response plan, organizing an incident response team, leveraging cyber intelligence and external partners to aid in response, handling public and private communications about the incident, and post-breach restoration. Particular attention will be paid to establishing a strong understanding of cybersecurity indicators and motives for espionage activities from both an external and rogue insider's perspective. Students will learn about host-based and network incident response tools and digital forensic tools, including techniques and tactics for their effective use. This section of the course includes key hands-on activities that are typically used in post-breach analysis and investigations, such as the forensic analysis of network storage, hard drives, and memory. Students will also become familiar with post-breach report construction and examine the proper drafting and use of such reports for submission to legal counsel, the courts, and organizational leaders.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5570 Leadership Seminar for Technology Professionals

This seminar is designed to develop the leadership capacity of professionals working in the information technology and cybersecurity fields. Although domain expertise plays an important role in the success of a technology professional, it's when this expertise is integrated with the ability to lead people that transforms the merely competent into multi-dimensional force multipliers for the organization. In this course, students will participate in an immersive, seminar-based learning experience targeted toward professional and personal development on a range of essential leadership skills. Students will benefit from interaction with industry experts in the IT and cybersecurity fields and receive coaching support to achieve professional and personal goals. Each student will complete a series of self- and multi-rater assessments as well as a personal leadership development plan to gain insight and build competencies critical to effective leadership. Topics include creating a shared vision, strategy development, building and sustaining a healthy culture, essentials of finance and budgeting, driving results, energizing people for performance, innovation, emotional intelligence, navigating organizational politics, managing up, negotiations, stress resilience, talent coaching and development, effective communication, and time management.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5587 Cloud Security

Today's organizations are more and more focused on delivering faster results and better products and services and doing this securely in an ever-evolving technological landscape. Cloud-based technologies have enabled the critical capabilities, functionality and innovations necessary to transform the way organizations survive and thrive in this competitive environment. As such, the cloud requires cybersecurity practitioners to think differently about managing risk, producing resilient solutions, and dealing with third-party providers. In this course, students will learn best practices for cloud security to include methods for architecting and applying security-related features in a cloud platform. Through case studies, standards, best practices, and studio exercises, students will develop the necessary skills to identify the security challenges of a cloud environment in support of the ongoing operations of the enterprise.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5588 Managerial AI in Cybersecurity

This course bridges the gap between strategic leadership and technical execution, preparing cybersecurity managers to govern the rapid transition from traditional Machine Learning to autonomous Agentic AI. Students will move beyond high-level theory to master the "business of AI," aligning AI initiatives with organizational objectives while managing the complex lifecycle of autonomous systems. The curriculum focuses on Security by Design, teaching managers how to architect governance using a Separation of Duties (SoD) framework. This approach divides responsibility between the "Agent Plane" (DevOps/Operations) and the "Guard Plane" (Cybersecurity), ensuring rigorous oversight of autonomous reasoning and actions. Students will evaluate unique AI threat landscapes—including prompt injection, jailbreaking, and hallucination—and implement Guard Model Architectures to mitigate these risks. Weaving technical validation with ethical responsibility, the course covers the NIST AI Risk Management Framework and the EU AI Act, preparing leaders to navigate the legal and compliance challenges of enterprise AI.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5589 Cybersecurity Risk and Governance of Third-Party Ecosystems

This graduate-level course examines cybersecurity risk as an enterprise management problem, emphasizing how security weaknesses, control gaps, and governance failures manifest in real-world incidents—particularly across third-party and supply-chain relationships. Using case studies drawn from notable breaches, outages, fraud events, and regulatory actions, students learn to translate technical risk into business impact and actionable executive oversight. The course is designed for current or aspiring CISO-level leaders and focuses on establishing and governing a comprehensive Third-Party Risk Management (TPRM) program. Students will develop the ability to set risk appetite and minimum security requirements for vendors, evaluate and prioritize third-party exposure, oversee due diligence and continuous monitoring, and ensure contract language, assurance mechanisms, and escalation paths align with organizational objectives. Topics include vendor segmentation and criticality, security questionnaires and evidence-based validation, audit and attestation frameworks, incident notification and response coordination, cloud/SaaS and managed service provider risk, fourth-party dependencies, data protection and privacy obligations, and reporting metrics suitable for senior leadership and boards. By the end of the course, students will be able to design and communicate an oversight model that balances security, speed, cost, and compliance—enabling resilient operations in a highly interconnected vendor ecosystem.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5998 Applied Research Study

Applied Research Study (ARS) is an advanced, project-based course designed to allow students to develop in-depth knowledge and further their education building on the education offered in the Programs. Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education, and society. Students collaborate with an adjunct faculty advisor to collect data. Findings are applicable and may be implemented upon completion of a study. Applied research focuses on answering one specific applied research question for a client or sponsor. Applied Research Study must have prior approval of a faculty sponsor and the Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5999 Independent Study

Submission of the Independent Study Proposal with Approval of the Faculty Sponsor and Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

Online Master of Cybersecurity Management (Sever)

Total units required: 30

In order to earn the degree, all courses must be passed with a C– or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the degree.

Course numbers below are subject to change. Please contact the Sever Institute Assistant Director of Academic & Student Services for accurate academic advising information.

Code	Title	Units
Required: 21 units		
CYBER 5560	Cybersecurity Technologies and Threats	3
CYBER 5561	Oversight for Excellence: Cybersecurity Management and Governance	3
CYBER 5566	Cybersecurity Risk Management	3
CYBER 5567	The Hacker Mindset: Cyber Attack Fundamentals	3
CYBER 5588	Managerial AI in Cybersecurity	3
CYBER 5589	Cybersecurity Risk and Governance of Third-Party Ecosystems	3
CYBER 5562	Efficient and Effective Cybersecurity Operations	3
Electives: Choose 9 units		
CYBER 5563	Enterprise Network Security	3
CYBER 5564	Access Control and Identity Management	3
CYBER 5565	Cybersecurity Analytics	3
CYBER 5568	Emerging Issues and Technology in Cybersecurity	3
CYBER 5569	Incident Response and Business Continuity	3
ETEM 5581	Leading in a Technology-Rich World	3
ETEM 5587	Communication Excellence for Influential Leadership	3
Bridge Course*		
CYBER 5559	Introduction to Cybersecurity	3

* The bridge course is offered for students with limited to no cybersecurity background. The successfully completed course will count toward the 9 required elective units.

Online Master of Engineering Management

The competitive, part-time Online Master of Engineering Management program bridges the gap between technology and business by providing students with the technical expertise and leadership skills needed to advance their careers.

This program brings together Washington University faculty and industry-leading experts to help students learn to strategize, lead, make informed decisions, manage financials, and leverage both existing and emerging technology. The courses prepare individuals to utilize common management tactics across all of the engineering disciplines.

Part-time Master's Degree: 30 units, 2.5 years+ to complete

Email: sever@wustl.edu

Website: <https://sever.wustl.edu/degree-programs/engineering/index.html>

Faculty

Program Director

John Bade

Director of Graduate Studies, Engineering Management

PhD, Missouri University of Science & Technology

MBA, Saint Louis University

ME, Missouri University of Science & Technology

For a list of our program faculty, please visit our website.

Requirements

- Online Master of Engineering Management (p. 157)

Courses

ETEM 5504 Engineering Management & Financial Intelligence

Discover the full picture of how business works within the organization. This course walks the student through the complete business cycle -- the roles the various functions play in a business operation as well as how information is used to make business decisions (e.g. financial data, marketing data, production data, economic data). To bring these learnings to life, this course also uses management simulation games and classroom competitions. Includes strategy, product planning and management, sales and support, research and development, manufacturing and supply chain, with particular emphasis on accounting, finance and the use of financial statements.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5505 Decision Analysis & Optimization

Expand the ability to analyze and optimize complex business situations by leveraging the key data. Decision-making in today's complex world requires advanced analytical methods and tools, including mathematical modeling and quantitative techniques. Powerful tools for forecasting, finance, operations, production and logistics. Emerging technologies such as the Industrial Internet of Things (IIoT) and Block Chain are enabling a whole new set of possibilities!

Credit 3 units.

Typical periods offered: Fall, Spring, Summer



ETEM 5507 Strategic Engineering Management

Learn the frameworks and process for developing a strategy focused on technology acquisition and value return. This course will cover the entire lifecycle of strategy development, from discovery and business case development, to evaluation and selection, and finally deployment and realization (value return). The tools in this course will help students determine direction when faced with a technology / automation investment decision. These strategies are built on so much more than just functional capabilities of a given technology and in turn, this course is structured to introduce students to all facets that go into a successful Technology Strategy.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5508 Marketing Innovation

Explore the intersection of marketing strategies and engineering processes as a way to enhance product development and market competitiveness. This course equips future engineering leaders with an understanding of essential marketing principles and the rationale behind effective strategy and implementation. Students will acquire the skills to critically evaluate a marketing plan, identify opportunities to align marketing activities to achieve their business goals, and segment/target customers.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5510 Understanding Emerging & Disruptive Technologies

The current era of rapid technology innovation is causing significant disruption to markets and societies. Blockbuster was the darling of Wall Street in 2004 and filed for bankruptcy in 2010. Blockbuster CEO in 2008: Neither Redbox nor Netflix are even on the radar screen in terms of competition. Blockbuster is not alone in their blindness. Microsoft laughed off the first iPhone, and laughed off Google. IBM laughed off the first personal computer. These should be a warning to all business leaders. Numerous technologies are threatening disruption today. Understanding what they are and how they might disrupt will make or break countless companies in the coming years.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5520 Introduction to Innovation & Entrepreneurship

What exactly is innovation, and what is entrepreneurship? How do they drive business and society? Where do good ideas come from? Can anyone learn to be innovative or be an entrepreneur, and does thinking like an engineer help or hinder this process? What does an innovative organization look and act like? What barriers exist to innovation/entrepreneurship, and can they be overcome? This course introduces important frameworks and concepts, offers the student hands-on individual and team learning, includes numerous guest lecturers, and cultivates essential communication skills, all with the goal of fostering an understanding of, and confidence in, innovation and entrepreneurship - both for the individual as well as for the organization.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5521 Human Performance in the Organization

Gain insights and practice in the art and science of leadership. This course addresses the leadership and management capabilities required to move into positions of greater responsibility, with a focus on technology-based organizations. Topics include leadership, goals, motivation and performance, management of change, conflict and effectiveness, organizational development and work design. Because when a leader gets better, everyone gets better.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5525 Innovating for Defense

This interdisciplinary entrepreneurial course gives students the unique opportunity to solve real problems facing the U.S. Department of Defense (DoD) and the U.S. Intelligence Community (IC). This course is open to all students who want to solve real problems for real stakeholders in real time. In consultation with course instructors, students will form their own interdisciplinary teams to explore a challenge experienced by a dedicated DoD problem sponsor who will be regularly engaged with the team. Student teams learn and use the Lean Startup methodology and the Mission Model Canvas made famous by Stanford University to iteratively cut through the complexity of the problem. Note: This course is sponsored by the U.S. DoD. It was originally developed at Stanford University and is now taught at 30+ U.S. universities. A student does NOT have to be a citizen of the United States to take this course; none of the DoD problems are classified.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5527 Entrepreneurship: Challenges & Opportunities

In a world with endless entrepreneurial opportunities, what is the skillset needed to understand the stages from idea to market? This course covers how to quantify the size of the potential market for any entrepreneurial idea, to assess the technical feasibility and financial viability of the idea, to prioritize an initial market for the idea, and to develop a strategy for pursuing the initial market for the idea, whether at a startup or an existing business.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5528 Legal Concepts for Engineering and Technical Managers

With emerging technologies developing at a non-linear rate, the law must adapt just as quickly. As engineering managers, you will be an integral collaborator with your legal team as these laws evolve. Whether it is determining who owns a patent for an invention developed by artificial intelligence, working through smart contracts, or even run-of-the-mill product liability issues, having a strong understanding of legal concepts will help you interact with attorneys and provide recommendations to guide your team through potential legal crossroads.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5530 Project Planning Methodologies

Build expertise with today's critical project management methodologies in our fast-paced world. Variations of waterfall are widely used in industry, but new uses of agile are being discovered every day, both inside and outside of software-based organizations. This course exposes the student to the fundamental and emerging techniques and tools used to manage successful projects of various sizes and complexity -- managing cost, schedule, quality, risk, solution and requirements -- while adapting to today's fast-paced and uncertain business environment. This course has a Connect fee associated with it. Please check the course materials for the updated amount.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5531 Introduction to Agile Project Management

SCRUM, XP, Kanban, ScrumBan, SAFe - these are some of the key frameworks and processes covered in this course. Agile as a mindset, a skillset, and a toolset are all critical in our fast-paced world. Today's businesses have either started or will soon begin their Agile journey. This course will use books from industry recognized experts in the

field of Agile development as well as case studies and varying practical assignments. Students will come away with a solid understanding of the core agile concepts, processes, frameworks, roles, and practices that are shown to deliver leading Market and Business value.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5532 The Art & Science of Risk Management

This course focuses on why many project managers miss requirements for schedule, budget or even both. The course concentrates on key risk management techniques practiced by leading project and program managers and taught through fact-filled lectures, case work and project execution as applied to information systems, engineering, financial, product/process and design projects/programs in today's fast-moving environment. Students will take away key value propositions, including risk identification, risk quantification, risk monitoring, risk control and risk mitigation. This course will enable the student to address common scope, schedule, quality and cost risk events that occur on complex projects. Project risk management examines the types of risk, with a focus on understanding the process of risk identification, assessment, prevention, mitigation, and recovery; governance, auditing, and control of confidentiality; integrity; and availability of data. Using common operational, strategic, tactical, and technological scenarios, the course work provides a comprehensive approach to the challenges faced by managers when global data is readily available, risk is pervasive, regulations are ever-increasing, and the threat of disruption from potential crises is real.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5581 Leading in a Technology-Rich World

Leadership has fundamentally changed from top-down, autocratic and task-focused to collaborative and people-focused in just a few generations. Great senior leaders now get their people to do the greatest things. They must constantly learn, think innovatively, move and adapt very quickly, and collaborate over short and long distances. Students will learn new leadership skills, explore their individual leadership styles, and discuss the senior leadership challenges in an evolving tech-rich world.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5582 Human Performance in the Organization

Why do some careers soar and others stall? Why it is easy to build relationships with some people - but not others? Why some teams function well and consistently outperform others? Curious about what kind of managers are leaders, or will be? Want to know more about how organizations decide who to hire and who to promote? Human Performance in the Organization is designed to help answer these questions. The content is a mix of relevant theory, personal reflection, and practical application. Our goal is to understand human performance at all levels of the organization. Topics include performance and career management; negotiation and influence; power and politics; mentoring and coaching; high-performance teams; conflict management; talent development and succession planning; and change management.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5586 Cross-Cultural Negotiation

This course introduces students to and gives them practice with principle-based tools and techniques to reach agreements across varied cultures. Best practices from the most famous negotiators of ancient history (i.e., the Phoenicians) are studied and used as a methodology that includes the role of a third party in resolving

conflict. The cross-cultural elements are based on multicultural experiences, research studies and the real-life experiences of the instructor. The course is highly interactive (about 70% of the course work). Participants learn through role plays and simulation as well as through readings and case-study analysis.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5587 Communication Excellence for Influential Leadership

Exceptional communicators become extraordinary leaders. This course will guide students to learn to exceptionally communicate their message by applying refined nuances that inspire and transform those with whom they converse. Through a proven communicative process, students will acquire skills necessary to differentiate them as leaders. Students will learn how to communicate across a variety of settings using strategies that result in clear, vivid, and engaging exchanges. Students will practice: storytelling; creating and using clear visuals; engaging listeners; demonstrating passion when speaking; responding to questions with clarity and brevity, and, using their distinctive voice as a leadership asset. Each student will learn how to assess his or her own communication capabilities, adjust to different listeners, and how to evaluate speaker effectiveness and provide valuable feedback to others. Video recordings will be used to demonstrate incremental communicative changes throughout the course, and to show how these strategies bring about outstanding leadership.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5600 Supply Chain for Engineering Managers

This course provides a comprehensive introduction to the fundamentals of supply chain management by applying theoretical concepts to actual quantitative and qualitative problem sets across various economic sectors. Through a case-based approach, students explore both the mechanics and the business context of strategic and tactical decisions across the end-to-end supply chain. Special emphasis is given to the intersections of supply chain and engineering, including product lifecycle management, strategic sourcing, and high-tech manufacturing.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5602 Systems Engineering

This course focuses on leadership involvement and the strategies essential for designing and implementing successful systems. It highlights the importance of asking the right questions, identifying problems early, leveraging data, aligning with key requirements, and crafting holistic solutions that address the entire system

Credit 3 units.

Typical periods offered: Summer 4, Summer 3, Summer 2, Summer 1, Summer Half B, Summer Half A, Summer, Spring, Summer Intersession, Fall

ETEM 5985 Master of Engineering Management Capstone

As the integrative finale of the MEM program, this course transitions students from theory to professional practice. Functioning as a graduate-level consulting team, students partner with industry sponsors to tackle a real-world challenge. The students will work closely with the sponsor throughout the semester. The capstone requires the synthesis of technical and business acumen to define project scope, execute rigorous data-driven analysis, and develop viable solutions. The semester concludes with a formal delivery of strategic recommendations to organizational stakeholders and a comprehensive technical paper. This course validates the student's ability to lead complex projects and deliver measurable value in a professional environment.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5998 Applied Research Study

Applied Research Study (ARS) is an advanced, project-based course designed to allow students to develop in-depth knowledge and further their education building on the education offered in the Programs. Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education, and society. Students collaborate with an adjunct faculty advisor to collect data. Findings are applicable and may be implemented upon completion of a study. Applied research focuses on answering one specific applied research question for a client or sponsor. Applied Research Study must have prior approval of a faculty sponsor and the Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

Online Master of Engineering Management (Sever)

Total units required: 30

In order to earn the degree, all courses must be passed with a C– or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the degree.

Code	Title	Units
Required: 24 units		
ETEM 5504	Engineering Management & Financial Intelligence	3
ETEM 5507	Strategic Engineering Management	3
ETEM 5508	Marketing Innovation	3
ETEM 5510	Understanding Emerging & Disruptive Technologies	3
ETEM 5530	Project Planning Methodologies	3
ETEM 5581	Leading in a Technology-Rich World	3
ETEM 5582	Human Performance in the Organization	3
ETEM 5985	Master of Engineering Management Capstone	3
Electives: Choose 6 units		
ETEM 5505	Decision Analysis & Optimization	3
ETEM 5531	Introduction to Agile Project Management	3
ETEM 5532	The Art & Science of Risk Management	3
ETEM 5586	Cross-Cultural Negotiation	3
ETEM 5587	Communication Excellence for Influential Leadership	3

Graduate Certificates

Graduate Certificate in Construction Management

The Graduate Certificate in Construction Management is a 15-unit program designed for working professionals. Students will be prepared for every aspect of leading a construction project or organization. Created for any professional of the built environment, our curriculum incorporates traditional themes like cost, time, risk and quality management with multidisciplinary topics such as business, finance, ethics and law. Lecture and lab-based education provides students with an environment for practical application utilizing best practices that address current issues and developments in the industry.

Graduate Certificate: 15 units, 10-15 months to complete

Email: sever@wustl.edu

Website: <https://sever.wustl.edu/degree-programs/construction/index.html>

Faculty

Program Director

Steve W. Bannes

Director of Graduate Studies, Construction Management

Professor of Practice

MS, Education, Southwest Baptist University

BS, Construction Engineering & Management, Southern Illinois University Edwardsville

For a list of our program faculty, please visit our website.

Requirements

- Graduate Certificate in Construction Management (p. 159)

Courses

CNST 5532 Specialized Topics in Construction Estimating

This course explores the application of cost estimating principles and estimating within a project management framework in conjunction with scope definition, quality control, planning and scheduling, risk management and loss prevention techniques, local conditions, information and communication, and working relations with

stakeholders. Using a single building project, the course introduces the application of basic quantity surveying and estimating principles using a methodical approach with suggested check lists and techniques for arriving at a reliable cost estimate including direct, indirect, and contingency costs and profits. Student's estimating efforts culminate with a competitive bid day scenario.

Credit 3 units.

Typical periods offered: Fall, Spring

CNST 5550 Site Infrastructure Construction Strategies

This course provides a broad perspective of the means, methods, and procedures associated with managing civil engineering and heavy construction projects. Topics include strategic bidding and estimating, heavy equipment, marine construction heavy civil operations and bridge building. Integration of scheduling, estimating, and construction contracts with a project based approach. *There will be a \$60 fee for use of the required licensed software used in this class.*

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5572 Legal Aspects of Construction

A survey of the legal problems of the construction manager, including but not limited to liability in the areas of contracts, agency, torts, insurance, bad judgment and oversight.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5573 Fundamentals in Construction Management

In this course, students will be exposed to the overall construction process from initial concept through startup of the completed facility. The focus is to provide familiarization of the construction and contracting process and potential involvements by construction managers in the planning, design, construction, and post construction phases. Additional topics are introduced to provide a foundation which will prepare students for future construction management coursework. Case studies and industry examples are used throughout the course to authenticate the lectures and assignments.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5574 Construction Project Planning and Scheduling

Project planning and scheduling process utilizing current techniques including critical path analysis for effective and logical scheduling of construction projects. Identification of project activities and their relationships; schedule development, analysis, and updating; relationship of project costs and resources to the schedule; legal implications; effective communication of schedule information; development of procedures to monitor actual field progress; computer application in project scheduling.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5579 Advanced Construction Management

A comprehensive study of the operations encountered in the management of a construction firm. Topics include estimating, scheduling, forms of contracts, risk analysis and management, extra work orders, claims and disputes, construction safety, and contract close-out.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CNST 5580 Digital Construction Technology: Principles and Practices

This course focuses on BIM's philosophy of integration between designers, construction professional, and owners, in order to overcome both technological and implementation changes using Virtual Design and Construction (VDC) and Integrated Project Delivery (IPD). VDC is a methodology that relies on a multidisciplinary collaboration of the digital simulation of design & construction. IPD, on the other hand, integrates people, systems, business structures and practices into a process to optimize efficiency and productivity. In this course, students will learn about BIM's application by exploring 3D, 4D aspects of BIM including geometry, spatial relationships, quantity take off, estimation and scheduling. Along with that, students also will learn about Virtual Design and Construction (VDC) and Integrated Project Delivery (IPD) system that are integral component of a successful BIM projects.

Credit 3 units.

Typical periods offered: Fall, Spring

CNST 5981 MCM - M.Arch Capstone Project Phase 1

In the capstone course sequence (CNST 5981 and CNST 5982), M.Arch + MCM dual degree program students apply constructability principles to their ARCH 7520: Degree Project and successfully demonstrate their application. Constructability principles include analysis of construction methods and procedures, as well as project cost, time, value, quality, and safety. Phase 1 students will develop a Constructability Review, Analysis, and Plan (CAAP) for their project. The CAAP is a plan to focus and guide the work in CNST 5982 – Phase 2. It includes: · Identification of the specific constructability issue(s) you will evaluate (assess/analyze). · Methodology to be used in gathering information and conducting the analysis · Identification of the Phase 2 deliverables After completing CNST 5981, students will enroll and complete CNST 5982.

Credit 1 unit.

Typical periods offered: Fall, Spring, Summer

CNST 5982 MCM - M.Arch Capstone Project Phase 2

In the capstone course sequence (CNST 5981 and CNST 5982), M.Arch + MCM dual degree program students apply constructability principles to their ARCH 7520: Degree Project and successfully demonstrate their application. Constructability principles include analysis of construction methods and procedures, as well as project cost, time, value, quality, and safety. Students will enroll and complete CNST 5982 – Phase 2 in the semester following ARCH 7520: Degree Project and completion of CNST 5981. CNST 5982 – Phase 2 students will execute the Constructability Review, Analysis, and Plan (CAAP) developed in CNST 5981 – Phase 1. This work will be incorporated into the final report, the Constructability Review and Analysis (CRA) Report. It will include: · The Constructability Review and Analysis, and · Results/Conclusions – Lessons learned

Credit 2 units.

Typical periods offered: Fall, Spring, Summer

CNST 5998 Applied Research Study

Applied Research Study (ARS) is an advanced, project-based course designed to allow students to develop in-depth knowledge and further their education building on the education offered in the Programs. Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education, and society. Students collaborate with an adjunct faculty advisor to collect data. Findings are applicable and may be implemented upon completion of a study. Applied research focuses on answering one specific applied research question for a client or sponsor. Applied Research Study must have prior approval of a faculty sponsor and the Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

Graduate Certificate in Construction Management (Sever)

In order to earn the certificate, all courses must be passed with a C- or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the certificate.

Code	Title	Units
Required: 15 units		
CNST 5532	Specialized Topics in Construction Estimating	3
CNST 5572	Legal Aspects of Construction	3
CNST 5573	Fundamentals in Construction Management	3
CNST 5574	Construction Project Planning and Scheduling	3
ETEM 5587	Communication Excellence for Influential Leadership	3

Graduate Certificate in Cybersecurity Management

As technology and cybersecurity threats continue to grow and evolve, so does the need for highly skilled cybersecurity leaders who can direct and protect critical information infrastructures. Securing an organization's data requires a refined combination of technical skills, managerial acumen, and leadership expertise. This on-campus, part-time, five-course (15-credit-hour) graduate certificate is designed for mid- and senior level cybersecurity professionals. The goal of the program is to educate cybersecurity practitioners in the fundamentals of managing the people, technology, and resources necessary to lead cybersecurity organizations. The curriculum provides students with the knowledge needed to protect from, defend against, respond to, and recover after cyber threats and manage the organization's technology-based risk exposure. Students will acquire the expertise needed to successfully execute a range of core cybersecurity functions, including governance, risk management, operations, and incident

response. The program places particular emphasis on business-related skills such as communicating with non-technical line-of-business leaders and peers, speaking the language of business, and strategy formulation and development. Graduates of this certificate program will be well prepared to step into positions of greater responsibility and to make larger and more consequential contributions to their organizations. Graduates of this program will be equipped to solve complex cybersecurity problems and to ensure the enterprise's ongoing vitality and prosperity.

- **Graduate Certificate:** 15 units, 10-15 months to complete

Email: sever@wustl.edu

Website: <https://sever.wustl.edu/degree-programs/cybersecurity/index.html>

Faculty

For a list of our program faculty, please visit our website.

Requirements

- Graduate Certificate in Cybersecurity Management (p. 162)

Courses

CYBER 5559 Introduction to Cybersecurity

This course is intended as a comprehensive introduction to the cybersecurity field. It covers a broad range of cyber security terms, definitions, historical perspectives, concepts, processes, technologies, and trends with a focus on managing risk and the employment of cybersecurity as an organizational enabler. This course is largely asynchronous with some mandatory synchronous meetings. Details will be noted in the syllabus.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5560 Cybersecurity Technologies and Threats

This course presents a comprehensive survey of cybersecurity technology, including basic theory and concepts. Students will gain hands-on familiarity with cybersecurity technology through lab exercises, in-class studios, and scenarios. Topics covered include security considerations surrounding operating systems, the web, email, databases, wireless technology, the cloud, and the Internet of Things. Also addressed are cryptography, secure software design, physical security, and human factors in cybersecurity.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5561 Oversight for Excellence: Cybersecurity Management and Governance

This course takes a comprehensive approach to the management of the organizational cybersecurity function. It also explores the principles of information technology governance. Course work provides a deeper understanding of best practices for managing cybersecurity processes and meeting multiple needs of enterprise management by balancing business risks and operational and technical imperatives. Toward this end, the course addresses a range of topics necessary for success, including the elements of and how to establish

a governance program, cybersecurity management frameworks, developing and implementing a cybersecurity strategy, deploying cybersecurity policy and controls, ensuring standards and regulatory compliance, functional and budgetary advocacy, interfacing with the C-suite and board, and talent acquisition and development.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5562 Efficient and Effective Cybersecurity Operations

In this course, students will gain understanding of what it takes to manage the people, process, and technology for effective and efficient day-to-day cybersecurity operations. Using the Cybersecurity Operations Center (CSOC) as the fundamental exemplar, students will learn the functions and processes that comprise a typical CSOC with an underlying focus on continually optimizing operations and processes to ensure agility and performance. Students will examine options for structuring the CSOC and core CSOC functions and processes such as threat intelligence; monitoring, detection, and threat assessment; vulnerability management; incident response; prevention, including awareness training; partner and third-party coordination; analytics, metrics, and reporting; training; and CSOC technologies and instrumentation.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5563 Enterprise Network Security

This course presents a detailed and comprehensive study of the architecture and defensive approaches to protect enterprise network environments against cyber threats. Students will gain practical experience in secure network architectures and design approaches. Using a building-block approach along with case studies and design exercises, the course will establish the value of applied foundational security frameworks and system models. Specific topics include defensive network design, advanced treatment of appropriate security implementation tools and techniques, boundary defense, secure wireless and mobility solutions, remote and business partner access, and third-party and vendor interactions to ensure appropriate enterprise network solutions are implemented.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5564 Access Control and Identity Management

Business advancements due to technologies such as cloud, mobility, and the need to access information from anywhere using any device have made identity management and access control a critical component of cybersecurity. In this course, students will gain understanding of organizational and technical identity management and access control frameworks. They will also learn central concepts such as least privileged access, authentication, and authorization, which protect applications and systems from unapproved access. Topics covered include single sign-on, privileged account management, provisioning, role management, and directory services. Students will complete a real-world identity management and access control business case to identify risks and controls, and they will also create a strategy and roadmap to address challenges and propose solutions.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5565 Cybersecurity Analytics

This course provides an introduction to use of data analytics in support of an organization's cybersecurity function. The course is designed to increase student understanding of how data analytics can be used to manage security and how data analytics can be deployed in support of risk-based assessment and decision making. Students who complete this course successfully will be able to apply data analytics techniques

and tools to help organizations discover anomalies pertaining to cyber threats; to implement, assess and monitor basic security functions; to respond to emerging threats or prioritized requests as defined by organizational stakeholders; to depict cybersecurity risk posture within the context of compliance and regulatory requirements; and to construct a comprehensive cybersecurity analytics framework.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5566 Cybersecurity Risk Management

In this course, students will gain deeper appreciation of the challenges faced by enterprises when addressing cybersecurity risks. The course will cover the evolution of cyber threats, including attacker methods and their targets across different industries. Students will be able to understand the differences between enterprise, operational and cybersecurity risk management and the role that each play (or should play) in managing risks to an organization. Students will gain technical understanding of industry-leading frameworks (COSO, ISO, NIST, FAIR) and become conversant with their strengths and weaknesses as well as the applicability and practicality of their implementation.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5567 The Hacker Mindset: Cyber Attack Fundamentals

This course is designed to provide an introductory understanding of how offensive security techniques practically operate. During this course, students will use hacking techniques to compromise systems, collect data, and perform other tasks that fall under the generally understood use of the term hacker. These techniques will be related to risk-based defensive security practices, with a view toward enhancing the student's understanding of what it takes to be a successful defender. By the conclusion of the course, students will have a baseline technical understanding of hacking techniques; they will have executed offensive security operations and increased their technical understanding of what it takes to deal with cyber threats.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5568 Emerging Issues and Technology in Cybersecurity

Each new technology advancement brings with it promises and challenges. Will it be used for good or lead to disaster? This course examines contemporary and near-future cybersecurity threats and the potential security impact of new technologies. Topics include new forms of computing and communications and their implications for cybersecurity practitioners as well as incipient threat vectors. Historical security incidents will also be used to provide context and insight into the relationship of technology and security. Throughout the course, students will be challenged to develop strategies and responses to deal with emerging technologies and threats in the ever-evolving cybersecurity domain.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5569 Incident Response and Business Continuity

This course focuses on the end-to-end process and methods to deal with cybersecurity incidents. Using recent examples of cyber breaches and incidents, students explore how CISOs react and respond to these incidents and learn best practices for doing so. Topics include developing an incident response plan, organizing an incident response team, leveraging cyber intelligence and external partners to aid in response, handling public and private communications about the incident, and post-breach restoration. Particular attention will be paid to establishing a strong understanding of cybersecurity indicators and motives for espionage activities from both an external and rogue insider's perspective. Students will learn about host-based and



network incident response tools and digital forensic tools, including techniques and tactics for their effective use. This section of the course includes key hands-on activities that are typically used in post-breach analysis and investigations, such as the forensic analysis of network storage, hard drives, and memory. Students will also become familiar with post-breach report construction and examine the proper drafting and use of such reports for submission to legal counsel, the courts, and organizational leaders.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5570 Leadership Seminar for Technology Professionals

This seminar is designed to develop the leadership capacity of professionals working in the information technology and cybersecurity fields. Although domain expertise plays an important role in the success of a technology professional, it's when this expertise is integrated with the ability to lead people that transforms the merely competent into multi-dimensional force multipliers for the organization. In this course, students will participate in an immersive, seminar-based learning experience targeted toward professional and personal development on a range of essential leadership skills. Students will benefit from interaction with industry experts in the IT and cybersecurity fields and receive coaching support to achieve professional and personal goals. Each student will complete a series of self- and multi-rater assessments as well as a personal leadership development plan to gain insight and build competencies critical to effective leadership. Topics include creating a shared vision, strategy development, building and sustaining a healthy culture, essentials of finance and budgeting, driving results, energizing people for performance, innovation, emotional intelligence, navigating organizational politics, managing up, negotiations, stress resilience, talent coaching and development, effective communication, and time management.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5587 Cloud Security

Today's organizations are more and more focused on delivering faster results and better products and services and doing this securely in an ever-evolving technological landscape. Cloud-based technologies have enabled the critical capabilities, functionality and innovations necessary to transform the way organizations survive and thrive in this competitive environment. As such, the cloud requires cybersecurity practitioners to think differently about managing risk, producing resilient solutions, and dealing with third-party providers. In this course, students will learn best practices for cloud security to include methods for architecting and applying security-related features in a cloud platform. Through case studies, standards, best practices, and studio exercises, students will develop the necessary skills to identify the security challenges of a cloud environment in support of the ongoing operations of the enterprise.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5588 Managerial AI in Cybersecurity

This course bridges the gap between strategic leadership and technical execution, preparing cybersecurity managers to govern the rapid transition from traditional Machine Learning to autonomous Agentic AI. Students will move beyond high-level theory to master the "business of AI," aligning AI initiatives with organizational objectives while managing the complex lifecycle of autonomous systems. The curriculum focuses on Security by Design, teaching managers how to architect governance using a Separation of Duties (SoD) framework. This approach divides responsibility between the "Agent Plane" (DevOps/Operations) and the "Guard Plane" (Cybersecurity), ensuring rigorous oversight of autonomous reasoning and actions.

Students will evaluate unique AI threat landscapes—including prompt injection, jailbreaking, and hallucination—and implement Guard Model Architectures to mitigate these risks. Weaving technical validation with ethical responsibility, the course covers the NIST AI Risk Management Framework and the EU AI Act, preparing leaders to navigate the legal and compliance challenges of enterprise AI.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5589 Cybersecurity Risk and Governance of Third-Party Ecosystems

This graduate-level course examines cybersecurity risk as an enterprise management problem, emphasizing how security weaknesses, control gaps, and governance failures manifest in real-world incidents—particularly across third-party and supply-chain relationships. Using case studies drawn from notable breaches, outages, fraud events, and regulatory actions, students learn to translate technical risk into business impact and actionable executive oversight. The course is designed for current or aspiring CISO-level leaders and focuses on establishing and governing a comprehensive Third-Party Risk Management (TPRM) program. Students will develop the ability to set risk appetite and minimum security requirements for vendors, evaluate and prioritize third-party exposure, oversee due diligence and continuous monitoring, and ensure contract language, assurance mechanisms, and escalation paths align with organizational objectives. Topics include vendor segmentation and criticality, security questionnaires and evidence-based validation, audit and attestation frameworks, incident notification and response coordination, cloud/SaaS and managed service provider risk, fourth-party dependencies, data protection and privacy obligations, and reporting metrics suitable for senior leadership and boards. By the end of the course, students will be able to design and communicate an oversight model that balances security, speed, cost, and compliance—enabling resilient operations in a highly interconnected vendor ecosystem.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5998 Applied Research Study

Applied Research Study (ARS) is an advanced, project-based course designed to allow students to develop in-depth knowledge and further their education building on the education offered in the Programs. Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education, and society. Students collaborate with an adjunct faculty advisor to collect data. Findings are applicable and may be implemented upon completion of a study. Applied research focuses on answering one specific applied research question for a client or sponsor. Applied Research Study must have prior approval of a faculty sponsor and the Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5999 Independent Study

Submission of the Independent Study Proposal with Approval of the Faculty Sponsor and Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

Graduate Certificate in Cybersecurity Management (Sever)

Total units required: 15

In order to earn the certificate, all courses must be passed with a C- or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the certificate.

Student select five courses from the list below for a total of 15 units:

Code	Title	Units
Required: 15 units		
CYBER 5560	Cybersecurity Technologies and Threats	3
CYBER 5561	Oversight for Excellence: Cybersecurity Management and Governance	3
CYBER 5566	Cybersecurity Risk Management	3
CYBER 5588	Managerial AI in Cybersecurity	3
CYBER 5589	Cybersecurity Risk and Governance of Third-Party Ecosystems	3
CYBER 5567	The Hacker Mindset: Cyber Attack Fundamentals	3

Graduate Certificate in Engineering Management

The competitive Engineering Management program bridges the gap between technology and business by providing students with the technical expertise and leadership skills needed to advance their careers. The 15-unit Graduate Certificate in Engineering Management is available for part-time, working professional students.

This program brings together Washington University faculty and industry-leading experts to help students learn to strategize, lead, make informed decisions, manage financials, and leverage both existing and emerging technology. The courses prepare individuals to utilize common management tactics across all of the engineering disciplines.

- **Graduate Certificate:** 15 units, 10-15 months to complete

Email: sever@wustl.edu
 Website: <https://sever.wustl.edu/degree-programs/engineering/index.html>

Faculty

Program Director

John Bade

Director of Graduate Studies, Engineering Management and Project Management

PhD, Engineering, Missouri University of Science & Technology

MBA, Saint Louis University

ME, Missouri University of Science & Technology

For a list of our program faculty, please visit our website.

Requirements

- Graduate Certificate in Engineering Management (p. 165)

Courses

ETEM 5504 Engineering Management & Financial Intelligence

Discover the full picture of how business works within the organization. This course walks the student through the complete business cycle -- the roles the various functions play in a business operation as well as how information is used to make business decisions (e.g. financial data, marketing data, production data, economic data). To bring these learnings to life, this course also uses management simulation games and classroom competitions. Includes strategy, product planning and management, sales and support, research and development, manufacturing and supply chain, with particular emphasis on accounting, finance and the use of financial statements.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5505 Decision Analysis & Optimization

Expand the ability to analyze and optimize complex business situations by leveraging the key data. Decision-making in today's complex world requires advanced analytical methods and tools, including mathematical modeling and quantitative techniques. Powerful tools for forecasting, finance, operations, production and logistics. Emerging technologies such as the Industrial Internet of Things (IIoT) and Block Chain are enabling a whole new set of possibilities!

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5507 Strategic Engineering Management

Learn the frameworks and process for developing a strategy focused on technology acquisition and value return. This course will cover the entire lifecycle of strategy development, from discovery and business case development, to evaluation and selection, and finally deployment and realization (value return). The tools in this course will help students determine direction when faced with a technology /

automation investment decision. These strategies are built on so much more than just functional capabilities of a given technology and in turn, this course is structured to introduce students to all facets that go into a successful Technology Strategy.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5508 Marketing Innovation

Explore the intersection of marketing strategies and engineering processes as a way to enhance product development and market competitiveness. This course equips future engineering leaders with an understanding of essential marketing principles and the rationale behind effective strategy and implementation. Students will acquire the skills to critically evaluate a marketing plan, identify opportunities to align marketing activities to achieve their business goals, and segment/target customers.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5510 Understanding Emerging & Disruptive Technologies

The current era of rapid technology innovation is causing significant disruption to markets and societies. Blockbuster was the darling of Wall Street in 2004 and filed for bankruptcy in 2010. Blockbuster CEO in 2008: Neither Redbox nor Netflix are even on the radar screen in terms of competition. Blockbuster is not alone in their blindness. Microsoft laughed off the first iPhone, and laughed off Google. IBM laughed off the first personal computer. These should be a warning to all business leaders. Numerous technologies are threatening disruption today. Understanding what they are and how they might disrupt will make or break countless companies in the coming years.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5520 Introduction to Innovation & Entrepreneurship

What exactly is innovation, and what is entrepreneurship? How do they drive business and society? Where do good ideas come from? Can anyone learn to be innovative or be an entrepreneur, and does thinking like an engineer help or hinder this process? What does an innovative organization look and act like? What barriers exist to innovation/entrepreneurship, and can they be overcome? This course introduces important frameworks and concepts, offers the student hands-on individual and team learning, includes numerous guest lecturers, and cultivates essential communication skills, all with the goal of fostering an understanding of, and confidence in, innovation and entrepreneurship - both for the individual as well as for the organization.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5521 Human Performance in the Organization

Gain insights and practice in the art and science of leadership. This course addresses the leadership and management capabilities required to move into positions of greater responsibility, with a focus on technology-based organizations. Topics include leadership, goals, motivation and performance, management of change, conflict and effectiveness, organizational development and work design. Because when a leader gets better, everyone gets better.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5525 Innovating for Defense

This interdisciplinary entrepreneurial course gives students the unique opportunity to solve real problems facing the U.S. Department of Defense (DoD) and the U.S. Intelligence Community (IC). This course is open to all students who want to solve real problems for real stakeholders in real time. In consultation with course instructors, students will form their own interdisciplinary teams to explore a challenge experienced by a dedicated DoD problem sponsor who will be regularly engaged with the team. Student teams learn and use the Lean Startup methodology and the Mission Model Canvas made famous by Stanford University to iteratively cut through the complexity of the problem. Note: This course is sponsored by the U.S. DoD. It was originally developed at Stanford University and is now taught at 30+ U.S. universities. A student does NOT have to be a citizen of the United States to take this course; none of the DoD problems are classified.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5527 Entrepreneurship: Challenges & Opportunities

In a world with endless entrepreneurial opportunities, what is the skillset needed to understand the stages from idea to market? This course covers how to quantify the size of the potential market for any entrepreneurial idea, to assess the technical feasibility and financial viability of the idea, to prioritize an initial market for the idea, and to develop a strategy for pursuing the initial market for the idea, whether at a startup or an existing business.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5528 Legal Concepts for Engineering and Technical Managers

With emerging technologies developing at a non-linear rate, the law must adapt just as quickly. As engineering managers, you will be an integral collaborator with your legal team as these laws evolve. Whether it is determining who owns a patent for an invention developed by artificial intelligence, working through smart contracts, or even run-of-the-mill product liability issues, having a strong understanding of legal concepts will help you interact with attorneys and provide recommendations to guide your team through potential legal crossroads.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5530 Project Planning Methodologies

Build expertise with today's critical project management methodologies in our fast-paced world. Variations of waterfall are widely used in industry, but new uses of agile are being discovered every day, both inside and outside of software-based organizations. This course exposes the student to the fundamental and emerging techniques and tools used to manage successful projects of various sizes and complexity -- managing cost, schedule, quality, risk, solution and requirements -- while adapting to today's fast-paced and uncertain business environment. This course has a Connect fee associated with it. Please check the course materials for the updated amount.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5531 Introduction to Agile Project Management

SCRUM, XP, Kanban, ScrumBan, SAFe - these are some of the key frameworks and processes covered in this course. Agile as a mindset, a skillset, and a toolset are all critical in our fast-paced world. Today's businesses have either started or will soon begin their Agile journey. This course will use books from industry recognized experts in the

field of Agile development as well as case studies and varying practical assignments. Students will come away with a solid understanding of the core agile concepts, processes, frameworks, roles, and practices that are shown to deliver leading Market and Business value.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5532 The Art & Science of Risk Management

This course focuses on why many project managers miss requirements for schedule, budget or even both. The course concentrates on key risk management techniques practiced by leading project and program managers and taught through fact-filled lectures, case work and project execution as applied to information systems, engineering, financial, product/process and design projects/programs in today's fast-moving environment. Students will take away key value propositions, including risk identification, risk quantification, risk monitoring, risk control and risk mitigation. This course will enable the student to address common scope, schedule, quality and cost risk events that occur on complex projects. Project risk management examines the types of risk, with a focus on understanding the process of risk identification, assessment, prevention, mitigation, and recovery; governance, auditing, and control of confidentiality; integrity; and availability of data. Using common operational, strategic, tactical, and technological scenarios, the course work provides a comprehensive approach to the challenges faced by managers when global data is readily available, risk is pervasive, regulations are ever-increasing, and the threat of disruption from potential crises is real.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5581 Leading in a Technology-Rich World

Leadership has fundamentally changed from top-down, autocratic and task-focused to collaborative and people-focused in just a few generations. Great senior leaders now get their people to do the greatest things. They must constantly learn, think innovatively, move and adapt very quickly, and collaborate over short and long distances. Students will learn new leadership skills, explore their individual leadership styles, and discuss the senior leadership challenges in an evolving tech-rich world.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5582 Human Performance in the Organization

Why do some careers soar and others stall? Why it is easy to build relationships with some people - but not others? Why some teams function well and consistently outperform others? Curious about what kind of managers are leaders, or will be? Want to know more about how organizations decide who to hire and who to promote? Human Performance in the Organization is designed to help answer these questions. The content is a mix of relevant theory, personal reflection, and practical application. Our goal is to understand human performance at all levels of the organization. Topics include performance and career management; negotiation and influence; power and politics; mentoring and coaching; high-performance teams; conflict management; talent development and succession planning; and change management.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5586 Cross-Cultural Negotiation

This course introduces students to and gives them practice with principle-based tools and techniques to reach agreements across varied cultures. Best practices from the most famous negotiators of ancient history (i.e., the Phoenicians) are studied and used as a methodology that includes the role of a third party in resolving

conflict. The cross-cultural elements are based on multicultural experiences, research studies and the real-life experiences of the instructor. The course is highly interactive (about 70% of the course work). Participants learn through role plays and simulation as well as through readings and case-study analysis.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5587 Communication Excellence for Influential Leadership

Exceptional communicators become extraordinary leaders. This course will guide students to learn to exceptionally communicate their message by applying refined nuances that inspire and transform those with whom they converse. Through a proven communicative process, students will acquire skills necessary to differentiate them as leaders. Students will learn how to communicate across a variety of settings using strategies that result in clear, vivid, and engaging exchanges. Students will practice: storytelling; creating and using clear visuals; engaging listeners; demonstrating passion when speaking; responding to questions with clarity and brevity, and, using their distinctive voice as a leadership asset. Each student will learn how to assess his or her own communication capabilities, adjust to different listeners, and how to evaluate speaker effectiveness and provide valuable feedback to others. Video recordings will be used to demonstrate incremental communicative changes throughout the course, and to show how these strategies bring about outstanding leadership.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5600 Supply Chain for Engineering Managers

This course provides a comprehensive introduction to the fundamentals of supply chain management by applying theoretical concepts to actual quantitative and qualitative problem sets across various economic sectors. Through a case-based approach, students explore both the mechanics and the business context of strategic and tactical decisions across the end-to-end supply chain. Special emphasis is given to the intersections of supply chain and engineering, including product lifecycle management, strategic sourcing, and high-tech manufacturing.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5602 Systems Engineering

This course focuses on leadership involvement and the strategies essential for designing and implementing successful systems. It highlights the importance of asking the right questions, identifying problems early, leveraging data, aligning with key requirements, and crafting holistic solutions that address the entire system

Credit 3 units.

Typical periods offered: Summer 4, Summer 3, Summer 2, Summer 1, Summer Half B, Summer Half A, Summer, Spring, Summer Intersession, Fall

ETEM 5985 Master of Engineering Management Capstone

As the integrative finale of the MEM program, this course transitions students from theory to professional practice. Functioning as a graduate-level consulting team, students partner with industry sponsors to tackle a real-world challenge. The students will work closely with the sponsor throughout the semester. The capstone requires the synthesis of technical and business acumen to define project scope, execute rigorous data-driven analysis, and develop viable solutions. The semester concludes with a formal delivery of strategic recommendations to organizational stakeholders and a comprehensive technical paper. This course validates the student's ability to lead complex projects and deliver measurable value in a professional environment.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

ETEM 5998 Applied Research Study

Applied Research Study (ARS) is an advanced, project-based course designed to allow students to develop in-depth knowledge and further their education building on the education offered in the Programs. Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education, and society. Students collaborate with an adjunct faculty advisor to collect data. Findings are applicable and may be implemented upon completion of a study. Applied research focuses on answering one specific applied research question for a client or sponsor. Applied Research Study must have prior approval of a faculty sponsor and the Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

Graduate Certificate in Engineering Management (Sever)

Total units required: 15

In order to earn the certificate, all courses must be passed with a C– or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the certificate.

Code	Title	Units
Required: 15 units		
ETEM 5504	Engineering Management & Financial Intelligence	3
ETEM 5507 or ETEM 5508	Strategic Engineering Management Marketing Innovation	3
ETEM 5510	Understanding Emerging & Disruptive Technologies	3
ETEM 5530	Project Planning Methodologies	3
ETEM 5581 or ETEM 5582	Leading in a Technology-Rich World Human Performance in the Organization	3
Total Units		15

Online Graduate Certificate in Cybersecurity Management

As technology and cybersecurity threats continue to grow and evolve, so does the need for highly skilled cybersecurity leaders who can direct and protect critical information infrastructures. Securing an organization's data requires a refined combination of technical skills, managerial acumen, and leadership expertise. This fully online, part-time, five-course (15-credit-hour) graduate certificate is designed for mid- and senior level cybersecurity professionals. The goal of the program is to educate cybersecurity practitioners in the fundamentals of managing the people, technology, and resources necessary to lead cybersecurity organizations. The curriculum provides students with the knowledge needed to protect from, defend against, respond to, and recover after cyber threats and to manage the organization's technology-based risk exposure. Students will acquire the expertise needed to successfully execute a range of core cybersecurity functions, including governance, risk management, operations, and incident response. The program places particular emphasis on business-related skills such as communicating with non-technical line-of-business leaders and peers, speaking the language of business, and strategy formulation and development. Graduates of this certificate program will be well prepared to step into positions of greater responsibility and to make larger and more consequential contributions to their organizations. Graduates of this program will be equipped to solve complex cybersecurity problems and to ensure the enterprise's ongoing vitality and prosperity.

- **Graduate Certificate:** 15 units, 10-15 months to complete

Email: sever@wustl.edu

Website: <https://sever.wustl.edu/degree-programs/cybersecurity/index.html>

Faculty

For a list of our program faculty, please visit our website.

Requirements

- Online Graduate Certificate in Cybersecurity Management (p. 168)

Courses

CYBER 5559 Introduction to Cybersecurity

This course is intended as a comprehensive introduction to the cybersecurity field. It covers a broad range of cyber security terms, definitions, historical perspectives, concepts, processes, technologies, and trends with a focus on managing risk and the employment of cybersecurity as an organizational enabler. This course is largely asynchronous with some mandatory synchronous meetings. Details will be noted in the syllabus.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5560 Cybersecurity Technologies and Threats

This course presents a comprehensive survey of cybersecurity technology, including basic theory and concepts. Students will gain hands-on familiarity with cybersecurity technology through lab exercises, in-class studios, and scenarios. Topics covered include security considerations surrounding operating systems, the web, email, databases, wireless technology, the cloud, and the Internet of Things. Also addressed are cryptography, secure software design, physical security, and human factors in cybersecurity.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5561 Oversight for Excellence: Cybersecurity Management and Governance

This course takes a comprehensive approach to the management of the organizational cybersecurity function. It also explores the principles of information technology governance. Course work provides a deeper understanding of best practices for managing cybersecurity processes and meeting multiple needs of enterprise management by balancing business risks and operational and technical imperatives. Toward this end, the course addresses a range of topics necessary for success, including the elements of and how to establish a governance program, cybersecurity management frameworks, developing and implementing a cybersecurity strategy, deploying cybersecurity policy and controls, ensuring standards and regulatory compliance, functional and budgetary advocacy, interfacing with the C-suite and board, and talent acquisition and development.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5562 Efficient and Effective Cybersecurity Operations

In this course, students will gain understanding of what it takes to manage the people, process, and technology for effective and efficient day-to-day cybersecurity operations. Using the Cybersecurity Operations Center (CSOC) as the fundamental exemplar, students will learn the functions and processes that comprise a typical CSOC with an underlying focus on continually optimizing operations and processes to ensure agility and performance. Students will examine options for structuring the CSOC and core CSOC functions and processes such as threat intelligence; monitoring, detection, and threat assessment; vulnerability management; incident response; prevention, including awareness training; partner and third-party coordination; analytics, metrics, and reporting; training; and CSOC technologies and instrumentation.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5563 Enterprise Network Security

This course presents a detailed and comprehensive study of the architecture and defensive approaches to protect enterprise network environments against cyber threats. Students will gain practical experience in secure network architectures and design approaches. Using a building-block approach along with case studies and design exercises, the course will establish the value of applied foundational

security frameworks and system models. Specific topics include defensive network design, advanced treatment of appropriate security implementation tools and techniques, boundary defense, secure wireless and mobility solutions, remote and business partner access, and third-party and vendor interactions to ensure appropriate enterprise network solutions are implemented.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5564 Access Control and Identity Management

Business advancements due to technologies such as cloud, mobility, and the need to access information from anywhere using any device have made identity management and access control a critical component of cybersecurity. In this course, students will gain understanding of organizational and technical identity management and access control frameworks. They will also learn central concepts such as least privileged access, authentication, and authorization, which protect applications and systems from unapproved access.

Topics covered include single sign-on, privileged account management, provisioning, role management, and directory services. Students will complete a real-world identity management and access control business case to identify risks and controls, and they will also create a strategy and roadmap to address challenges and propose solutions.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5565 Cybersecurity Analytics

This course provides an introduction to use of data analytics in support of an organization's cybersecurity function. The course is designed to increase student understanding of how data analytics can be used to manage security and how data analytics can be deployed in support of risk-based assessment and decision making. Students who complete this course successfully will be able to apply data analytics techniques and tools to help organizations discover anomalies pertaining to cyber threats; to implement, assess and monitor basic security functions; to respond to emerging threats or prioritized requests as defined by organizational stakeholders; to depict cybersecurity risk posture within the context of compliance and regulatory requirements; and to construct a comprehensive cybersecurity analytics framework.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5566 Cybersecurity Risk Management

In this course, students will gain deeper appreciation of the challenges faced by enterprises when addressing cybersecurity risks. The course will cover the evolution of cyber threats, including attacker methods and their targets across different industries. Students will be able to understand the differences between enterprise, operational and cybersecurity risk management and the role that each play (or should play) in managing risks to an organization. Students will gain technical understanding of industry-leading frameworks (COSO, ISO, NIST, FAIR) and become conversant with their strengths and weaknesses as well as the applicability and practicality of their implementation.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5567 The Hacker Mindset: Cyber Attack Fundamentals

This course is designed to provide an introductory understanding of how offensive security techniques practically operate. During this course, students will use hacking techniques to compromise systems, collect data, and perform other tasks that fall under the generally understood use of the term hacker. These techniques will be related to risk-based defensive security practices, with a view toward enhancing the student's understanding of what it takes to be



a successful defender. By the conclusion of the course, students will have a baseline technical understanding of hacking techniques; they will have executed offensive security operations and increased their technical understanding of what it takes to deal with cyber threats. Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5568 Emerging Issues and Technology in Cybersecurity

Each new technology advancement brings with it promises and challenges. Will it be used for good or lead to disaster? This course examines contemporary and near-future cybersecurity threats and the potential security impact of new technologies. Topics include new forms of computing and communications and their implications for cybersecurity practitioners as well as incipient threat vectors. Historical security incidents will also be used to provide context and insight into the relationship of technology and security. Throughout the course, students will be challenged to develop strategies and responses to deal with emerging technologies and threats in the ever-evolving cybersecurity domain.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5569 Incident Response and Business Continuity

This course focuses on the end-to-end process and methods to deal with cybersecurity incidents. Using recent examples of cyber breaches and incidents, students explore how CISOs react and respond to these incidents and learn best practices for doing so. Topics include developing an incident response plan, organizing an incident response team, leveraging cyber intelligence and external partners to aid in response, handling public and private communications about the incident, and post-breach restoration. Particular attention will be paid to establishing a strong understanding of cybersecurity indicators and motives for espionage activities from both an external and rogue insider's perspective. Students will learn about host-based and network incident response tools and digital forensic tools, including techniques and tactics for their effective use. This section of the course includes key hands-on activities that are typically used in post-breach analysis and investigations, such as the forensic analysis of network storage, hard drives, and memory. Students will also become familiar with post-breach report construction and examine the proper drafting and use of such reports for submission to legal counsel, the courts, and organizational leaders.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5570 Leadership Seminar for Technology Professionals

This seminar is designed to develop the leadership capacity of professionals working in the information technology and cybersecurity fields. Although domain expertise plays an important role in the success of a technology professional, it's when this expertise is integrated with the ability to lead people that transforms the merely competent into multi-dimensional force multipliers for the organization. In this course, students will participate in an immersive, seminar-based learning experience targeted toward professional and personal development on a range of essential leadership skills. Students will benefit from interaction with industry experts in the IT and cybersecurity fields and receive coaching support to achieve professional and personal goals. Each student will complete a series of self- and multi-rater assessments as well as a personal leadership development plan to gain insight and build competencies critical to effective leadership. Topics include creating a shared vision, strategy development, building and sustaining a healthy culture, essentials of finance and budgeting, driving results, energizing people

for performance, innovation, emotional intelligence, navigating organizational politics, managing up, negotiations, stress resilience, talent coaching and development, effective communication, and time management.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5587 Cloud Security

Today's organizations are more and more focused on delivering faster results and better products and services and doing this securely in an ever-evolving technological landscape. Cloud-based technologies have enabled the critical capabilities, functionality and innovations necessary to transform the way organizations survive and thrive in this competitive environment. As such, the cloud requires cybersecurity practitioners to think differently about managing risk, producing resilient solutions, and dealing with third-party providers. In this course, students will learn best practices for cloud security to include methods for architecting and applying security-related features in a cloud platform. Through case studies, standards, best practices, and studio exercises, students will develop the necessary skills to identify the security challenges of a cloud environment in support of the ongoing operations of the enterprise.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5588 Managerial AI in Cybersecurity

This course bridges the gap between strategic leadership and technical execution, preparing cybersecurity managers to govern the rapid transition from traditional Machine Learning to autonomous Agentic AI. Students will move beyond high-level theory to master the "business of AI," aligning AI initiatives with organizational objectives while managing the complex lifecycle of autonomous systems. The curriculum focuses on Security by Design, teaching managers how to architect governance using a Separation of Duties (SoD) framework. This approach divides responsibility between the "Agent Plane" (DevOps/Operations) and the "Guard Plane" (Cybersecurity), ensuring rigorous oversight of autonomous reasoning and actions. Students will evaluate unique AI threat landscapes—including prompt injection, jailbreaking, and hallucination—and implement Guard Model Architectures to mitigate these risks. Weaving technical validation with ethical responsibility, the course covers the NIST AI Risk Management Framework and the EU AI Act, preparing leaders to navigate the legal and compliance challenges of enterprise AI.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5589 Cybersecurity Risk and Governance of Third-Party

Ecosystems

This graduate-level course examines cybersecurity risk as an enterprise management problem, emphasizing how security weaknesses, control gaps, and governance failures manifest in real-world incidents—particularly across third-party and supply-chain relationships. Using case studies drawn from notable breaches, outages, fraud events, and regulatory actions, students learn to translate technical risk into business impact and actionable executive oversight. The course is designed for current or aspiring CISO-level leaders and focuses on establishing and governing a comprehensive Third-Party Risk Management (TPRM) program. Students will develop the ability to set risk appetite and minimum security requirements for vendors, evaluate and prioritize third-party exposure, oversee due diligence and continuous monitoring, and ensure contract language, assurance mechanisms, and escalation paths align with organizational objectives. Topics include vendor segmentation and criticality, security questionnaires and evidence-based validation, audit and attestation frameworks, incident notification and response coordination, cloud/SaaS and managed service provider risk, fourth-party dependencies,

data protection and privacy obligations, and reporting metrics suitable for senior leadership and boards. By the end of the course, students will be able to design and communicate an oversight model that balances security, speed, cost, and compliance—enabling resilient operations in a highly interconnected vendor ecosystem.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5998 Applied Research Study

Applied Research Study (ARS) is an advanced, project-based course designed to allow students to develop in-depth knowledge and further their education building on the education offered in the Programs. Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education, and society. Students collaborate with an adjunct faculty advisor to collect data. Findings are applicable and may be implemented upon completion of a study. Applied research focuses on answering one specific applied research question for a client or sponsor. Applied Research Study must have prior approval of a faculty sponsor and the Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

CYBER 5999 Independent Study

Submission of the Independent Study Proposal with Approval of the Faculty Sponsor and Program Director.

Credit 3 units.

Typical periods offered: Fall, Spring, Summer

Online Graduate Certificate in Cybersecurity Management (Sever)

Total units required: 15

In order to earn the certificate, all courses must be passed with a C– or higher. In addition, a student must have a cumulative grade point average of at least 2.70 over all courses applied toward the certificate.

Course numbers below are subject to change. Please contact the Sever Institute Assistant Director of Academic & Student Services for accurate academic advising information.

Code	Title	Units
Required: 15 units		
CYBER 5560	Cybersecurity Technologies and Threats	3
CYBER 5561	Oversight for Excellence: Cybersecurity Management and Governance	3

CYBER 5566	Cybersecurity Risk Management	3
CYBER 5567	The Hacker Mindset: Cyber Attack Fundamentals	3
CYBER 5588	Managerial AI in Cybersecurity	3

Degrees Offered

- Aerosol Science & Engineering, Joint MS (EECE) (p. 108)
- Aerospace Engineering, MSAE (MEMS) (p. 136)
- Biomedical Engineering, Combined MD/PhD (BME) (p. 53)
- Biomedical Engineering, MS (BME) (p. 47)
- Biomedical Engineering, PhD (BME) (p. 50)
- Combined Master of Engineering/Master of Business Administration, MEng/MBA (EECE) (p. 111)
- Computational & Data Sciences, PhD (CDS) (p. 57)
- Computer Engineering, MS (CSE) (p. 76)
- Computer Engineering, MS (ESE) (p. 95)
- Computer Engineering, PhD (CSE) (p. 72)
- Computer Science & Engineering, MEng (CSE) (p. 80)
- Computer Science, MS (CSE) (p. 74)
- Computer Science, PhD (CSE) (p. 70)
- Controls Certificate (ESE) (p. 98)
- Cybersecurity Engineering Certificate (CSE) (p. 82)
- Cybersecurity Engineering, MS (CSE) (p. 78)
- Data Mining & Machine Learning Certificate (CSE) (p. 82)
- Electrical Engineering, MSEE (ESE) (p. 92)
- Electrical Engineering, PhD (ESE) (p. 90)
- Energy, Environmental, & Chemical Engineering, MEng (EECE) (p. 110)
- Energy, Environmental, & Chemical Engineering, MS (EECE) (p. 110)
- Energy, Environmental, & Chemical Engineering, PhD (EECE) (p. 108)
- Engineering Data Analytics & Statistics, MSDAS (ESE) (p. 94)
- Financial Engineering Certificate (ESE) (p. 99)
- Graduate Certificate in Construction Management (Sever) (p. 159)
- Graduate Certificate in Cybersecurity Management (Sever) (p. 162)
- Graduate Certificate in Engineering Management (Sever) (p. 165)
- Imaging Science & Engineering Certificate (ESE) (p. 99)
- Imaging Science, MS (IS) (p. 117)
- Imaging Science, PhD (IS) (p. 114)
- Master of Construction Management (Sever) (p. 140)
- Master of Construction Management/Master of Architecture (Sever) (p. 140)
- Master of Cybersecurity Management (Sever) (p. 144)
- Master of Engineering Management (Sever) (p. 147)



- Master of Information Systems Management (Sever) (p. 150)
- Materials Science & Engineering, Interdisciplinary PhD (MSE) (p. 121)
- Materials Science & Engineering, MS (MEMS) (p. 136)
- Materials Science & Engineering, PhD (IMSE) (p. 134)
- Mechanical Engineering, MEng (MEMS) (p. 137)
- Mechanical Engineering, MSME (MEMS) (p. 135)
- Mechanical Engineering, PhD (MEMS) (p. 133)
- Online Graduate Certificate in Cybersecurity Management (Sever) (p. 168)
- Online Master of Cybersecurity Management (Sever) (p. 153)
- Online Master of Engineering Management (Sever) (p. 157)
- Quantum Engineering Certificate (ESE) (p. 101)
- Robotics and Intelligent Systems, MEng (ESE) (p. 97)
- Systems Science & Mathematics, MSSSM (ESE) (p. 93)
- Systems Science & Mathematics, PhD (ESE) (p. 91)

Doctoral Program Information

Doctor of Philosophy

The Doctor of Philosophy (PhD) degree is not only an exploration of the knowledge in a given discipline but also an original contribution to it. To the extent that doctoral education has been successful, the student's relationship to learning is significantly changed. Having made a discovery, developed an insight, tested a theory or designed an application, the PhD recipient is no longer a student but a colleague of the faculty. It is for this reason that the PhD is the highest degree offered by a university.

The core mission of PhD programs at research universities is to educate the future faculty of other research universities and institutions of higher education. Graduates of Washington University participate in research and teaching; they also make valuable contributions to society by applying the analytical and creative skills required for scholarship to careers in the business, government and nonprofit sectors.

Among the critical components the university provides for these purposes are a small and select graduate student body, faculty members dedicated to scholarly work, and the physical facilities needed for research. In these regards, Washington University compares favorably to the finest graduate institutions in the world. However, the key ingredients of PhD completion must be provided by the student: a love of learning and a desire to increase the sum of human knowledge. Motivation and perseverance are prerequisites for success in PhD programs.

General Requirements

Candidates for doctoral degrees at Washington University must complete all courses required by their department; maintain satisfactory academic progress; pass certain examinations; fulfill residence and teaching requirements (if applicable); write, defend and submit a dissertation; and apply for program completion in Workday.

Engineering-based doctoral degrees require a minimum of 72 units. The doctoral program requires 36 to 48 units of course work and 24 to 36 units of research. The specific distribution decisions are made by the individual programs and departments.

The doctorate can be awarded only to those students whose knowledge of their field of specialization meets contemporary standards. Course work completed more than seven years prior to the date the degree is awarded generally cannot be accepted as satisfying degree requirements. No courses will be accepted toward degree requirements if the course exceeds the 10-year maximum time period unless they are formally approved by the McKelvey Doctoral Committee. In addition, all milestone requirements for the degree must be completed within seven years from the time the student is admitted to a graduate program.

The doctoral degree has a residency requirement of one year. To satisfy the requirement, the student must devote full time for two consecutive semesters to academically relevant activities on the Washington University campus. A limited amount of outside employment may be permitted, but only with the approval of the department or program chairman and/or the dean. Candidates for the Doctor of Philosophy degree and the Doctor of Science degree are required to follow the guidelines of the Office of the Provost and of the McKelvey School of Engineering.

Advisor & Doctoral Committee

Once admitted to graduate standing, each doctoral student will have an advisor appointed by the chair or director of the designated area of specialization. It is the responsibility of the advisor to help the student plan a graduate program.

Each department within McKelvey School of Engineering has its own policy related to the selection of a doctoral committee; therefore, students should consult with their faculty advisor regarding the appointment of their doctoral committee.

Doctoral Qualifying Examination

To be admitted to candidacy for a doctoral degree, the student must pass a comprehensive qualifying examination that may consist of both written and oral portions. The examination is administered by the student's department or program, and the student should consult

their advisor for information concerning the scope of the examination and the dates on which it is given. The examining panel will consist of faculty members approved by the department chair or the program director.

Doctoral Dissertation

Doctoral candidates must submit a satisfactory dissertation that involves independent creative work in an area of specialization and that demonstrates an ability for critical and constructive thinking. It must constitute a definite contribution to knowledge in some field of engineering. The research that is the subject of the dissertation must have been performed under the supervision of a member of the faculty of McKelvey School of Engineering. The candidate must defend the dissertation during a final oral examination by an examining committee to be nominated by the advisor and approved by the appropriate dean.

For specific information about preparing the dissertation for submission, candidates should refer to the thesis and dissertation submission procedures on the McKelvey School of Engineering webpage.

Each candidate for the doctoral degree must electronically submit a final approved version of their dissertation. The dissertation should include an abstract that embodies the principal findings of the research and that has been approved by the doctoral committee as ready for publication. Such an abstract will be published in Dissertation Abstracts, which announces the availability of the dissertation for distribution.

Administration

Dean's Office

314-935-6350

Department of Biomedical Engineering

314-935-6164

Department of Computer Science & Engineering

314-935-6160

Department of Electrical & Systems Engineering

314-935-5565

Department of Energy, Environmental & Chemical Engineering

314-935-6070

Department of Mechanical Engineering & Materials Science

314-935-6047

McKelvey Engineering Information Technology

314-933-3333

McKelvey Engineering Office of Graduate Programs

314-935-5830

Doctoral Program Policies

To view additional policies for PhD students, please refer to the University PhD Policies & Requirements (p. 32) section of this *Bulletin*.

Admissions

Eligibility

Washington University encourages and gives full consideration to all applicants for admission and financial aid, without regard to race, color, age, religion, sex, sexual orientation, gender identity or expression, national origin, veteran status, disability or genetic information.

McKelvey School of Engineering is strongly interested in recruiting, enrolling, retaining and graduating students from diverse backgrounds. Applications for admission by students from diverse backgrounds to any of our degree programs are encouraged and welcomed. To the greatest extent possible, students with disabilities are integrated into the student population as equal members.

To be considered for admission into a graduate degree program, applicants must hold a bachelor's degree from an accredited institution prior to starting the graduate program. Most of the engineering degree programs require a previous degree in science, technology, engineering or mathematics.

Current engineering graduate students who wish to be admitted into another engineering graduate program must be admitted at least one semester prior to their anticipated graduation semester.

Students may be admitted to study for the PhD degree directly from baccalaureate study or after undertaking other graduate or professional education, whether at Washington University or at another accredited institution.

Application Process

The application is available online through the McKelvey School of Engineering website. Applications are ready for final consideration after the required items from the application checklist have been submitted.

Please review our application checklist for details on all materials needed for a complete application.

Degree programs set their own application deadlines. Applicants should check deadlines through the McKelvey School of Engineering. It is generally advantageous to the applicant to complete the application well in advance of the deadline.



Admission and financial aid awards are for a specific academic year; students who do not matriculate that year must normally reapply. Admitted students can request a deferral of admission for up to one year from the admissions office. Applicants to whom admission is not offered may reapply for a future semester.

Admission of International Students

International students considering application to Washington University for graduate study should have a general familiarity with academic practices and university customs in the United States. International students are required to obtain a valid visa for study and maintain their immigration status. International students are required to report valid official English proficiency test scores for application. Please refer to our application checklist for additional information.

Attendance

Each professor in the McKelvey School of Engineering decides how many absences a student may have and still pass the course. Professors are expected to give reasonable consideration to unavoidable absences and to the feasibility of making up work that has been missed. Students are expected to explain to their professors the reasons for any absences and to discuss with them the possibility of making up missed assignments.

Units and Grades

The following grades are used in calculating the grade point average:

Grade Scale	Grade Points per Unit
A or A+	4.0
A-	3.7
B+	3.3
B	3.0
B-	2.7
C+	2.3
C	2.0
C-	1.7
D+	1.3
D	1.0
D-	0.7
F	0.0

The following grades and notations are ignored in calculating the grade point average:

Grade/Notation	Value
Pass	Pass
No Pass	No pass
I	Coursework incomplete; final grade pending
W	Withdrawal
N	No grade submitted; final grade pending
R	Retaken course
L	Successful audit
Z	Unsuccessful audit
Exam Credit	Exam Credit
Transfer Credit	Transfer credit
Not Transferred	Course attempted, not transferred

Auditing a Course

A student may register for some courses as an auditor. The criteria for a successful audit are determined by the course instructor, and the student should work with the instructor to ensure that these criteria are understood. Generally speaking, the completion of homework and the taking of exams are not required. The grade L signifies a successful audit, and the grade Z signifies an unsuccessful audit. Neither grade affects a student's grade-point average, and the course's units do not contribute to the student's total cumulative degree-seeking units. *Audit courses do not count toward any degree, nor do they count toward full-time status determination.* They do count toward the 21-unit cap per semester, and audit units are charged at the standard full-time or part-time per-unit rate. Class attendance is normally required to earn a grade of L; unsatisfactory attendance will result in a grade of Z.

Incomplete Grades

Incomplete Coursework

Washington University expects students to finish their coursework on time or remove themselves by dropping or withdrawing from the course by published deadlines. When situations outside a student's control arise, preventing timely course completion, a grade of I indicates that work is outstanding. McKelvey students may request an incomplete grade of I only in a course in which they have substantially completed the work, including any requirements of attendance or engagement. Students must also be passing the course based on materials submitted thus far to be eligible for an incomplete I grade.

This policy allows but does not compel I grades in the above circumstances. Grading is the purview of the faculty, as governed by school policies, and they may choose to deny requests for incomplete grades.

Impact of Incomplete Grades

An incomplete will prevent a student from moving forward in a sequence of courses when the unfinished course is required (prerequisite) to move ahead. An Incomplete is also factored into academic standing reviews and Satisfactory Academic Progress (SAP) reviews.

Finishing Incomplete Coursework

Incomplete grades will change to final failing grades one calendar year (365 days) following the last day of the term in which the course was taken if the student does not submit missing work and the instructor does not submit a final grade. Therefore, students must complete missing work and submit it with enough time to allow the instructor to evaluate the work and submit the grade before the 365-day window ends. Instructors may establish an earlier deadline than the University's deadline in this policy. Students and instructors are strongly encouraged to establish an agreement specifying the work remaining and the deadline for it to be submitted; some schools may require this (see school specific policies).

Students must not re-enroll in an upcoming section of the unfinished course to make up the incomplete; re-enrollment invokes the course retake policy. Students planning to graduate before the grade change deadline must complete courses and receive grades before graduating. Incompletes remaining at the time of degree conferral will be changed to final grades of failure. Grade changes are not permitted after a degree has been conferred.

N Grades – No Grade Submitted

In the rare event that an instructor is unable to submit a grade by the grade deadline, an N, signifying that the grade has not yet been submitted, may temporarily appear as a transcript notation on the student's record. N grades will change to final failing grades one calendar year (365 days) following the last day of the term in which the course was taken if the instructor does not submit a final grade.

Course Retake Policy

Students whose performance in a course has not met their expectations are permitted to retake courses in which they have earned a B- or lower (grades of P for Pass, A+, A, A-, B+, B, and Incomplete are not eligible for retakes; audits — whether successful or unsuccessful — are also not eligible for retakes). When a course is repeated, the attempt with the best grade will be used to calculate credit and will factor into the student's GPA. The other attempt(s) will have the letter R (denoting the retake) placed next to the grade. All registrations will show on the transcript; however, only the grade and units of the enrollment with the best grade will be used to calculate the student's GPA.

If an engineering student repeats a course elsewhere (i.e., as a preapproved transfer course from another university), the student must take the course for credit and earn a C or better for the units to transfer to Washington University. After an official transcript showing the final grade for the repeated course is received, the symbol R next to the first enrollment's grade indicates that the course was later retaken. The original grade will no longer figure into the student's GPA, nor will the transfer course grade figure into the GPA. The grade for the transfer course does not display on the student's Washington University record, but the units for the transfer course will count toward the degree program.

Student Grievance

From time to time, students may feel that they have legitimate complaints regarding academic matters or an interaction with a faculty member. It is important that students and faculty have a common understanding of how such complaints may be expressed and resolved. Students with complaints regarding academic matters should initially seek resolution from their faculty advisor, then from their director of graduate studies, and finally from the chair of their degree program. Complaints that remain unresolved may be addressed to the Associate Dean of Graduate Programs. The final court of appeal for all doctoral students in the school is the Vice Dean of Research and Graduate Education. Washington University policies state that members of the university community can expect to be free from discrimination and harassment. Students, faculty, staff and outside organizations working on campus are required to abide by specific policies prohibiting harassment. An allegation of discrimination or harassment may be appealed to the Vice Chancellor for Human Resources, who will determine whether to convene the Title IX Grievance Committee to hear the case.

Additional Course Information

To count toward a graduate degree, courses must be offered at the graduate level, taken for a grade (except for research courses, as described below), and approved in advance by the student's advisor and program as eligible to count toward the student's degree. Depending on the program, graduate-level work begins with courses numbered at the 4000 or 5000 level. *Audited courses and non-research courses taken on a Pass/No Pass basis cannot be counted toward the degree.* Students should consult their advisors regarding these options.

Courses designed to signify engagement in research for the purposes of the PhD degree will only be graded on a Pass/No Pass scale. Students will receive regular feedback through discussion with their research advisor. Students will also receive formal feedback about their research and overall degree progress via an annual review process as outlined in each department's handbook.

All McKelvey doctoral programs require a minimum of 72 units of a combination of coursework and research units to be completed for a degree. Students should consult their program handbooks for courses specific to their program.

Master's Degrees

Doctoral students who have not previously earned a master's degree in the same field as their PhD may earn the MS on the way to their PhD. Those who wish to obtain a master's degree must first discuss this with their research advisor. Once they have the approval of their research advisor, they should request the addition of the MS program through the McKelvey School of Engineering Academic Services office. The request will be routed to the appropriate department for approval. Once approved, the MS must be added at the end of a semester and prior to applying for program completion. An MS program will not be opened mid-semester. Doctoral students should note that transferring courses into a master's program is done on a course-by-course basis and should consult the master's handbook for that procedure.

Transfer Credit

A maximum of 24 units of graduate credit earned at institutions other than Washington University may be applied toward the PhD degree. Transfer credit must be recommended by the advisor, department or program chair and approved by the appropriate registrar with receipt of an official transcript. No graduate courses carrying grades lower than B can be accepted for transfer toward any graduate degree.

Students who have previously earned a master's degree from Washington University may be eligible to count all graduate-level credit earned for the Master's degree toward their doctoral degree. Eligible courses are at the discretion of the program director.

Students transferring to McKelvey with a faculty member may be eligible to transfer more than the 24-unit maximum at the discretion of the program director.

Registration and Enrollment Policies

Full-Time and Length of Enrollment

Students admitted to a PhD program in the McKelvey School of Engineering must maintain full-time continuous enrollment throughout the approved length of the program. McKelvey PhD programs are to be completed within six years under normal conditions. During those years, students will be considered full-time with one or a combination of the following enrollments: registered for 9 or more course units (including doctoral research units); or registered in EGS 9000 Full-Time Graduate Research/Study or EGS 9001 Full-Time Graduate Study in Absentia (discussed further below). These courses indicate the student's full-time engagement in research or academic writing and should be used once a student has completed the 72-unit requirement for the program. PhD students

who are not registered as above may find themselves in a part-time status and could be in jeopardy of the loss of certain benefits or be in violation of their visa status. Part-time enrollments will be permitted only in extraordinary circumstances. EGS 9002 Full-Time Graduate Study Extension (discussed further below) should be used for enrollment in circumstances requiring a seventh year.

In-Absentia Enrollment

During a student's period of regular registration, they may have a need or opportunity to study away from Washington University. Recommendations from departments for students' registration in absentia will be considered by the school on a case-by-case basis. If approved, the student will be registered for EGS 9001 Full-Time Graduate Study in Absentia. Students may be allowed to register for EGS 9001 Full-Time Graduate Study in Absentia for up to four consecutive or nonconsecutive fall/spring semesters. Semesters in which a student is registered in absentia are counted as part of the student's program length.

Leaves of Absence (Medical and Personal)

A student may request and be approved for a leave of absence during their regular registration period if they are not registered in absentia. Personal leaves of absence must be approved by the degree program and may be allowed for up to one year at a time. Extensions must be reapplied. Medical leaves of absence require authorization from WashU Cares at the beginning of the leave and again in order to return from the leave. At the end of any leave of absence, a student is reinstated under the conditions prevailing at the time the leave was granted.

Approved leaves of absence are not counted as part of a student's program length and will not be approved for semesters beyond the stated program length, including enrollment extension. While on a leave of absence, the student is not registered and has no student status at Washington University, including financial support. Students who begin a leave during a semester will be dropped from all course registration for that semester and will receive no course credit for work completed during that semester prior to the leave. Taking a leave may therefore adversely affect loan deferment, visa status, the right to rent university-owned housing, and so on. Most visa types would prevent international students from remaining in the United States while taking a leave of absence; such students should consult the Office for International Students and Scholars as well as their faculty advisor.

The continuation of student health insurance and access to the Student Health Center depends on various factors as to the kind of leave (medical or personal), the length of time the student has already been covered during the current insurance year, and the student's location during the leave. Students should consult the Student Health Center webpage for current policies related to leaves of absence; these policies may change annually if insurance carriers change.

Enrollment Extension

Students may be permitted to register for one additional year beyond their program length when approved by their department or program. These students will be registered in EGS 9002 Full-Time Graduate Study Extension, which confers full-time enrollment status. Students registered for EGS 9002 Full-Time Graduate Study Extension may or may not receive financial support, but they are eligible to receive other benefits available to full-time PhD students, including health insurance and wellness fee subsidies.

Degree Candidacy Extended

Upon the recommendation of their departments or programs, students who do not complete their PhD degrees within their program length and potential one-year enrollment extension may remain doctoral candidates for up to five years. Departmental recommendations and Associate Dean of Graduate Programs approval are required for each year of extended degree candidacy. Extended degree candidates are not registered for any courses, have no enrollment status, and receive none of the benefits available to registered Washington University students, including student loan deferment. Students who do confer their degrees within the five-year extension period do so from a closed program status and do not re-enroll.

Reinstatement

Graduate students who do not register in one of the scenarios described under the full-time enrollment policy may have to apply for reinstatement if they wish to re-enroll at a future time. For reinstatement information, students should contact the Engineering Office of Graduate Programs at 314-935-5830 or eng-gradstudserv@wustl.edu. Students seeking reinstatement may be required to pay a reinstatement fee, take special reinstatement examinations, and repeat previous work if their previous work fails to meet contemporary standards. Doctoral candidates who apply for reinstatement may be required to repeat qualifying examinations.

Withdrawal

Students wishing to withdraw from their programs must give notice in writing to the Director of Graduate Studies for their program. The program should provide notice to the McKelvey School of Engineering Academic Services office of the withdrawal and the effective dates on which to drop enrollment and financial support.

Academic Progress, Probation, and Suspension

Satisfactory Academic Progress

Satisfactory academic progress for students in PhD programs is monitored by the school as well as by the degree program. Failure to maintain satisfactory academic progress may result in a student's immediate dismissal or in their placement on academic probation for the ensuing year. Most financial awards — and all federally funded awards — are contingent on the maintenance of satisfactory academic progress. The following are minimal standards of satisfactory academic progress for PhD students; students should consult their specific program handbooks as they may have stricter and/or additional standards but may not directly conflict with the below:

1. Students are expected to proceed at a pace appropriate to enable them to finish within the time limits and milestone markers of their program. Students are expected to have completed all PhD requirements except for the dissertation by no later than the end of the fourth year of full-time graduate study.
2. Students are expected to maintain a cumulative grade-point average of at least 3.0.
3. Students are expected not to carry at one time any more than 9 credit units for which the grades of I (incomplete), X (final examination missed), or N (not yet submitted) are recorded.
4. Students must satisfactorily pass the qualifying exam process as identified by their program by the time frame stated in their program handbook.
5. Students must identify a research mentor by the time frame identified in their program handbook.
6. After four years of full-time graduate study, doctoral students who cannot identify three faculty members who are willing to serve on their Research Advisory Committee are not considered to be making satisfactory academic progress. The Title, Scope and Procedure form must be filed before the fifth year in order to identify the membership of the student's Research Advisory Committee.
7. Students may take up to six years to complete the PhD, depending on the program. A one-year extension is available if circumstances warrant (see "Degree Candidacy Extended" above). Extensions are obtained by application of the student to the degree program and approved by the school.

Probation for Academic Reasons

Except for circumstances justifying immediate dismissal, a student cannot be dismissed on the basis of academic performance without the opportunity to return to good standing during an identified period of probation. The purpose of probation is to do the following:

1) to explicitly warn the student of their status; 2) to provide the student with clear guidelines regarding the performance that will be necessary to return to good standing; and 3) to provide the student with reasonable time to meet these expectations. To meet these objectives, probation normally should be designated for a minimum of three months. When the probation criteria involve coursework, then the probation period would normally correspond to the semester's duration. A student on probation must receive a detailed letter from the Director of Graduate Studies stating the reasons for the probation and explicitly identifying the steps necessary for the student to return to good standing by the end of the probation period. A copy of this letter should be sent to the Associate Dean of Graduate Programs. If a student does not meet all criteria for good academic standing but the department does not wish to place the student on probation, an appeal for this exception can be made to the Vice Dean of Research and Graduate Education.

The explanation of academic performance issues leading to probation should be specific (e.g., low GPA, failed exam) and contain a clear statement of what must be done within a specified period of time in order for the student to return to good standing. This includes probation associated with faculty judgments of research potential, timely progress toward the degree, teaching performance, or professional activities. The expectations will be consistent with those held for all students in the program. They must be communicated in writing (as stated above), accompanied by the opportunity to meet with the Director of Graduate Studies or designated departmental faculty representatives for a clarifying discussion, and copied to the Associate Dean of Graduate Programs. If the student does satisfactorily meet the requirements of the probation, a written notice of reinstatement, including the date that the student has returned to good standing, will be provided to the student. Students may be reinstated before the end of the probation period if they have met the requirements for reinstatement. Copies of any letters or e-mails to the student as well as summary notes of discussions with the student regarding the student's placement on probation should be placed in the student's record, which the student has the right to review.

If the student does not meet the requirements of the probation by the specified time and the program recommends dismissal, the program will send a request for dismissal and a draft of the dismissal letter to the Associate Dean of Graduate Programs, along with copies of all previous communications and/or warnings. The draft dismissal letter will include the grounds for dismissal, the effective date of dismissal, and advice to the student that voluntary withdrawal from the program is an option. All academic dismissals require approval by the Vice Dean of Research and Graduate Education. If the student is an international student on a visa, the program should consult with the Office of International Students and Scholars prior to drafting the dismissal letter. It is often advisable for an international student to withdraw ahead of a dismissal to avoid an adverse impact on their future entry to the United States.

At the end of a first probation, the student may be 1) returned to good standing; 2) placed on a second consecutive probation; or 3) dismissed from the program. A second consecutive probation must be accompanied by a new letter identifying the steps required to return to good standing. While the purpose of the probationary period

is to provide the student with time to improve, the decision of the program at the end of a probationary period could involve immediate notification of dismissal. At the end of a second continuous probation, the student will be either returned to good standing or dismissed.

A third probation will be allowed only if it is not continuous. A fourth probation will not be allowed. A student whose performance would result in a fourth probation will be dismissed immediately. A leave of absence cannot be used by a student to delay or nullify the consequences of a third consecutive or fourth probation.

Each program must have a standard procedure (e.g., a graduate advisory committee) to manage decisions regarding placement on probation, removal from probation, recommendations for dismissal after a probationary period, and recommendations for immediate dismissal due to extreme underperformance. The procedure for managing such decisions must be applied to all students in the program and cannot be managed solely by an individual faculty member, including the student's research mentor, although the input provided by the research mentor may play a key role in the process.

Stipend support should continue during a probationary period unless the student is failing to meet the basic expectations of their position (e.g., repeatedly misses classes or is repeatedly absent from the lab and fails to carry out lab assignments). If a program or school decides to suspend stipend support under these circumstances, the student must be given a minimum of two weeks' notice prior to the withholding of such support. If the student's performance improves and they begin meeting the basic expectations of the program, stipend support should resume at that time. During all probationary semesters, tuition remission will remain as offered at initial enrollment.

The appeal of probation or dismissal by a student should follow the guidelines for Student Grievance Procedures in that it should begin at the most local level. In cases of probation or dismissal, a student may appeal within 14 calendar days to the department chair or another designated faculty representative or committee beyond the Director of Graduate Studies or the Graduate Advisory Committee, consistent with department or program procedures.

Appeals of probation end with the Chair of the department or program (i.e., placement on probation cannot be appealed to the Vice Dean of Research and Graduate Education). In cases where there is a perceived conflict of interest with the Chair or the Director of Graduate Studies, another member of the department can be designated to address the appeal process for probation or dismissal.

Dismissal for Academic Reasons

Academic dismissal is distinct from withdrawal (initiated by the student), deactivation of a student's record by a failure to register, and dismissal or other sanctions associated with the University Academic and Professional Integrity Policy or the University Student Judicial Code. Dismissals are recommended by the degree program and are not final until approved by the Vice Dean of Research and Graduate Education. Students may be dismissed immediately for extreme academic underperformance (refer to "Satisfactory

Academic Progress"). Students who encounter personal situations that contribute to academic underperformance during a semester should be informed of the option to request a leave of absence rather than continuing enrollment with poor performance. The ability to complete mentored teaching responsibilities is not a sufficient basis for remaining enrolled.

Most academic difficulties are not of the severity associated with immediate dismissal. The faculty are also responsible for evaluating the ability of the student to identify and undertake an original scholarly project at the level of excellence expected for a Washington University PhD and for determining whether the student is making timely progress toward completion of the degree. The program may place a high value on the quality of performance in mentored teaching and other professional activities. The judgment of the faculty on these issues can lead to academic dismissal for students who meet other criteria for good academic standing. Departments are expected to maintain written guidelines that help students understand the major categories of expectations for satisfactory progress. Such guidelines should be provided to students at the beginning of their academic program and reviewed with students on a regular basis.

For academic dismissal decisions, a graduate student may submit a final appeal of the dismissal to the Vice Dean of Research and Graduate Education. Appeal requests must be initiated at the appropriate level within 14 calendar days of formal notification of probation or dismissal, and appeals to the Vice Dean must be made within 14 calendar days of a decision by the Chair of the department to uphold a student's dismissal. Responses to appeals generally occur within the next 14 calendar days after the appeal is requested. Stipend support is discontinued at the time the student is notified of dismissal. The student is not eligible to receive stipend support during an appeal of dismissal; however, if the appeal is upheld, the student is eligible for stipend support covering the period of the dismissal appeal process. Students who have chosen to withdraw from their program or department (as opposed to taking an authorized leave) cannot appeal or seek reconsideration of this decision.

Satisfactory Academic Progress for Title IV Financial Aid

Federal regulations require that students receiving federal Title IV financial aid maintain Satisfactory Academic Progress (SAP). The minimum GPA requirements needed to maintain eligibility for SAP are dictated by the specific program of study. In each case, per the requirements of 34 C.F.R. 668.34(a)(4)(ii), the federal student aid program requires a minimum of a C average to maintain eligibility for aid, but an individual degree or certificate program may have a higher minimum GPA for federal SAP.

SAP is evaluated annually at the end of the spring semester. In order to maintain SAP and thus be eligible for federal financial aid, a student must maintain minimum requirements for cumulative GPA (≥ 2.0 for undergraduates, ≥ 2.70 for master's students, and ≥ 3.0 for doctoral students). A student must also maintain minimum requirements for

pace (credit earned for at least 67% of the credits attempted). In addition, the degree must be completed within the maximum time frame allowed for the program (defined as 150% of the required credits). Students who are not maintaining SAP will be notified by the McKelvey School of Engineering Academic Services office and, barring an approved appeal, are ineligible for aid for future semesters.

More information about Satisfactory Academic Progress is available from Student Financial Services.

Dissertation Dissenting Votes

In the rare case that there are faculty concerns that cannot be resolved through subsequent revisions and which therefore result in dissenting (negative) votes, the Committee Chair will refer the case to the Vice Dean of Research and Graduate Education. In the case of a single dissenting vote, the Committee Chair and the dissenting voter will be asked to explain the reasons for the dissent in a letter to the Vice Dean of Research and Graduate Education. After consulting with these and other members of the Committee, the Vice Dean may then decide to accept the majority opinion and approve the dissertation, or they may seek the opinion of an additional reader. After considering this additional evidence, the Vice Dean may either approve or decline to approve the dissertation. In the case of two or more dissenting votes, the Committee Chair and the dissenting voters will again be asked to explain the reasons for the dissent. The Vice Dean may then decide to decline to approve the dissertation, or they may ask the department or graduate program to name a Resolution Committee — consisting of three tenured or tenure-track professors at Washington University or elsewhere who did not serve on the original committee — to reexamine the dissertation and the candidate. A unanimous positive recommendation from this committee will be required in order for the Vice Dean to approve the dissertation. Failure of a department or graduate program to identify three faculty members to serve on this Resolution Committee will be tantamount to a rejection of the dissertation.

Advisor–Advisee Relationship

The relationship between an advisor and an advisee is critical to the success of a student in a PhD program. If a situation arises in which it is determined that the existing advisor–advisee relationship should be terminated, either by the advisor or the advisee, the student will enter into a 3-month probationary period so that the student can identify a new thesis research advisor. The student will continue to receive the customary stipend and allowances until an advisor for the thesis research is identified or for 3 months, whichever comes first. After the 3-month period, the student will either have established a new advisor–advisee relationship or will, at the discretion of the department, be provided a second 3-month probationary period. At the end of either probationary period, the student may be dismissed



from the program as not having made the appropriate academic progress. A third probation will not be permitted. A student is able to appeal the probation decision following the appropriate procedures as outlined elsewhere in these policies.

Academic Records

The university will strive to protect, to the greatest extent possible, the confidentiality of students involved in matters of voluntary or involuntary leave. Because the university has an obligation to preserve the security of its community, the university cannot guarantee complete confidentiality where it would conflict with the university's obligation to investigate meaningfully matters that may threaten a student's health or safety or the safety and security of the university community. When some disclosure of the university's information or sources is necessary, that disclosure will be limited to the extent possible. Medical records of a student will be protected in accordance with the Washington University Student Health Center Notice of Privacy Practices. The university will, to the extent permitted by law, keep confidential all records of committee reviews. The records maintained by the Case Conference Committee will be available only to the administrator and other university officials in accordance with FERPA. All records will be destroyed after a period of 10 years from the date of final decision on involuntary leave or the student's decision to take voluntary leave or 10 years from the date of graduation or last semester of enrollment.

Disability Resources

Services for students with hearing, temporary or permanent visual, orthopedic, learning or other disabilities are coordinated through Disability Resources. Identifying oneself as having a disability is voluntary.

To the greatest extent possible, students with disabilities are integrated as equal members of the total student population. Services provided for students with disabilities may include but are not limited to readers, note takers, special parking, tutoring, counseling, appropriate academic accommodations (e.g., alternate testing conditions), and referral to community resources. To receive accommodations or services, students must initiate a request for services and are encouraged to contact Disability Resources upon admission or once diagnosed. For more information, please visit the Disability Resources website.

Academic Integrity

All students in the McKelvey School of Engineering are expected to conform to high standards of conduct. Students should refer to the Office of the Provost for the full text of the Academic and Professional Integrity Policy for PhD Students.

Academic Calendar

In addition to the university's academic calendar, McKelvey maintains an Engineering Academic Calendar with dates and deadlines that are specific to McKelvey students. This calendar includes course information, which is also helpful for non-McKelvey students taking engineering courses.

Doctoral Program Financial Information

Tuition Policy

The 2026-27 tuition and fees for graduate students in the McKelvey School of Engineering can be found on the McKelvey Graduate Admissions webpage. Tuition for full-time students is determined by each student's prime division, not by the division that teaches the course. Students should check with their department before enrolling in courses outside their division.

Tuition and Fees

The maximum tuition fee is the equivalent of 9 semester units. Students who enroll for 9 or more units per semester are automatically regarded as full-time students and are charged a flat full-time rate. Students enrolled for fewer than 9 units are charged on a per-unit basis. The tuition rate is subject to annual change.

Tuition Remission

McKelvey will provide tuition remission for the length of the student's program as long as academic progress is being made. Students pursuing a certificate or an unrelated master's degree in addition to their PhD must consult the departments and advisors about credit sharing between the programs. To be eligible for tuition remission, courses must be offered at the graduate level. Depending on the program, graduate-level courses typically begin with courses numbered in the 5000s. Students wishing to enroll in courses outside of these parameters or to take courses through the School of Continuing & Professional Studies and receive tuition remission will need to provide justification of relevancy to their program from their advisor. Students pursuing a certificate or an unrelated master's degree in addition to their PhD must consult their departments and advisors for approval. Tuition remission may not be provided for these courses. In the event that a PhD student is responsible for the tuition of a course, they should consult the school refund timeline and policies for information.

Tuition Refund

Doctoral students in the McKelvey School of Engineering receive remission for tuition, health insurance, dental insurance, and the health and wellness fee. If a student withdraws from the program, this financial support will remain for the semester of the withdrawal. Students are always responsible for paying the activity fee and, if applicable, the international medical plan fee. These fees will not be refunded upon a withdrawal, so the student is still required to pay them. Note that charges are fully refunded through the add/drop period each semester, so if a student withdraws from the program during this time, all charges are automatically removed in full and no remission is provided.

Financial Aid

PhD students interested in applying for federal student loans should complete the Free Application for Federal Student Aid (FAFSA) for the appropriate academic year. For more information, contact mckelveygradfinancialaid@wustl.edu.

Insurance and Health-Related Subsidies

All full-time students on the Danforth Campus are charged a mandatory health fee that gives them access to the Student Health Center. In addition, they are enrolled in the student health insurance plan, or they may present proof of comparable coverage to opt out. International students are not allowed to waive health insurance. Both the health fee and the health insurance premium are subject to annual change. Effective as of August 1, 2023, McKelvey covers the cost of the health and dental insurance fees. Students receiving special fellowship support may have different arrangements for covering their health fees and insurance. Please consult the program information for specific questions.

Part-Time Employment

If a full-time supported graduate student wishes to accept part-time employment within Washington University or outside of the university, the following guidelines must be followed. The Internal Revenue Service, the Washington University Human Resources Office, and U.S. Citizenship and Immigration Services all make important distinctions between students and employees. *These guidelines are designed to assist graduate students in retaining their status as students.*

McKelvey students receiving support are allowed a maximum of 6 hours per week of additional part-time employment while maintaining their status as students. Students *must* consult and receive approval from their programs in order to accept an additional position, as not all programs allow employment outside of the program.

Part-time employment as noted in this policy is separate from the request for Curricular Practical Training (CPT) and/or internships. International students should consult with the Office for International Students and Scholars regarding requirements for CPT, and all students should consult with their program regarding taking an internship position. Students taking an internship/CPT may have a reduction in or even cease receipt of their financial support from the program.

Master's Program Information

Master of Engineering Versus Master of Science Degrees

Master of Engineering (MEng) degrees are typically viewed as terminal degrees allowing maximum flexibility in course selection. Master of Science (MS) degrees are more structured in terms of required coursework, and students with undergraduate degrees specifically in engineering are often better prepared to enter these master's programs. Graduates from MS programs are better prepared to move forward to doctoral programs, as they often become more involved in research experience. However, MS programs also include course-only options for those not interested in doing research.

There are different ways to earn a master's degree at Washington University:

- There are a number of Engineering disciplines that admit students who wish to pursue a terminal master's degree. In some programs, both the course option and thesis option are available.
- Undergraduate students at Washington University may apply for the Bachelor's/Master's Program in Engineering, in which graduation with a BS or AB is followed by graduate study leading to the master's degree. This option is described in the Bachelor's/Master's Program in Engineering section of the *Undergraduate Bulletin*.
- Students who have not previously earned a master's degree in the same field as their PhD may earn the MS on the way to their PhD. This option is available in some disciplines but not in all of them.
- Students who have not previously earned a master's degree in the same field as their PhD may be awarded an MS for work done in a PhD program that they are leaving without completing. This option is available in some disciplines but not in all of them.

General Requirements

Candidates for master's degrees should note that, in most MS programs, both the thesis option and the course option are available. The course option may be of particular interest to part-time students who, because of their employment, might find it more convenient than the thesis requirement. All candidates for the master's degrees should consult with their advisor to determine the option they will follow.

All requirements for master's degrees must be completed within six years from the time the student is admitted to graduate standing. A maximum of 6 units of graduate credit obtained at institutions other than Washington University may be applied toward the master's degree awarded by Engineering. Transfer credit must be recommended and approved by the department chair or program director and advisor, as well as by the Engineering registrar. No courses carrying grades lower than B can be accepted for transfer credit.

For the thesis option, a minimum of 24 units of graded coursework and a minimum of 6 units of Pass/No Pass research are required. The student must also write a satisfactory thesis prepared under the supervision of a member of the Engineering faculty. Candidates for master's degrees under the course option must submit a minimum of 30 units of approved graded graduate course credit. A department may have additional requirements beyond the minimum requirement stated previously. Students should consult with their advisor as several master's degrees require more than 30 graduate units.

Multiple Master's Degrees

To earn more than one master's degree from Engineering, the student's final program of coursework for each such master's degree must include a minimum of 15 units of preapproved courses not included as part of the final program of coursework for any other master's degree awarded by Engineering.

Master's Thesis

A candidate for the MS degree under the thesis option should prepare their thesis according to the Master's Thesis Format Guidelines found on the Engineering website.

The candidate's department chair or program director will appoint a thesis committee of three faculty members, with the student's advisor as chair, who will read the thesis and judge its acceptability.

Master's Final Examinations

The final examination for the MS candidates under the thesis option consists of an oral examination conducted by the thesis committee and any additional faculty members that the department or program chairman may wish to designate. At this examination, the candidate will present and defend the thesis.

Candidates for the MS under the course option may be required to pass a final examination. The form of this examination is determined by the faculty of the area of specialization, and students should consult their advisors, department chairs, or program directors for details concerning this examination.

Administration

Dean's Office

314-935-6350

Department of Biomedical Engineering

314-935-6164

Department of Computer Science & Engineering

314-935-6160

Department of Electrical & Systems Engineering

314-935-5565

Department of Energy, Environmental & Chemical Engineering

314-935-6070

Department of Mechanical Engineering & Materials Science

314-935-6047

McKelvey Engineering Information Technology

314-933-3333

McKelvey Engineering Office of Graduate Programs

314-935-5830

Sever Institute

314-935-5484

Master's Program Policies

Admissions

Eligibility

Washington University encourages and gives full consideration to all applicants for admission and financial aid, without regard to race, color, age, religion, sex, sexual orientation, gender identity or expression, national origin, veteran status, disability or genetic information.

McKelvey School of Engineering is strongly interested in recruiting, enrolling, retaining and graduating students from diverse backgrounds. Applications for admission by students from diverse backgrounds to any of our degree programs are encouraged and welcomed. To the greatest extent possible, students with disabilities are integrated into the student population as equal members.

To be considered for admission into a graduate degree program, applicants must hold a bachelor's degree from an accredited institution prior to starting the graduate program. Most of the engineering degree programs require a previous degree in science, technology, engineering or mathematics.

Current engineering graduate students who wish to be admitted into another engineering graduate program must be admitted at least one semester prior to their anticipated graduation semester.

Application Process

The application is available online through the McKelvey School of Engineering website. Applications are ready for final consideration after the required items from the application checklist have been submitted.

Please review our application checklist for details on all materials needed for a complete application.

Degree programs set their own application deadlines. Applicants should check deadlines through the McKelvey School of Engineering. It is generally advantageous to the applicant to complete the application well in advance of the deadline.

Admission and financial aid awards are for a specific academic year; students who do not matriculate that year must normally reapply. Admitted students can request a deferral of admission for up to one year from the admissions office. Applicants to whom admission is not offered may reapply for a future semester.

Admission of International Students

International students considering application to Washington University for graduate study should have a general familiarity with academic practices and university customs in the United States. International students are required to obtain a valid visa for study and maintain their immigration status. International students are required to report valid official English proficiency test scores for application. Please refer to our application checklist for additional information.

Students Not Candidate for Degree (SNCD)

SNCD admission may be granted to qualified students who hold a bachelor's degree or its equivalent, who wish to enroll in graduate courses on a non-degree basis, and who receive approval from a degree program. Examples include students in good standing at other graduate schools and students who wish to test their capabilities in a graduate setting. Students in this category may take a maximum of 9 units, and they may later apply to a degree program and transfer these units to meet degree requirements. SNCD students are not eligible for Title IV Federal Funding. Please contact Engineering Graduate Admissions for application requirements.

Attendance

Each professor in the McKelvey School of Engineering decides how many absences a student may have and still pass the course. Professors are expected to give reasonable consideration to unavoidable absences and to the feasibility of making up work that has been missed. Students are expected to explain to their professors the reasons for any absences and to discuss with them the possibility of making up missed assignments.

Units and Grades

The following grades are used in calculating the grade point average:

Grade	Points per Unit
A or A+	4.0
A-	3.7
B+	3.3
B	3.0
B-	2.7
C+	2.3
C	2.0
C-	1.7
D+	1.3
D	1.0
D-	0.7
F	0.0

The following grades and notations are ignored in calculating the grade point average:

Grade/Notation	Value
Pass	Pass
No Pass	No pass
I	Coursework incomplete; final grade pending
W	Withdrawal
N	No grade submitted; final grade pending
R	Retaken course
L	Successful audit
Z	Unsuccessful audit
Exam Credit	Exam credit
Transfer Credit	Transfer credit
Not Transferred	Course attempted, not transferred



Auditing a Course

A student may register for some courses as an auditor. The criteria for a successful audit are determined by the course instructor, and the student should work with the instructor to ensure that these criteria are understood. Generally speaking, the completion of homework and the taking of exams are not required. The grade L signifies a successful audit, and the grade Z signifies an unsuccessful audit. Neither grade affects a student's grade-point average, and the course's units do not contribute to the student's total cumulative degree-seeking units. *Audit courses do not count toward any degree, nor do they count toward full-time status determination.* They do count toward the 21-unit cap per semester, and audit units are charged at the standard full-time or part-time per-unit rate. Class attendance is normally required to earn a grade of L; unsatisfactory attendance will result in a grade of Z.

Incomplete Grades

Incomplete Coursework

Washington University expects students to finish their coursework on time or remove themselves by dropping or withdrawing from the course by published deadlines. When situations outside a student's control arise and prevent timely course completion, a grade of I indicates that work is outstanding. McKelvey students may request an incomplete grade of I only in a course in which they have substantially completed the work, including any requirements of attendance or engagement. Students must also be passing the course based on materials submitted thus far to be eligible for an incomplete I grade.

This policy allows but does not compel I grades in the above circumstances. Grading is the purview of the faculty, as governed by school policies, and they may choose to deny requests for incomplete grades.

Impact of Incomplete Grades

An Incomplete will prevent a student from moving forward in a sequence of courses when the unfinished course is required (prerequisite) to move ahead. An Incomplete is also factored into academic standing reviews and Satisfactory Academic Progress (SAP) reviews.

Finishing Incomplete Coursework

Incomplete grades will change to final failing grades on the last day of the semester following the one in which the course was taken if the student does not submit missing work and the instructor does not submit a final grade. Therefore, students must complete missing work and submit it with enough time to allow the instructor to evaluate the work and submit the grade before the 120-day window ends. For example, a student working with a fall semester Incomplete must submit their work to the instructor in time for them to evaluate

the work and assign a final grade by mid-April of the following year. Instructors may establish an earlier deadline than Washington University's deadline in this policy. Students and instructors are strongly encouraged to establish an agreement specifying the work remaining and the deadline for it to be submitted; some schools may require this (see school-specific policies).

Students must not re-enroll in an upcoming section of the unfinished course to make up the Incomplete; re-enrollment invokes the course retake policy. Students planning to graduate before the grade change deadline must complete courses and receive grades before graduating. Incompletes remaining at the time of degree conferral will be changed to final grades of failure. Grade changes are not permitted after a degree has been conferred.

N Grades – No Grade Submitted

In the rare event that an instructor is unable to submit a grade by the grade deadline, an N, signifying that the grade has not yet been submitted, may temporarily appear as a transcript notation on the student's record. N grades will change to final failing grades on the last day of the semester following the one in which the course was taken if the instructor does not submit a final grade.

Course Retake Policy

Students whose performance in a course has not met their expectations are permitted to retake courses in which they have earned a B- or lower (grades of P for Pass, A+, A, A-, B+, B, and Incomplete are not eligible for retakes; audits — whether successful or unsuccessful — are also not eligible for retakes). When a course is repeated, the attempt with the best grade will be used to calculate credit and will factor into the student's GPA. The other attempt(s) will have the letter R (denoting the retake) placed next to the grade. All registrations will show on the transcript; however, only the grade and units of the enrollment with the best grade will be used to calculate the student's GPA.

If an engineering student repeats a course elsewhere (i.e., as a preapproved transfer course from another university), the student must take the course for credit and earn a C or better for the units to transfer to Washington University. After an official transcript showing the final grade for the repeated course is received, the symbol R next to the first enrollment's grade indicates that the course was later retaken. The original grade will no longer figure into the student's GPA, nor will the transfer course grade figure into the GPA. The grade for the transfer course does not display on the student's Washington University record, but the units for the transfer course will count toward the degree program.

Student Grievance

From time to time, students may feel that they have legitimate complaints regarding academic matters or an interaction with a faculty member. It is important that students and faculty have a common understanding of how such complaints may be expressed

and resolved. Students with complaints regarding academic matters should initially seek resolution from their faculty advisor, then from their Director of Graduate Studies, and finally from the Chair of their degree program. Complaints that remain unresolved may be addressed to the Associate Dean of Graduate Programs. The final court of appeal for all doctoral students in the school is the Vice Dean of Research and Graduate Education. Washington University policies state that members of the university community can expect to be free from discrimination and harassment. Students, faculty, staff and outside organizations working on campus are required to abide by specific policies prohibiting harassment. An allegation of discrimination or harassment may be appealed to the Vice Chancellor for Human Resources, who will determine whether to convene the Title IX Grievance Committee to hear the case.

Additional Course Information for Graduate Students

To count toward a graduate degree, courses must be offered at the graduate level and approved in advance by the student's advisor and program as eligible to count toward the student's degree. Depending on the program, graduate-level work begins with courses numbered at the 4000 or 5000 level. *Audited courses and non-research courses taken on a Pass/No Pass basis cannot be counted toward the degree.* Students should consult their advisors regarding these options.

Transfer Credit

A maximum of 6 units of graduate credit obtained at institutions other than Washington University may be applied toward the master's degree. Approved transfer credit for undergraduate coursework completed at a different institution cannot be posted until a letter is received from that institution's registrar, which states the graduate-level coursework was not used to satisfy undergraduate degree requirements.

Transfer credit must be recommended by the advisor, department or program chair and approved by the McKelvey Engineering Academic Services office. No graduate courses carrying grades lower than B can be accepted for transfer toward any graduate degree.

No courses will be accepted toward degree requirements if the course exceeds the 10-year maximum time period, unless those courses have the formal approval of the McKelvey Master's Council.

Student Status

All graduate students in Engineering must register each fall and spring semester until all degree requirements are complete. All registrations require online approval by the student's faculty advisor. Students should register in one of the two categories listed below.

Graduate students who do not register in one of the two categories may have to apply for reinstatement if they wish to re-enroll at a future time. Students should contact the Engineering Office of Graduate Programs at 314-935-5830. Students seeking reinstatement may be required to pay a reinstatement fee, take special reinstatement examinations, and repeat previous work if their previous work fails to meet contemporary standards.

Active Status

A graduate student is viewed as having an active full-time status if enrolled in 9 or more units or an active part-time status if enrolled in fewer than 9 units. Graduate students must be authorized by their advisor prior to registration. International master's students on F1 and J1 visas are required to take a minimum of 9 units per semester except during their final semester. In order to have part-time status during their final semester, international master's students must complete a Reduced Course Load form, which is available from the Office of International Students and Scholars (OISS).

Continuing Student Status

The Continuing Student Status course option may be used when graduate students are approved to register for fewer than 9 units but still need to maintain their full-time status. When students are registered for the Master's Continuing Student Status course (EGS 7883 Master's Continuing Student Status), they will still be viewed as having a full-time status, even if they are taking fewer than 9 units. Placeholder courses are 0-unit audit courses with no tuition charges associated with them for engineering students; however, students may be charged health insurance and/or student activity fees associated with full-time status. The EGS 7883 Master's Continuing Student Status course option is contingent upon advisor and departmental approval. **Note:** The 7883 status is not available for master's students on F1 and J1 visas; domestic master's students may register under the 7883 status only during their final semester and with departmental approval.

Academic Probation and Suspension

The following are the minimal standards to remain in good academic standing as a master's student. Degree programs may set stricter standards, but they may not relax those listed below. Acceptability of grades below B– for the fulfillment of degree requirements is determined by individual departments.

- A master's student is eligible for academic probation if a semester or cumulative GPA drops below 2.70.
- A master's student is eligible for academic suspension if any one of the following occurs:
 - The student earns a semester or cumulative GPA less than 2.00, or
 - The student has been on probation for two semesters and has not attained a 2.70 cumulative GPA.



Academic probation represents a warning that things are not going well academically. Students placed on academic probation may continue to stay enrolled in their degree programs but must meet with the Director of Graduate Student Affairs. This meeting will serve as an opportunity for the student to identify areas for improvement and to create a strategy for success for the duration of their degree program.

Academic probation can also indicate a decision by the department to allow a student otherwise eligible for suspension to continue their studies under a probationary status. In these cases, academic probation may include additional student limitations, such as limit on enrolled units. If a student is given probation in lieu of suspension, the conditions of the probation cannot be appealed.

Academic suspension represents being dismissed from the program. Students placed on academic suspension are not eligible to enroll or to continue their degree programs. There is no guarantee that students who have been suspended will be allowed to return.

- Students who are suspended may appeal to the McKelvey Master's Council. Appeals should be sent to the McKelvey School of Engineering Academic Services office, who will then forward the appeal statement for review. If a student decides not to appeal an academic suspension or if a student's appeal is not successful, registration for the upcoming semester will be cancelled, and the student's academic record will be closed.

Students who have been suspended may apply for reinstatement after one year has passed. Reinstatement requests should be sent to the McKelvey School of Engineering Academic Services office, who will forward the requests to the program director. Students requesting reinstatement will need to show that they have successfully completed challenging full-time coursework at a different institution (generally, for at least one year), that they have been employed in a full-time position (generally, for at least one year), or a combination of the two (school and work).

Satisfactory Academic Progress for Title IV Financial Aid

Federal regulations require that students receiving federal Title IV financial aid maintain Satisfactory Academic Progress (SAP). The minimum GPA requirements needed to maintain eligibility for SAP are dictated by the specific program of study. In each case, per the requirements of 34 C.F.R. 668.34(a)(4)(ii), the federal student aid program requires a minimum of a C average to maintain eligibility for aid, but an individual degree or certificate program may have a higher minimum GPA for federal SAP.

SAP is evaluated annually at the end of the spring semester. In order to maintain SAP and thus be eligible for federal financial aid, a student must maintain minimum requirements for cumulative GPA (≥ 2.0 for undergraduates, ≥ 2.70 for master's students, and ≥ 3.0 for doctoral students). A student must also maintain minimum requirements for pace (credit earned for at least 67% of the credits attempted). In addition, the degree must be completed within the maximum time

frame allowed for the program (defined as 150% of the required credits). Students who are not maintaining SAP will be notified by the McKelvey School of Engineering Academic Services office and, barring an approved appeal, are ineligible for aid for future semesters.

More information about Satisfactory Academic Progress is available from Student Financial Services.

Disability Resources

Services for students with hearing, temporary or permanent visual, orthopedic, learning or other disabilities are coordinated through Disability Resources. Identifying oneself as having a disability is voluntary.

To the greatest extent possible, students with disabilities are integrated as equal members of the total student population. Services provided for students with disabilities may include but are not limited to readers, note takers, special parking, tutoring, counseling, appropriate academic accommodations (e.g., alternate testing conditions), and referral to community resources. To receive accommodations or services, students must initiate a request for services and are encouraged to contact Disability Resources upon admission or once diagnosed. For more information, please visit the Disability Resources website.

Leaves of Absence

Engineering students may request to take a leave of absence. For information about how to request a leave of absence, please visit the university's Time Away: Leave of Absence, Withdrawal, and Reinstatement Process webpage. For a leave of absence, students in good standing are assured re-enrollment within the next year. In order to return, students should notify the McKelvey School of Engineering and request a reinstatement in Workday at least six weeks prior to the beginning of the appropriate term.

A student wishing to take a medical leave of absence or be reinstated from a medical leave of absence must have a recommendation from WashU Cares. Additional steps are required in this case and are outlined at the link above. After review of the recommendation made by WashU Cares, the school will decide whether or not to grant the leave or reinstatement request.

Academic Integrity

All students in the McKelvey School of Engineering are expected to conform to high standards of conduct. To review our school statement on university policies on Academic Integrity as well as our violation allegation process, please visit the Academic Integrity at McKelvey webpage.

Academic Calendar

In addition to the university's academic calendar, McKelvey maintains an Engineering Academic Calendar with dates and deadlines that are specific to McKelvey students. This calendar includes course information, which is also helpful for non-McKelvey students taking engineering courses.

Master's Program Financial Information

Tuition Policy

The 2026-27 tuition and fees for graduate students in the McKelvey School of Engineering can be found on the McKelvey Graduate Admissions webpage. Tuition for full-time students is determined by each student's prime division, not by the division that teaches the course. Students should check with their department before enrolling in courses outside their division.

Students who will receive reimbursement from their employers are responsible for tuition being paid by the due date. Employer reimbursements that are contingent upon course completion and/or a satisfactory grade will not exempt the student from stated due dates and the assessment of penalties.

All *full-time* graduate students in Engineering (DSc and master's) are assessed tuition at a full-time tuition rate. *Part-time* graduate students are assessed tuition on a per-unit basis. If a full-time student withdraws from courses to become a part-time student after the add/drop (100%) period, tuition is recalculated to the part-time per-unit rate for the remaining units, and the refund schedule below is applied to the tuition of the withdrawn courses. Part-time students should also follow the refund schedule below. Refunds are computed from the date on which the course is dropped, as reflected in the Student Information System. Refund checks are made available as soon as possible (usually four to six weeks after the drop is completed).

Period of Withdrawal	Percent of Refund
1st or 2nd week of classes	100%
3rd or 4th week of classes	80%
5th or 6th week of classes	60%
7th or 8th week of classes	50%
9th or 10th week of classes	40%
After 10th week of classes	No refund

Note: After the date of the first class meeting, refunds are not granted for *short courses*, which run less than the full semester length. Questions concerning the refund policy should be directed to the Engineering Accounting Office at 314-935-6183.

Financial Aid

Master's students are expected to be self-supporting and are generally not eligible for any institutional financial assistance. However, participants in the bachelor's/master's program and the dual degree program could qualify for tuition remission. All master's students who attend at least half-time (i.e., 3 units in the summer and 4.5 units in the fall and spring) and who are U.S. citizens or permanent residents may be eligible for federal student loans.

Students should complete the Free Application for Federal Student Aid (FAFSA) for the appropriate academic year. For more information, contact mckelveygradfinancialaid@wustl.edu.

Loans

The federal government provides a number of student loan programs, and there are rules and requirements for each program. These programs are subject to change by the government agencies that oversee them, and they require that detailed financial information be provided by the student. For more information about federal loans available to graduate students, please visit the Engineering website.

Postdoctoral Training

Postdoctoral appointments at WashU are full-time academic positions focused on mentored research and professional development under the guidance of faculty mentors. They are supported through research grants, individual fellowships, or institutional training programs. Their primary purpose is to help highly trained individuals acquire the professional skills needed for their chosen career path.

Because of this focus, postdoctoral appointments are inherently time-limited; they are capped at five years including any experience at other institutions following the doctoral degree. All postdoctoral appointees are eligible for university-sponsored benefits, and the postdoctoral experience is regulated by postdoc-specific policies and institutional normative.

WashU is proud to be an institutional member of the National Postdoctoral Association, which reflects our commitment to excellence in postdoctoral education.

Postdoc Categories

At WashU, there are two categories of postdocs:

1. *Postdoctoral Research Scholars* receive external funding in the form of a stipend and are considered non-employees.
2. *Postdoctoral Research Associates* receive a salary from the university and are considered employees.

Office of Postdoctoral Affairs

The Office of Postdoctoral Affairs (OPA), under the Office of the Vice Chancellor for Research, serves postdoctoral research associates and scholars across both the Danforth and Medical campuses. The OPA provides comprehensive resources to help postdocs achieve their career and professional development goals, advocates for postdoctoral issues, and offers guidance on recruitment and postdoctoral life. It also fosters a vibrant and inclusive postdoctoral community through networking, social events, and peer support.

The OPA postdoc curriculum includes signature programs in the following areas:

- *A career development series* to equip postdocs with essential skills for navigating diverse career pathways and achieving success in both academic and industry settings;
- *Leadership and communication training* to advance leadership capabilities while strengthening grant writing, publishing, and science communication skills;
- *Wellness and community engagement* that promotes holistic development, well-being, and meaningful integration into the WashU community;

- *Fellowships and awards* that recognize excellence and provide competitive opportunities for research and professional growth; and
- *An annual postdoc symposium and research seminars* that showcase innovative research and foster interdisciplinary collaboration across campuses.

Postdoc Organizations

The OPA supports recognized postdoc-led groups, including three major organizations:

1. WashU Postdoc Society (WUPS)
2. WashU Black Postdoctoral Association
3. Postdoc Peer Mentoring Program

Additional Information

For more information about programs, resources, and upcoming events, visit the OPA website.

Cross-School Interdisciplinary PhD Programs

There are certain graduate programs that span more than one school at Washington University. Please visit the following pages to learn more about these programs:

- Division of Biology & Biomedical Sciences (p. 186)
- Division of Computational & Data Sciences (p. 199)
- Institute of Materials Science & Engineering (p. 202)

Division of Biology & Biomedical Sciences

The Roy and Diana Vagelos Division of Biology & Biomedical Sciences at Washington University offers exceptional doctoral education at one of the nation's preeminent biomedical research centers. The Division includes 11 doctoral programs:

- Biochemistry, Biophysics, & Structural Biology
- Biomedical Informatics & Data Science
- Cancer Biology
- Computational & Systems Biology
- Developmental, Regenerative, & Stem Cell Biology
- Immunology
- Molecular Cell Biology
- Molecular Genetics & Genomics
- Molecular Microbiology & Microbial Pathogenesis
- Neurosciences
- Plant & Microbial Biosciences

A collaborative, interdisciplinary approach to research and education is a hallmark of Washington University and the Division. As a university-wide consortium, the Division transcends departmental lines and removes traditional boundaries of scientific fields. Faculty and graduate students regularly cross disciplines, devising novel questions and approaches that might otherwise go unexplored. The Division consists of over 700 PhD and MD/PhD students, with more than 700 faculty members from 39 departments.

Washington University in St. Louis provides unique opportunities for translating basic science into practical application. In addition, the Division's associations with internationally prominent local institutions provide exciting opportunities. Students in the biomedical sciences enrich their work with the clinical perspective of our outstanding

medical school; students also benefit from our close affiliation with the internationally renowned Missouri Botanical Garden, as well as the Saint Louis Zoo, the Tyson Research Center, the National Great Rivers Research & Education Center, and the Donald Danforth Plant Science Center.

To help prepare graduates for careers in academia, government, industry or another field of their choice, educational opportunities are offered for skill development and career exploration. The Division offers a career-planning curriculum where students can pursue noncredit elective credentials to build transferable professional skills in four areas that apply to a wide variety of scientific careers: leadership, entrepreneurship, science communication, and teaching. Through the Next Generation of Science Scholars, students are provided networking and community-building events, professional development seminars, and scientific community outreach opportunities. Professionals from a variety of fields (e.g., biotech startups, patent law) provide presentations and Q&A sessions to students throughout the year. In addition, the DBBS holds partnerships with groups such as the Center for Teaching and Learning, the Center for Career Engagement, and student organizations such as ProSPER, InPrint, the BALSAs Group, and the Young Scientist Program. Students have multiple opportunities to develop experiences relevant to their future career goals.

DBBS students can reference the DBBS Student Handbook for student guidelines across all Division programs.

Email: DBBS-Info@email.wustl.edu

Website: <http://dbbs.wustl.edu>

Faculty

Associate Dean for Graduate Education

Steven Mennerick

John P. Feighner Professor of Neuropsychopharmacology, Professor of Psychiatry, Associate Dean for Biology and Biomedical Sciences, Professor of Neuroscience
PhD, Washington University in St. Louis

Associate Directors

Eric Herzog

Professor of Biology, Professor of Neuroscience, Viktor Hamburger Distinguished Professor
PhD, Syracuse University

Heather True

Professor of Cell Biology and Physiology, David English Smith Professorship in Medicine
PhD, University of Illinois-Urbana-Champaign

Faculty Program Directors: Biochemistry, Biophysics, & Structural Biology

Thomas Brett

Associate Professor of Medicine, Associate Professor of Biochemistry and Molecular Biophysics, Associate Professor of Cell Biology and Physiology

PhD, University of Nebraska – Lincoln

Eric Galburt

Associate Professor of Biochemistry and Molecular Biophysics
PhD, University of Washington

Faculty Program Directors: Biomedical Informatics & Data Science

Philip Payne

Professor of Medicine, Director, Institute for Informatics, Professor, Professor of Computer Science and Engineering, Associate Dean for Health Information and Data Science for the School of Medicine, Chief Scientist for the School of Medicine, Janet and Bernard Becker Professor of Medicine

PhD, Columbia University

Po-Yin Yen

Associate Professor of Medicine, Division of General Medicine & Geriatrics, Associate Professor, Goldfarb School of Nursing, Barnes Jewish College

PhD, Columbia University

Faculty Program Directors: Cancer Biology

Grant Challen

Professor, Division of Oncology, Department of Medicine
PhD, University of Queensland, Brisbane, Australia

Jason Weber

Professor, Departments of Medicine, Cell Biology & Physiology, and Biology

PhD, Saint Louis University

Faculty Program Directors: Computational & Systems Biology

Gautam Dantas

Professor of Pathology and Immunology, Co-Division Chief - Division of Laboratory and Genomic Medicine, Professor of Biomedical Engineering, Professor of Molecular Microbiology, Professor of Pediatrics, Conan Professorship in Laboratory and Genomic Medicine
PhD, University of Washington – Seattle

Nancy Saccone

Associate Professor of Genetics
PhD, Brown University

Faculty Program Directors: Developmental, Regenerative, & Stem Cell Biology

Mayssa Mokalled

Associate Professor of Developmental Biology
PhD, UT Southwestern Medical Center at Dallas

Andrew Yoo

Phil and Sima Needleman Distinguished Professor of Developmental Biology

PhD, Columbia University

Faculty Program Director: Immunology

Eynav Klechevsky

Associate Professor of Pathology and Immunology
PhD, Israel Institute of Technology, Haifa, Israel and The Baylor Institute for Immunology Research

Faculty Program Directors: Molecular Cell Biology

Ben Major

Alan A. and Edith L. Wolff Professorship in Cell Biology and Physiology, Professor of Cell Biology and Physiology, Professor of Otolaryngology
PhD, University of Utah

Maria Remedi

Professor of Medicine and Cell Biology & Physiology
PhD, National University of Cordoba, Argentina

Faculty Program Directors: Molecular Genetics & Genomics

John Edwards

Associate Professor of Medicine
PhD, Columbia University

Jim Skeath

Professor of Genetics, Assistant Dean Academic Pathway Programs
PhD, University of Wisconsin – Madison

Faculty Program Directors: Molecular Microbiology & Microbial Pathogenesis

Megan Baldrige

Associate Professor of Medicine, Associate Professor of Molecular
Microbiology
MD/PhD, Baylor College of Medicine

Andrew Kau

Associate Professor, Division of Allergy and Immunology, Associate
Division Chief - Research
MD/PhD, Washington University in St. Louis

Faculty Program Directors: Neurosciences

Martha Bagnall

Associate Professor of Neuroscience
PhD, University of California – San Diego

Alexxai Kravitz

Associate Professor of Psychiatry, Interim Division Director for
Basic Neuroscience, Associate Professor of Neuroscience, Associate
Professor of Anesthesiology
PhD, University of Pennsylvania

Faculty Program Directors: Plant & Microbial Biosciences

Barbara Kunkel

Professor of Biology, Associate Chair of Undergraduate Education
PhD, Harvard University

Xuehua Zhong

Professor of Biology, Dean's Distinguish Professorial Scholar
PhD, The Ohio State University

DBBS mentors and educators are key to our training mission. Those who serve as primary mentors are DBBS Program Members, and others who participate in the educational mission are General Members.

Visit the DBBS website to learn about DBBS Faculty Membership or to search DBBS Faculty by last name, program, or expertise.

Degree Requirements

- Biochemistry, Biophysics, & Structural Biology, PhD
- Biomedical Informatics & Data Science, PhD
- Cancer Biology, PhD
- Computational & Systems Biology, PhD
- Developmental, Regenerative, & Stem Cell Biology, PhD
- Immunology, PhD
- Molecular Cell Biology, PhD
- Molecular Genetics & Genomics, PhD
- Molecular Microbiology & Microbial Pathogenesis, PhD
- Neurosciences, PhD
- Plant & Microbial Biosciences, PhD

Courses

For questions about course listings, please email
dbbscurriculum@wustl.edu.

BBS 5011 Ethics & Research Science

This course prepares DBBS graduate students to analyze and address ethical and professional issues across the range of their professional roles and responsibilities. The primary goals are for students to recognize complex situational dynamics and ethical issues and to develop professional and ethical problem-solving skills. The course examines ethical challenges related to research design and data collection, management, ownership, security, sharing, analysis, interpretation, and reporting while providing practical guidance on these issues. The course also examines the fundamentals of the broader research environment, including principles of ethics in genetics and human and animal subjects research, regulatory issues in biological and biomedical research, publication and authorship, and collaboration in science.

Credit 1 unit.



Typical periods offered: Spring Half B, Spring Half A, Spring, Spring Intersession, Summer

BBS 5014 Biotech Industry Innovators

Late one Friday afternoon in April 1976, the late venture capitalist Robert Swanson met with biochemist Herb Boyer, PhD, at his UCSF lab. Swanson had requested 10 minutes of Boyer's time; when the meeting ended, three hours later, the foundations had been laid for the formation of Genentech, the first biotechnology company, and the beginnings of the biotechnology industry. This course, The Basics of Bio-Entrepreneurship, investigates issues and choices that inventor/scientists encounter when considering the applications and commercialization of early stage scientific discoveries. This course is intended for anyone interested in working in the medical device, life-, bio-, or pharma-sciences industries as a founder, scientist, entrepreneur, manager, consultant, or investor. It focuses on the decision processes and issues that researchers and their business partners face when considering how a discovery might best be moved from academia to successful commercialization.

Credit 3 units.

Typical periods offered: Fall, Spring

BBS 5053 Immunobiology I

Immunobiology I is taught by the faculty members of the Immunology Program. This course covers in depth modern immunology and are based on Janeway's Immunobiology 10th Edition textbook. The topics include: basic concepts in immunology, innate immunity: the first lines of defense, the induce responses of innate immunity, antigen recognition by B-cell and T-cell receptors, the generation of lymphocyte antigen receptors, antigen presentation to T lymphocytes and signaling through immune system receptors.

Credit 4 units.

Typical periods offered: Fall

BBS 5054 Immunobiology II

Immunobiology II is taught by the faculty members of the Immunology Program. This course covers in depth modern immunology and are based on Janeway's Immunobiology 10th Edition textbook. The topics include: the development and survival of lymphocytes, T cell-mediated immunity, the humoral immune response, dynamics of adaptive immunity, the mucosal immune system, failures of host defense mechanisms, allergy and allergic diseases, autoimmunity and transplantation, and manipulation of the immune response.

Credit 4 units.

Typical periods offered: Spring

BBS 5068 Fundamentals of Molecular Cell Biology

This is a core course for incoming graduate students in Cell and Molecular Biology programs to learn about research and experimental strategies used to dissect molecular mechanisms that underlie cell structure and function, including techniques of protein biochemistry. Enrolling students should have backgrounds in cell biology and biochemistry. The format is two lectures and one small group discussion section per week. Discussion section focuses on original research articles.

Credit 4 units.

Typical periods offered: Fall

BBS 5075 Introduction to Coding and Statistical Thinking for Genetics and Genomics

This course is designed for first-year DBBS students who have had little to no prior experience in programming or statistics. The course will cover common statistical practices and concepts in the life sciences, such as error bars, summary statistics, probability and distributions,

and hypothesis testing. The class will also teach students basic programming skills for statistical computation, enabling them to retrieve and analyze small and large data sets from online databases and other sources.

Credit 2 units.

Typical periods offered: Fall

BBS 5084 Single Molecule Biophysics Journal Club

Molecular motors in the cell harness chemical energy to generate mechanical work in a host of processes including cell motility, DNA replication and repair, cell division, transcriptional regulation, and intracellular transport. The purpose of this course is to discuss recent advances in the field of molecular motors. Special emphasis will be placed on understanding and critically evaluating single molecule studies. The course will consist of both journal club presentations and small group discussions.

Credit 1 unit.

Typical periods offered: Spring

BBS 5098 Graduate Research Fundamentals

This course introduces first-year Ph.D. students to the foundational skills, knowledge, and habits of mind required of successful independent biological scientists: 1) Social dynamics in the scientific research enterprise 2) Epistemology and ethics of bio research methods 3) Development and communication of research questions and results 4) Interdisciplinary scientific thinking. Class sessions and homework introduce these topics; major assignments prompt student to connect them with the broader scope of graduate training in lab rotations, course work, and interdisciplinary scientific seminars. The interactive, student-driven class structure facilitates autodidactic development while integrating small group activities and peer mentoring from advanced DBBS students.

Credit 0.5 units.

Typical periods offered: Fall

BBS 5123 Experimental Hematopoiesis Journal Club

Journal club in which papers that describe significant advances in the field of experimental hematopoiesis are discussed. Students are expected to present one paper per semester and attend the weekly (1 hour) session.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5137 TriMED: Membrane Excitability and Disease

TriMED consists of seminars, work-in-progress talks and journal club presentations. It meets Monday lunchtime (1-2pm, with lunch provided) from Jan - end April and from Sept - end November (1 credit each semester). Any student signed up for credit has to attend regularly and make one half hour presentation (either of their own research, or of a paper). The attendees are a mix of students, post-docs and faculty, but the goal is for trainee experience. The course is designed to fulfil interest in membrane proteins or signaling, ion channels, electrophysiology, neurobiology or excitability more broadly.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5138 Journal Club for the Molecular Mechanism of Aging

Why do we age? What causes aging? How is our life span determined? This journal club will address such fundamental, but challenging questions of aging and longevity. Recent studies on aging and longevity are now unveiling regulatory mechanisms of the complex biological phenomenon. We'll cover the latest progress in this exciting field

and stimulate discussions on a variety of topics including aging-related diseases. One hour of paper presentation or research talk and discussion per every two weeks. Registered students are expected to have at least one presentation for 1 unit credit.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5146 Principles and Applications of Biological Imaging

Principles and Applications of Biological Imaging will introduce the interdisciplinary nature of the imaging sciences and conduct a comprehensive survey of the array of interrelated topics that define biological imaging. The course will cover the basics of the optical, magnetic resonance, CT, SPECT and PET imaging modalities, and microscopy, while focusing on applications of imaging to different disease states, such as oncology, neurology, cardiology and pulmonary diseases.

Credit 3 units.

Typical periods offered: Fall

BBS 5147 Contrast Agents for Biological Imaging

Contrast Agents in Biological Imaging will build the chemistry foundations for the design and use of contrast agents in imaging applications such as nuclear medicine, magnetic resonance imaging (MRI) and optical imaging. The course will include lectures on the design of radiopharmaceuticals for gamma scintigraphy and positron emission tomography, MRI contrast agents and agents for optical imaging, including bioluminescence and fluorescence microscopy. One year of general chemistry, one semester of organic chemistry required.

Credit 3 units.

Typical periods offered: Spring

BBS 5148 Metabolism Journal Club

The purpose of the Metabolism Journal Club is to introduce the graduate students to advanced topics spanning the biochemistry, cell biology and genetics of cellular and whole body metabolism. Under the guidance of the course directors, students will select recent topical articles for discussion in the weekly journal club. Students will be expected to provide a succinct introduction to the topic and lead discussion of the data presented in the journal article. Students will be evaluated on the basis of their presentation and their participation in the seminar throughout the semester.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5152 Rad Journal Club (Regeneration, Aging, and Development)

Focuses on developing a dialog around current topics in developmental and regenerative biology at the molecular, cellular and systems levels.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5191 Pathobiology of Human Disease States

Three human disease states will be discussed in detail. Topics will include background clinical and epidemiological information, followed by a detailed examination of the molecular and cellular events that underlie the disease state. Examples of pertinent topics include Alzheimer's disease, AIDS, leukemia, cystic fibrosis, sickle cell anemia, diabetes, etc.

Credit 2 units.

Typical periods offered: Fall

BBS 5192 Cancer Biology Journal Club

This journal club covers current papers in molecular oncology, cancer genetics and contemporary molecular biology. Presentations will be given by students, post-docs and faculty, then discussed.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5196 Special Emphasis Pathway in Cancer Biology

This course is designed to present pre- and postdoctoral trainees with an organized educational format to explore major contemporary topics in cancer biology. The elective will provide an integrated view of cancer research including basic science, translational science, and clinical investigation. Approximately 60 minutes will be devoted to a didactic presentation by a faculty member with interaction by the participants. The remaining 30 minutes will be used to discuss a pivotal research paper from this field, preselected by the faculty member. Outside reading (30-60 min/week) will be required.

Credit 2 units.

Typical periods offered: Spring

BBS 5201 Membrane Protein Biophysics Journal Club

Cells are encapsulated by lipid bilayers providing a physical barrier for the passage of charged molecules and ions in and out of the cell. The proteins that reside within this layer of oil are called membrane proteins, and they act as the molecular gatekeepers, controlling the passage of ions, nutrients, waste products and signaling elements, across cell membranes. This journal club focuses on examining key literature in the field that investigates how membrane proteins fold, adopt certain structures, and how they function inside of the strange environment of the lipid membrane. The papers will be selected from biophysical studies that combine new and notable research with key historical work, for a broad perspective of the science being conducted in this complex and emerging field. Special emphasis will be placed on emerging topics, such as regulation of protein function by lipid composition, membrane protein synthesis and folding, cutting-edge developments in membrane biophysics. The course will consist of both journal club presentations, as well as small group discussions in the form of chalk-talks.

Credit 1 unit.

Typical periods offered: Spring

BBS 5217 Special Topics in Microbial Pathogenesis

Primarily for graduate and MSTP students, this course involves oral presentation and discussion of current research articles on pathogenic microorganisms (bacteria, viruses, parasites, and fungi). Discussion will include design of specific aims for research proposals. Emphasis will be on literature that addresses the cellular and molecular basis of host-pathogen interactions. Students are expected to prepare all articles covered and to participate actively in each discussion. Class meets twice per week for 1.5 hours each.

Credit 2 units.

Typical periods offered: Spring

BBS 5224 Molecular, Cell and Organ Systems

This course will introduce Ph.D. and MSTP students to fundamental problems in cell and molecular biology at the systems level. The course is divided into 5 themes: 1) microbial systems; 2) organ development and repair; 3) cardiovascular system and disease; 4) tumor & host systems; and 5) metabolic systems and disease. Topics within each theme highlight current research concepts, questions, approaches and findings at the molecular, cellular and physiological levels. Students will write an original research grant proposal on a topic of their choosing in one of the 5 themes. Students will critique proposals anonymously in an NIH-like study section.

Credit 3 units.

Typical periods offered: Spring

BBS 5235 Genetics Journal Club

This journal club will be focused on the Genetics department seminar series. Students will present one or a few recent papers by the seminar speaker scheduled for that week. Students will provide a brief written evaluation (on a form that will be provided) of their peers' presentations, and the faculty advisors will meet with each student after the presentation to provide feedback.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5255 Experimental Skeletal Biology Journal Club

The journal club, which meets weekly, focuses on cellular and molecular biology of the skeleton. Emphasis is placed on gaining insights into normal skeletal homeostasis as well as systemic disorders of bone. Papers presented for review are selected from the most competitive journals. Participants are encouraged to think outside of the box and discuss novel molecular discoveries that may impact bone cell function.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5272 Advanced Topics in Immunology

This course uses a journal club format to discuss contemporary issues in the cell and molecular biology of the immune system. Discussions focus on the use of current approaches to analyze the cellular and molecular basis of immunity. Topics include mechanisms of antigenic specificity, diversity, cell communication, differentiation, activation, and effector activity.

Credit 2 units.

Typical periods offered: Fall

BBS 5282 Chromatin Structure and Gene Expression

This special topics course will use *Epigenetics* ed. by Allis, Jenuwein, Reinberg, and Caparros (2007, Cold Spring Harbor Laboratory Press) as the organizing text. Each week a faculty member will provide a background lecture on an important topic or model system, and a student will present and lead discussion of a paper from the current scientific literature related to the previous week's background lecture. Topics to be considered will include background on chromatin structure, histone modifications and histone variants; epigenetic regulation in yeast, other fungi, ciliates, flies, mammals and plants; dosage compensation in different systems; DNA methylation and imprinting in mammals; stem cells, nuclear transplantation and reprogramming; and the epigenetics of cancer and other human diseases (some variation in topics in different years). Students enrolled in the course will be required to present one paper and to come prepared to each session, with a question for discussion.

Credit 2 units.

Typical periods offered: Spring

BBS 5284 Current Research in Chromatin, Epigenetics and Nuclear Organization

This journal club considers papers from the current literature on chromatin structure and function, with an emphasis on regulation of transcription, epigenetics and genomics. Presentations are given by students, postdocs and faculty, with discussion by all. Students enrolled for credit are expected to attend regularly, and to present a minimum of one paper during the term, with consultation and critique from the faculty.

Credit 1 unit.

Typical periods offered: Spring

BBS 5285 Current Topics in Human and Mammalian Genetics

This course aims to provide both biologists and those with mathematical backgrounds with a basis in mammalian genetics. The course will include the following modules: Nucleic acid biochemistry; Gene and chromosome organization; Introduction to Human Genetics; Mutations and DNA repair; Cancer Genetics; Genomic methodologies; Biochemical genetics; Murine Genetics; Epigenetics; Neurodegenerative diseases; Mitochondrial disorders; Pharmacogenetics; Introduction to human population genetics; Applications of modern human genetics; Introduction to web-based informatics tools for molecular genetics. One of the required courses in the Quantitative Human Statistical Genetics graduate program.

Credit 3 units.

Typical periods offered: Fall

BBS 5288 Special Topics in Molecular Genetics

A special topics course with lectures and discussion on the molecular basis of cancer including cell cycle regulation, tumor suppressor genes, tumor invasion, angiogenesis, immune evasion, resistance to apoptosis, signaling, imaging, gene expression, chromosomal translocations, and viral oncology.

Credit 2 units.

Typical periods offered: Spring

BBS 5303 Protein NMR Journal Club

This journal club covers the recent literature on protein NMR with a focus on using NMR to study protein function, NMR dynamics, and novel methods that expand the range of systems accessible to solution NMR studies. Students, postdocs and faculty discuss a recent paper and present background information on the relevant technical aspects of NMR. Students receive 1 credit for participation and presenting one paper.

Credit 1 unit.

Typical periods offered: Fall

BBS 5311 Dynamics in Mesoscopic Molecular Systems

This course will provide a background in the theory of the dynamics of mesoscopic systems and introduction to methods for measuring the dynamics of these systems. It will include measurement methods, some of which are in common use and others that have only recently been introduced. This course would be useful for biophysics students and others that are interested in molecular processes and mechanisms in small systems such as cells.

Credit 3 units.

Typical periods offered: Spring

BBS 5312 Macromolecular Interactions

This course will cover equilibria, kinetics and mechanisms of macromolecular interactions from a quantitative perspective. Thermodynamics, multiple binding equilibria (binding polynomials), linkage phenomena, cooperativity, allostery, macromolecular assembly, analysis of binding isotherms, enzyme catalysis and mechanism, steady-state and pre-steady-state kinetics, kinetic simulation, and isotope effects.

Credit 3 units.

Typical periods offered: Spring

BBS 5318 DNA Repair

This course is an advanced graduate course that explores all aspects of DNA damage and the cellular responses to DNA damage. It is designed for graduate students who have a working knowledge of chemistry, molecular biology and cellular biology, and for interested postdocs and researchers. Specific topics that will be covered are: The chemical basis

of DNA damage, specific DNA repair mechanisms, cell cycle responses to damage, translesion DNA replication and mutagenesis, and human diseases related to defects in DNA damage response. The course consists of a lecture module, open to all, and a discussion module for registered students. In addition, several invited speakers in the field of DNA repair will give seminars and meet with registered students for discussion. Students will present and discuss research papers. Grades will be given based on student presentation and participation. Prerequisite; Permission of instructor.

Credit 2 units.

Typical periods offered: Spring

BBS 5319 Molecular Foundations of Medicine

This course will cover fundamental aspects of biochemistry and cell biology from a medical perspective. The course begins with a treatment of protein structure and the function of proteins in the cytoskeleton and cell motility. The principles of enzyme kinetics and regulation are then discussed and basic pathways for the synthesis and metabolism of carbohydrates and lipids are introduced. This leads in to a discussion of membrane structure and the function cellular organelles in biological processes including energy production, protein degradation and protein trafficking.

Credit 3 units.

Typical periods offered: Fall

BBS 5327 Optical Spectroscopy: Theory and Applications

Spectroscopic methods to be covered include fluorescence, both ensemble and single molecule, and absorption (circular dichroism); fluorescence correlation spectroscopy will also be discussed. The quantum chemistry /physics behind these methods will be reviewed.

Credit 2 units.

Typical periods offered: Fall

BBS 5328 Structural Biology Journal Club

Multi-laboratory research colloquia for DBBS graduate students focused on structural biology and complementary biophysical techniques. Course credit requires student presentation for credit.

Credit 1 unit.

Typical periods offered: Spring

BBS 5336 Computational Biophysics Journal Club

This course covers a combination of classic and recent publications on computational methods for studying biomolecules. Students participating for credit will be required to present at least once.

Credit 1 unit.

Typical periods offered: Spring

BBS 5357 Chemistry and Physics of Biomolecules

This course covers three major types of biomolecular structures: proteins, nucleic acids, and membranes. Basic structural chemistry is presented as well as the biophysical techniques used to probe each type of structure. Selected topics covered include protein folding, protein design, X-ray crystallography, NMR spectroscopy, nucleic acid bending and supercoiling, nucleic acid:protein interactions, RNA folding, membrane organization, fluidity, permeability and transport, and membrane channels. The weekly discussion section will cover problem sets and present current research papers. This is one of the required courses for the biochemistry and for the molecular biophysics graduate programs. Prior course work in biochemistry and physical chemistry is recommended but not required.

Credit 3 units.

Typical periods offered: Fall

BBS 5358 Biochemical and Biophysical Investigations of Infectious Diseases Journal Club

Biochemical and biophysical approaches continue to advance as powerful approaches to the understanding of human disease processes. This journal club covers recent papers in which these approaches address aspects of infectious diseases or inflammation. Students who enroll for credit will be expected to participate in weekly presentations and to present one to two papers along with accompanying background information.

Credit 1 unit.

Typical periods offered: Spring

BBS 5392 Molecular Microbiology & Pathogenesis

Course is devoted to studying microorganisms, particularly those that cause disease, with an emphasis on the molecular interactions between pathogens and hosts. First third of the course focuses on virology, second third on bacteriology and the last third on eukaryotic pathogens.

Credit 4 units.

Typical periods offered: Fall, Spring

BBS 5393 Molecular Virology Journal Club

Journal club covering a broad range of topics in virology with an emphasis on pathogenesis or molecular biology of medically important viruses. A minimum of one student presentation with faculty critique.

Credit 0.5 units.

Typical periods offered: Fall, Spring

BBS 5397 Current Literature in Microbiology

Presentations by students on a broad range of topics of current interest in microbiology. The course will emphasize presentations and discussion skills. Credit requires attendance and participation at all sessions and one presentation.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5412 Tropical and Molecular Parasitology

Graduate level seminar course focusing on current scientific literature in molecular parasitology. The journal club will meet biweekly during the Fall and Spring semesters. Students will attend both semesters in order to receive one credit. The seminar series will run jointly with a research conference in Tropical and Molecular Parasitology. Outside speakers will be invited for the seminar series to emphasize important developments in tropical medicine and molecular parasitology. In advance of the invited speakers, topics will focus on their previous research publications.

Credit 0.5 units.

Typical periods offered: Fall

BBS 5417 Hematology Division Journal Club: Current Topics in Cellular, Molecular, and Stem Cell Biology

This journal club covers a broad range of topics of current interest, including the fields of biochemistry, molecular biology, cell biology, developmental biology, and immunology. Speakers usually give a brief background to introduce the topic and then focus on one-two papers from the current literature. Presentations are given by graduate students, post-doctorates, and faculty. Each attendee presents two-three times per year. Participants are expected to attend all the sessions. This journal club was founded in 1966.

Credit 1 unit.

Typical periods offered: Fall, Spring



BBS 5425 Immunology of Infectious Diseases Journal Club

The goal of this Journal Club (JC) is to provide 2nd year students in MMMP program a platform to discuss new and emerging concepts on mechanisms by which host immune responses mediate protection against infectious diseases. This exercise will also enable the student who attend the fundamental Immunology course to apply their knowledge to understand the basis for immunology of infectious diseases. The format will include faculty who will select cutting-edge papers and head the discussion during the JC session.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5426 ID Gateway: Translational and Public Health Aspects of Basic Infectious Disease Research

This course provides an opportunity for students, postdoctoral fellows, infectious disease fellows and faculty to explore issues at the interface between patient care, public health and basic research in the area of microbial pathogenesis.

Credit 2 units.

Typical periods offered: Spring

BBS 5445 DNA Metabolism Journal Club

Presentation of current research papers in DNA replication, DNA repair, and DNA recombination, with an emphasis on basic biochemical and biophysical approaches.

Credit 1 unit.

Typical periods offered: Spring

BBS 5456 Advanced Crystallography

The advanced course in Protein Crystallography will address all aspects of modern protein crystallography including fundamentals of crystallography, the derivation of the structure factor and electron density equation, symmetry and space groups, direct methods, isomorphous replacement, molecular replacement, data collection, and crystal growing theory and techniques. Prerequisite, Physical Chemistry & Bio 5325 Protein Structure and Function. Two class hours per week.

Credit 2 units.

Typical periods offered: Spring

BBS 5469 Biochemistry, Biophysics, and Structural Biology Seminar

Student presentation of Biochemistry, Biophysics or Structural Biology topic. Second Year Students present from literature; senior students give formal research seminar. Attendance required of all BBSB Graduate Students.

Credit 0.5 units.

Typical periods offered: Fall, Spring

BBS 5480 Nucleic Acids & Protein Biosynthesis

Fundamental aspects of the structure, biosynthesis, and function of nucleic acids and the biosynthesis of proteins. Emphasis on mechanisms involved in the biosynthetic processes and the regulation thereof. Lecture course supplemented with student discussions of research papers.

Credit 3 units.

Typical periods offered: Fall

BBS 5483 Human Genetic Analysis

Basic Genetic concepts: meiosis, inheritance, Hardy-Weinberg Equilibrium, Linkage, segregation analysis; Linkage analysis: definition, crossing over, map functions, phase, LOD scores, penetrance, phenocopies, liability classes, multi-point analysis, non-parametric analysis (sibpairs and pedigrees), quantitative trait analysis,

determination of power for mendelian and complex trait analysis; Linkage Disequilibrium analyses: allelic association (case control designs and family based studies), QQ and Manhattan plots, whole genome association analysis; population stratification; Quantitative Trait Analysis: measured genotypes and variance components. Hands-on computer lab experience doing parametric linkage analysis with the program LINKAGE, model free linkage analyses with Genehunter and Merlin, power computations with SLINK, quantitative trait analyses with SOLAR, LD computations with Haploview and WGAViewer, and family-based and case-control association analyses with PLINK and SAS. The methods and exercises are coordinated with the lectures and students are expected to understand underlying assumptions and limitations and the basic calculations performed by these computer programs. Auditors will not have access to the computer lab sessions.

Credit 3 units.

Typical periods offered: Fall

BBS 5484 Genetics and Development of C. Elegans Journal Club

Students will present a research paper (or present their current thesis research) and the appropriate background material.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5487 Genetics and Genomics of Disease

The course will cover the use of genomic and genetic information in the diagnosis and treatment of disease, with an emphasis on current practice and existing gaps to be filled to achieve precision medicine. Areas of discussion include: bioinformatics methods; assessment of pathogenicity; use and curation of disease variant databases; discovery of incidental findings; genomics applications in Mendelian disease, complex traits, cancer, pharmacogenomics, and infectious disease; design of clinical trials with genetic data; ethical and policy issues.

Credit 2 units.

Typical periods offered: Fall, Spring

BBS 5488 Genomics

This course is designed for beginning graduate students who want to become familiar with the basic concepts and applications of genomics. The course covers a wide range of topics including how genomes are mapped and sequenced as well as the latest computational and experimental techniques for predicting genes, splice sites, and promoter elements. High throughput techniques for ascribing function to DNA, RNA, and protein sequences including microarrays, mass spectrometry, interspecies genome comparisons, and genome-wide knock-out collections will also be discussed. Finally, the use of genomic techniques and resources for studies of human disease will be discussed. A heavy emphasis will be put on students acquiring the basic skills needed to navigate databases that archive sequence data, expression data and other types of genome-wide data. Through problem sets, the students will learn to manipulate and analyze the large data sets that accompany genomic analyses by writing simple computer scripts. While students will become sophisticated users of computational tools and databases, programming and the theory behind it are not covered in this course.

Credit 4 units.

Typical periods offered: Spring

BBS 5489 Human Genetics Journal Club

In this biweekly journal club on Human Genetics we will present and discuss current cutting edge papers in human and mammalian molecular genetics. Students learn presentation skills, how to critique a paper and how to interact with a very active and critical audience. Any person interested in the current state of the art in Human

Genetics may attend this course. It is a requirement that all students wishing to earn credit in this course must present a 1.5 hour journal club talk and must regularly attend and participate in the journal club throughout the year.

Credit 0.5 units.

Typical periods offered: Fall, Spring

BBS 5491 Advanced Genetics

Fundamental aspects of organismal genetics with emphasis on experimental studies that have contributed to the molecular analysis of complex biological problems. Examples are drawn primarily from yeast, nematodes, fruit flies, mouse, and humans. Students will conceive and write an original research proposal with a substantial genetics component; the learning goal is to build skills in developing hypotheses from the literature and designing experimental approaches to test those hypotheses.

Credit 3 units.

Typical periods offered: Spring

BBS 5496 Seminar in Computational Molecular Biology

Students present current research papers and the appropriate background material in the field of Computational Biology. Arts & Sciences students must take this course for credit; Engineering students must take this course Pass/No Pass.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5499 Cancer Informatics Journal Club

This journal club will explore current topics in cancer informatics. Current literature will be reviewed for advanced cancer genome analysis methods, statistics, algorithms, tools, databases, and other informatics resources.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5500 Medical Genetics

A significant portion of the first-year course in basic medical genetics devoted to human and clinical genetics, with emphasis on how genomic information will transform the practice of medicine. Topics covered include population genetics; molecular basis of mutations; human functional genomics; mouse models of human disease; pharmacogenomics; metabolic defects. Lectures, small group discussions, patient information session.

Credit 2 units.

Typical periods offered: Spring

BBS 5501 Biology of the Visual System

The purpose of the course is to provide a fascinating view of vertebrate eye development, anatomy, physiology and pathology. Topics to be covered include the molecules that control eye formation, ocular stem cells, the physiology of transparency, hereditary ocular diseases, phototransduction, the neurobiology of the retina and central visual pathways, age-related eye diseases, and many others. The course is open to all second year graduates students and above. Ophthalmology residents and postdocs with an interest in vision are strongly encouraged to attend.

Credit 3 units.

Typical periods offered: Fall

BBS 5505 Independent Study in Fundamentals of Molecular and Microbial Genetics

This literature-based course will introduce students to seminal and current studies in molecular and microbial genetics. Students will read and present a minimum of 12 landmark papers that helped shape our understanding of molecular and microbial genetics. Emphasis will be placed on students' ability to comprehend and explain these studies via chalk talks. All presentations will be given by students.

Credit 2 units.

Typical periods offered: Fall, Spring

BBS 5507 Genome Engineering Methods and Applications

This course will cover the basic principles of genome engineering with emphasis on Cas9/CRISPR technology. It will consist of discussion sessions in which students will present assigned manuscripts followed by a general discussion of the topic directed by the instructor. The course will cover the mechanisms of genome editing using host DNA repair systems, the function of Cas9, and how Cas9 can be harnessed to introduce defined mutations into almost any genome. The use of Cas9 to activate or repress genes, alter chromatin modifications, and the application of these Cas9 systems to conducting genome-scale screens in mammalian cells as well as its use in studying cell fate will be highlighted. Finally, we will study how Cas9 methodologies can be used to introduce disease-associated variants into pluripotent stem cells (e.g. iPSCs) that can be differentiated into disease-relevant cell for use in functional genomic studies.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5512 Diseases of Membrane Transport & Excitability

Classes will consider the molecular basis of the disease as well as animal models and current clinical studies. Addressing studies from the level of basic biophysical and molecular properties of the underlying ion channels/transporters, to the cellular defects, to organ and animal outcomes and therapies., which will encourage and force students to develop their ability to integrate understanding at multiple levels. Students will be introduced to emerging ideas in clinical diagnosis, management and treatment, when appropriate, clinical specialists will allow student participants to directly observe and participate in the clinical experiences.

Credit 2 units.

Typical periods offered: Spring

BBS 5513 ITVS Project Building

The overall goal is to have intense guidance to construct a grant/fellowship application. Students should expect to have a near completed F30/F31 application by the end of this course. Students will study previous F30/F31 applications and sit on a mock panel to review real world grants from their peers. They will use this experience to understand the reviewers perspective when writing fellowships and grants in the future. Students will draft all portions of a research proposal with feedback from their peers, the course instructor and faculty mentors.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5540 Neural Sciences

An integrated course dealing with the structure, function and development of the nervous system. The course will be offered in the Spring of the first year Medical School calendar.

Credit 5 units.

Typical periods offered: Spring



BBS 5543 Oral Presentation of Scientific Data

Practical course on how to prepare and present scientific data to an audience. Meets once a week for 90 minutes.

Credit 1 unit.

Typical periods offered: Spring

BBS 5571 Cellular Neurobiology

This course will present a fully integrated overview of nerve cell structure, function and development at the molecular and cellular level. Broad topics to be covered include gene structure and regulation in the nervous system, basic neurophysiology, presynaptic and postsynaptic mechanisms of chemical neurotransmission, sensory transduction, neurogenesis and migration, axon guidance and synapse formation. Three 90 minute lectures plus one 75 minute paper discussion section per week. There will be four exams, as well as weekly quizzes.

Credit 6 units.

Typical periods offered: Fall

BBS 5572 Principles of Medicinal Chemistry

Overview of basic principles of medicinal chemistry covering drug targets and concepts of metabolism, efficacy and potency as relevant to drug design.

Credit 3 units.

Typical periods offered: Fall

BBS 5577 Synapses Journal Club

Synaptic function and malleability are fundamental to nervous system function and disease. This is an advanced seminar in the development, structure, and function of the synapse in health and disease. It is a natural extension of topics covered in Bio 5571. It may be primarily of interest to students in the Neurosciences Program, but also to students in MCB, Development, Biochemistry, Computational Biology, and Molecular Biophysics. Generally a topic for the semester helps focus the group; past topics have included Synapses and Disease, Neurotransmitter Transporters, Glutamate Receptors, Dendrites, GABA receptors. Participants (students, postdocs, and faculty) alternate responsibility for leading critical discussion of a current paper. Active participation offers the opportunity for students to hone their critical thinking and presentation skills. Students enrolling for credit will be expected to attend each week, to lead discussion once per semester and to provide written critiques (1-2 pages each) of two papers.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5617 Development Biology PhD Program Seminar

In response to student feedback for additional training in Developmental Biology obtained from surveys and group meetings, we propose a new seminar course in Developmental Biology. This once a week course will introduce student in the Developmental, Regenerative, and Stem Cell Biology PhD Program both to the classical embryological experiments that define key concepts in developmental biology, such as cellular fields, equivalence groups, cytoplasmic determinants, and the more modern experiments that uncovered the genetic and molecular basis of these processes. In general, the classes will be individual sessions on professional development, such as scientific presentation, how to navigate graduate school, etc.

Credit 1 unit.

Typical periods offered: Fall

BBS 5619 Advanced Cognitive, Computational, and Systems Neuroscience

This course will develop critical thinking and analysis skills with regard to topics in Cognitive, Computational and Systems Neuroscience. Course format will be a series of modules composed of intensive, faculty-led case studies on interdisciplinary topics at the intersection of psychology, computation and neuroscience. The goal will be to highlight the benefits of integrative, interdisciplinary approaches, by delving into a small set of topics from a variety of perspectives, rather than providing a survey-level introduction to a broader set of topic areas. Modules will involve a combination of lectures and student-led discussion groups, with students further expected to complete a multi-disciplinary integrative final review paper. Case-study topics will vary somewhat from year to year, but are likely to include some of the following: temporal coding as a mechanism for information processing, coordinate transformations in sensory-motor integration, mechanisms of cognitive control, motor control strategies including application to neural prosthetics, and memory systems in health and disease.

Credit 3 units.

Typical periods offered: Fall

BBS 5622 Cognitive, Computational, and Systems Neuroscience Project Building

The goal of this course is to help students in the CCSN Pathway develop the critical thinking skills necessary to develop and implement high quality, interdisciplinary research projects. Throughout the course of the semester, each student will develop a research plan in their chosen area of interest. The plan will be developed in consultation with at least two faculty members (from at least two different subdisciplines within the pathway) as well as the other students and faculty participating in the course. The culmination of this course will be for each student to produce an NIH-style grant proposal on the research project of their choosing. For most students, this will serve either as their thesis proposal or a solid precursor to the thesis proposal. The course will be designed to help facilitate the development of such a research plan through didactic work, class presentations, class discussion, and constructive feedback on written work. The course will begin with a review of written examples of outstanding research proposals, primarily in the form of grant submissions similar to those that the students are expected to develop (i.e., NRSA style proposals, R03 proposals). Review of these proposals will serve as a stimulus to promote discussion about the critical elements of good research proposals and designs in different areas. Each student will be expected to give three presentations throughout the semester that will provide opportunities to receive constructive feedback on the development and implementation of research aims. The first presentation (towards the beginning of the semester) will involve presentation of the student's general topic of interest and preliminary formulation of research questions. Feedback will emphasize ways to focus and develop the research hypotheses into well-formulated questions and experiments. The second presentation will involve a more detailed presentation of specific research questions (along the lines of NIH-style Specific Aims) and an initial outline of research methods. The final presentation will involve a fuller presentation of research questions and proposed methods. Feedback, didactic work, and group discussion throughout the semester will include guidance on critical components of the development of a research plan, including how to perform literature searches, formulate testable hypotheses, write critical literature summaries, and design experiments and analyses. The course will meet once a week, with faculty members from different tracks within the Pathway present at each meeting. This will allow students to receive feedback from several perspectives.

Credit 3 units.

Typical periods offered: Fall, Spring

BBS 5646 First-Year Fundamentals

This course will provide a two-part introduction to neuroscience research fundamentals. Namely, it will introduce elementary statistical analysis for neuroscience research as well as grant writing to support neuroscience-related research. Enrollment is limited to first-year neuroscience students.

Credit 0.5 units.

Typical periods offered: Spring

BBS 5648 Coding and Statistical Thinking in the Neurosciences

Students are introduced to scientific programming in Python. Students will learn common programming constructs and how to visualize and analyze data. Coding will be integrated into a statistics curriculum introducing summary statistics, probability distributions, simulation and hypothesis testing, and power analysis for experimental design.

Credit 3 units.

Typical periods offered: Fall, Spring

BBS 5651 Neural Systems

The course will consist of lectures and discussions of the sensory, motor and integrative systems of the brain and spinal cord, together with a weekly lab. The lectures will present aspects of most neural systems, and will be given by faculty members who have specific expertise on each topic. The discussions will include faculty led group discussions and papers presented and discussed by students. The labs will include human brain dissections, examination of histological slides, physiological recordings, behavioral methods, computational modeling, and functional neural imaging.

Credit 6 units.

Typical periods offered: Spring

BBS 5663 Neurobiology of Disease

This is an advanced graduate course on the pathology of nervous system disorders. This course is primarily intended to acquaint Neuroscience graduate students with a spectrum of neurological diseases, and to consider how advanced neuroscientific approaches may be applied to promoting recovery in the brain. Topics will be presented by Washington University faculty members and include: neurooncology, stroke, retinal disease, perinatal brain injury, neurodegenerative disorders, neuroinflammation, epilepsy, and psychiatric disorders. The class will meet for 2 hours each week. Each session will be led by a faculty guest with expertise in a specific neurological or psychiatric disease. In the first hour, the speaker will discuss clinical manifestations and pathophysiology. Where possible, the clinical presentation will be supplemented with a patient demonstration or videotape. After a 30 minute break for pizza and soda, the second hour will follow a journal club format. Two or three students will review current papers assigned by the speaker or course director. This course is offered in alternate years. Prerequisite: Introductory neuroscience course at the graduate or medical school level.

Credit 2 units.

Typical periods offered: Spring

BBS 5678 Clocksclub

Clocksclub focuses on recent advances in the study of biological timing including sleep and circadian rhythms. Participants discuss new publications and data on the molecules, cells and circuits underlying daily rhythms and their synchronization to the local environment. Students registered for this journal club will lead a discussion once during the semester.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5702 Current Approaches in Plant and Microbial Research

This course is designed to introduce graduate students and upper-division undergraduates to contemporary approaches and paradigms in plant and microbial biology. The course includes lectures, in-class discussions of primary literature and hands-on exploration of computational genomic and phylogenetic tools. Evaluations include short papers, quizzes, and oral presentations. Over the semester, each student works on conceptualizing and writing a short NIH-format research proposal. Particular emphasis is given to the articulation of specific aims and the design of experiments to test these aims, using the approaches taught in class. Students provide feedback to their classmates on their oral presentations and on their specific aims in a review panel.

Credit 4 units.

Typical periods offered: Spring

BBS 5703 Experimental Design and Analysis in Biological Research

In-depth exploration of landmark and current papers in genetics, molecular and cell biology, with an emphasis on prokaryotes and eukaryotic microbes. Class discussions will center on such key discoveries as the chemical nature of genetic material, the genetic code, oxygen producing light-spectrum, cell-cell signaling, transcriptional regulation, the random nature of mutation, and cell cycle regulation. Emphasis will be placed on what makes a good question or hypothesis, expedient ways to address scientific problems, and creative thinking. The last third of the course will consist of student-run seminars on selected topics to increase proficiency in the synthesis of new material and public presentation skills.

Credit 2 units.

Typical periods offered: Fall

BBS 5723 Seminar in Plant and Microbial Bioscience

This course emphasizing presentation skill and critical analysis counts towards the PMB Graduate Program's journal club course requirement. Students will be responsible for dividing and presenting 30 current research publications selected by the course masters. In addition to assembling brief PowerPoint presentations providing background and significance for their assigned articles, students are expected to provide classmates with a 1 page primer and short list of relevant references

Credit 2 units.

Typical periods offered: Fall, Spring

BBS 5801 Biochemistry & Molecular Biophysics Seminar Journal Club

This will be a journal club-based seminar course mirroring the topics covered by Biochemistry and Molecular Biophysics (BMB) seminar speakers during the concurrent semester. Students will present a paper published by one of the BMB seminar speakers one-week ahead of that speaker's seminar. This will allow students and faculty to become more familiar with the research programs of BMB invited speakers, likely stimulating discussion within the Q&A period after the seminar, as well as during informal meet-the-speaker lunch sessions. Students will be evaluated on their journal club presentation, attendance and class participation.

Credit 1 unit.

Typical periods offered: Spring

BBS 5840 Climate Change Reading Group

The Climate Change Reading Group is made up of multi-disciplinary faculty and students from multiple institutions in St Louis: WUSTL, UMSL, SLU, Missouri Botanical Garden, Danforth Center, and more. Many of us in different labs, departments, and institutions around STL are actively investigating aspects and effects of climate change; this reading group provides a venue for interacting with others in the community. Subject matter within the context of Climate Change will



be chosen each week by a different presenter. Students can join this reading group for 1 credit if they agree to read all papers, actively participate in discussions, find and present one high quality scientific paper on climate change in the field of their choice and moderate the discussion of this paper. The students will be evaluated on their participation, their understanding of the issues, and their presentation. Credit 1 unit.

Typical periods offered: Spring

BBS 5850 Seminar in Floristic Taxonomy

This weekly seminar provides an introduction to/overview of Plants, each semester progressively covering orders and families in a sequence derived from the Angiosperm Phylogeny Website (<http://www.mobot.org/MOBOT/Research/APweb/welcome.html>); in Spring 2015, the seminar will cover several crown orders of the monocots, including grasses and relatives. Weekly presentations include a summary of all relevant information (molecular, chemical, anatomical, embryological, morphological, ecological, geographical, historical/paleontological, etc.) about the plant group under consideration, review of the classification/phylogeny of the group, examination of fresh and/or preserved specimens, and discussion of relationships, human uses, and other relevant aspects of the biology of that group. Credit will be contingent on one (or two) seminar presentation(s) per student, regular attendance and active participation in group discussions.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5866 Communicating Science: Writing for Multiple Audiences

This course introduces strategies for writing effectively and communicating scientific research to a variety of audiences. Students will learn to reduce jargon, explain scientific concepts in common language, write clearly and concisely, and use sentence structure to maximum efficiency. Written assignments emphasize the significance and innovation in scientific research that appeal to broad audiences, including: the general public, students, policy makers, grant reviewers, and journal editors. This course meets biweekly and consists of lectures and small group sessions. You must enroll in both the lecture session (section 1) and a small group (section A, B, C, or D).

Credit 1 unit.

Typical periods offered: Spring

BBS 5867 Career Planning for Biological Scientists

This course will guide you through nationally recognized and evidence-based career exploration curricula. It is intended for DBBS Ph.D. students and bioscience postdocs who want to jump-start career planning and professional skills needed for a broad range of scientific careers. Topics include self-assessment, career exploration, and goal-setting for long-term success. You will work on a team to research the scientific career path of your choice. Each team will study the specific required knowledge, skills, and attributes of their career interest or employment sector. As part of this research project, you will complete a simulated job exercise and network with alumni or local leaders in your chosen field, gaining valuable real-world insights and creating essential professional connections.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5900 Research

Enrolled students will meet in-person with faculty for a minimum of 1 hour per week. Pass/No Pass Only.

Credit 12 units.

Typical periods offered: Fall, Spring, Summer

BBS 5902 Introduction to the Scholarship of Teaching and Learning

In this course, advanced graduate students and postdocs in STEM will 1) learn the fundamentals of the Scholarship of Teaching and Learning (SoTL)-which is the practice of developing, reflecting on, and evaluating teaching methods to improve student learning, 2) Develop a working knowledge of SoTL, which draws on research in education, STEM education, and cognitive science, 3) Understand how SoTL can lead to the dissemination of new knowledge to a broad audience of educators through publication and presentations., and 4) Develop the central elements of a SoTL project. These elements include articulating questions about classroom teaching that can be addressed in a SoTL research project; developing working hypotheses in response to the questions; designing an evaluative plan, including specific research methods, the type of data to be collected, and how the data will be analyzed in relation to the hypotheses; identifying and understanding necessary procedures to obtain IRB approval for the research.

Credit 1 unit.

Typical periods offered: Spring

BBS 5910 Nano Topics in Biology and Biomedical Sciences

This course will expose students to advanced topics, methods, and skills in biomedical sciences. The course will rapidly fill gaps in student knowledge in areas that are relevant to their research and or professional development. Each section of the course will be offered independently, sometimes in coordination with existing journal clubs and other seminars. Some sections will focus on technique; others will be theoretically or conceptually focused. Each section will be led by a faculty member drawn from DBBS in an area of their expertise. Objectives include deepening students knowledge and skill sets in critical thinking, experimental design, and technical prowess as related to the specific themes of each section.

Credit 0.5-1 units.

Typical periods offered: Fall, Spring

BBS 5911 Seminar in Biology & Biomedical Sciences

These seminars cover the recent literature in various areas not included in other courses, or in more depth than other courses. Credit to be arranged.

Credit 12 units.

Typical periods offered: Spring

BBS 5915 Teaching Practice in Biology & Biomedical Sciences

Students serve as teaching assistants for undergraduate and graduate level courses. Faculty-supervised activities include: lecture preparation and presentation; leading discussion and problem-solving sessions; laboratory instruction.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5922 Entering Mentoring

This course is a series of facilitated discussions aimed at developing and improving mentoring skills for those involved in supervising undergraduate research experiences. It is designed for postdocs and graduate students who are or will be 'bench mentors' for undergraduates doing Bio 500 and/or Summer Research. Participants will receive Entering Mentoring materials, including articles and worksheets to facilitate mentoring interactions with their mentee, plus several resource books relevant to mentoring. They will develop a mentoring philosophy statement, work on specific assignments designed to improve their relationship with their mentee and share their present and past experiences as mentors and mentees. Bench mentors will be eligible for a travel award to help defray expenses for attending a meeting with their mentee, if that student wins one of the HHMI SURF travel awards (4-5 awarded annually) or is otherwise being supported to present at a scientific meeting. Graduate students

and postdocs do NOT need to be mentoring a student at the time of the course; it is open to all with an interest in mentoring now or in the future. Note: The sessions will be held either at the beginning of the day or the end of the day at the Danforth campus. Once registration closes, an email will be sent to those registered to poll for the best days & times.

Credit 1 unit.

Typical periods offered: Fall, Spring

BBS 5923 Foundations in Cancer Biology

This basic cancer biology class is designed to provide a didactic foundation into cancer biology principles. These will include tumor suppressors & oncogenes, DNA damage pathways, protein modifications, tumor progression, metastasis, tumor microenvironment and numerous other topics relevant to cancer biology.

Credit 3 units.

Typical periods offered: Fall

BBS 5928 Experimental Cancer Biology

This basic cancer biology class is meant to coincide with the Foundation course. Topics will be discussed in parallel with Foundation course topics but from the perspective of the laboratory experimentalist. Experimental details will provide the basis for understanding how to ask and answer important questions in the cancer biology laboratory.

Credit 3 units.

Typical periods offered: Fall

BBS 5940 Foundations in Cancer Biology and Experimental Cancer Biology

This advanced course will teach the clinical perspective of cancer biology using topics from oncology, radiation biology, radiology, pathology, immunology and surgery. Students will learn to write a grant proposal that includes a clinical trial element while also shadowing physicians in a real cancer clinical setting.

Credit 3 units.

Typical periods offered: Spring

BBS 5989 Advanced Topics in Neuroscience

This course will expose upper-level and postdoctoral students to advanced topics and methods in neuroscience. The course will rapidly fill gaps in student knowledge in areas that may be relevant to new directions in thesis work or interest areas. Each section of the course will be offered asynchronously, sometimes in coordination with existing journal clubs and other seminars. Each section will meet for two hours per week for three weeks. Sections may start with a didactic component or a review paper, but they will quickly delve into the discussion of primary papers curated by faculty and covering a focused topic. It is expected that papers will cover both historical and current contexts. Some sections will focus on technique; others will be conceptually focused. Each section will be led by a faculty member drawn from the Neuroscience program in an area of their expertise. Objectives include deepening critical thinking, statistical knowledge, experimental design, and technical prowess.

Credit 0.5-1 units.

Typical periods offered: Fall, Spring

BBS 5999 Independent Work

This course is designed for individual students wishing to explore indepth specialized areas of literature or technology with one or more faculty members. Credit will vary with the amount of work and discussion, but cannot be more than 3 credits.

Credit 3 units.

Typical periods offered: Fall, Spring

BBS 9000 Full-Time Graduate Research/Study

Full-Time Graduate Research/Study

Credit 0 units.

Typical periods offered: Fall, Spring, Summer

BBS 9001 Full-Time Graduate Study in Absentia

Full-Time Graduate Study in Absentia

Credit 0 units.

Typical periods offered: Fall, Spring, Summer

BBS 9002 Full-Time Graduate Study Extension

Full-Time Graduate Study Extension

Credit 0 units.

Typical periods offered: Fall, Spring, Summer

Policies

The Vagelos Division of Biology & Biomedical Sciences has more than 700 students with access to over 700 faculty mentors with whom they may perform their dissertation work. This unparalleled flexibility results from the joint governance of DBBS by the Washington University School of Medicine and the School of Arts & Sciences — a 50-year-old model that fosters the most impactful science executed at the boundaries of fields, programs, disciplines, schools and departments. A hallmark of DBBS is our commitment to interdisciplinary collaboration. By transcending traditional academic boundaries, our programs consistently earn top-tier national and international rankings.

In this interdisciplinary environment, graduate students are governed by policies and guidelines established by the university, the School of Medicine, and DBBS. The policies identified here and elsewhere in this *Bulletin* are not to be considered a complete list. However, every attempt has been made to identify the location of those policies that affect most or all students in DBBS.

The University Policies (p. 18) page in this *Bulletin* outlines regulations for both graduate and undergraduate students. For further details, please consult the Office of the University Registrar website and the University Policies page of the WashU website. Graduate students are encouraged to review the specific policy categories relevant to their degree programs.

All DBBS students must follow the University PhD Policies & Requirements (p. 32) as set forth by the Provost's Office.

Degrees in DBBS are conferred by the School of Medicine; hence, students must follow the applicable policies as set forth by the school, including the relevant PhD Program Policies & Guidelines.

DBBS students can reference the DBBS Student Handbook for student guidelines across all Division programs.

Division of Computational & Data Sciences

The Division of Computational & Data Sciences (DCDS) at Washington University in St. Louis trains students interested in problems from across a range of disciplines that share a common reliance on data and computing.

The introduction of now-standard tools from statistical analysis and hypothesis testing transformed the practice of natural and social science in the mid-20th century. Emerging tools from computational and data science have the potential to bring about an even larger transformation of scientific practice, especially in the social sciences. The questions raised by data generated by and about human behavior are engaging and profound. However, many if not most of these questions can only be tackled using a multidisciplinary approach that combines a deep knowledge of the capabilities and operation of data science techniques with the domain expertise needed to apply them effectively to the problems under consideration.

Doctoral students in Computational & Data Sciences receive strong methodological training in modern computational and statistical methods, and they also acquire expertise in a particular social science application area.

The program is inherently interdisciplinary and brings together leading experts from across the university who are using data to solve some of the greatest challenges that our world faces today. Faculty include both data and computing experts as well as domain experts from different application areas.

Faculty

Eunhye Ahn

Assistant Professor, Brown School
PhD, University of Southern California

Ruopeng An

Assistant Professor, Brown School
PhD, Pardee RAND Graduate School

Dennis Barbour

Associate Professor, Biomedical Engineering
MD, Johns Hopkins University
PhD, Johns Hopkins University

Deanna Barch

Professor and Chair, Psychological & Brain Sciences
PhD, University of Illinois

Janine Bijsterbosch

Assistant Professor, Radiology
PhD, University of Sheffield

Ryan Bogdan

Associate Professor, Psychological & Brain Sciences
PhD, Harvard University

Todd Braver

Professor, Psychological & Brain Sciences, Radiology, and Neuroscience
PhD, Carnegie Mellon University

Michael Brent

Henry Edwin Sever Professor of Engineering, Computer Science & Engineering
PhD, Massachusetts Institute of Technology

Derek Brown

Associate Professor, Brown School
PhD, Duke University

Sheretta Butler-Barnes

Associate Professor, Brown School
PhD, Wayne State University

David Carter

Associate Professor, Political Science
PhD, University of Rochester

Yixin Chen

Professor, Computer Science & Engineering
PhD, University of Illinois

Dino Christenson

Associate Professor, Political Science
PhD, Ohio State University

Brett Drake

Professor, Brown School
PhD, University of California, Los Angeles

Ted Enamorado

Assistant Professor, Political Science
PhD, Princeton University

Randi Foraker

Associate Professor of Public Health, Brown School
PhD, The University of North Carolina at Chapel Hill

Patrick Fowler

Track Chair, Social Work & Public Health
Associate Professor, Brown School
PhD, Wayne State University

Roman Garnett

Assistant Professor, Computer Science & Engineering
PhD, University of Oxford

Aimilia Gastouni

Assistant Professor, Radiology
PhD, National Technical University of Athens

Chris Gill

Professor, Computer Science & Engineering
DSc, Washington University in St. Louis

Brian Gordon

Assistant Professor, Radiology
PhD, University of Illinois

Roch Guérin

Professor and Chair, Computer Science & Engineering
PhD, California Institute of Technology

Shenyang Guo

Professor, Brown School
PhD, University of Michigan–Ann Arbor

Ross Hammond

Associate Professor, Brown School
PhD, University of Michigan

Jenine Harris

Associate Professor, Brown School
PhD, Saint Louis University

Chien-Ju Ho

Assistant Professor, Computer Science & Engineering
PhD, University of California, Los Angeles

Josh Jackson

Associate Professor, Psychological & Brain Sciences
PhD, University of Illinois Urbana-Champaign

Nathan Jacobs

Professor, Computer Science & Engineering
PhD, Washington University in St. Louis

Kim Johnson

Associate Professor, Brown School
PhD, University of Minnesota

Melissa Jonson-Reid

Professor, Brown School
PhD, University of California, Berkeley

Brendan Juba

Assistant Professor, Computer Science & Engineering
PhD, Massachusetts Institute of Technology

Thomas Kannampallil

Assistant Professor, Anesthesiology
PhD, University of Illinois

Caitlin Kelleher

Associate Professor, Computer Science & Engineering
PhD, Carnegie Mellon University

Wouter Kool

Assistant Professor, Psychological & Brain Sciences
PhD, Princeton University

Matt Kreuter

Professor, Social Work & Public Health
PhD, The University of North Carolina at Chapel Hill

Albert Lai

Associate Professor and Deputy Director, Institute for Informatics
Associate Professor, Computer Science & Engineering
PhD, Columbia University

Calvin Lai

Assistant Professor, Psychological & Brain Sciences
PhD, University of Virginia

Matthew Lew

Assistant Professor, Electrical & Systems Engineering
PhD, Stanford University

Jr-Shin Li

Professor, Electrical & Systems Engineering
PhD, Harvard University

Fangqiong Ling

Assistant Professor, Energy, Environmental & Chemical Engineering
PhD, University of Illinois Urbana-Champaign

Chenyang Lu

Professor, Computer Science & Engineering
PhD, University of Virginia

Christopher Lucas

Assistant Professor, Political Science
PhD, Harvard University

Doug Luke

Professor, Brown School
PhD, University of Illinois

Phillip Marotta

Assistant Professor, Brown School
PhD, Columbia University

Andrew D. Martin

Professor, Political Science and Law
Chancellor, Washington University in St. Louis
PhD, Washington University in St. Louis

Timothy McBride

Professor, Brown School
PhD, University of Wisconsin–Madison

Jacob Montgomery

Track Chair, Political Science
Associate Professor, Political Science
PhD, Duke University

William Nomikos

Assistant Professor, Political Science
PhD, Yale University

Alvitta Ottley

Assistant Professor, Computer Science & Engineering
PhD, Tufts University

Neal Patwari

Professor, Electrical & Systems Engineering
Professor, Computer Science & Engineering
PhD, University of Michigan

Philip R.O. Payne

Professor and Director, Institute for Informatics
Professor, Computer Science & Engineering
PhD, Columbia University

Netanel Raviv

Assistant Professor, Computer Science & Engineering
PhD, Technion – Israel Institute of Technology

Zachariah Reagh

Assistant Professor, Psychological & Brain Sciences
PhD, University of California, Irvine

Andrew Reeves

Associate Professor, Political Science
PhD, Harvard University

Guillermo Rosas

Associate Professor, Political Science
PhD, Duke University

Betsy Sinclair

Professor, Political Science
PhD, California Institute of Technology

Bruno Sinopoli

Professor and Chair, Electrical & Systems Engineering
PhD, University of California, Berkeley

Aristeidis Sotiras

Assistant Professor, Radiology
PhD, École Centrale Paris

Fred Ssewamala

Associate Dean for Transdisciplinary Faculty Research, Brown School
PhD, Washington University in St. Louis

Joe Steensma

Professor of Practice, Brown School
EdD, Indiana Wesleyan University

Joshua Swamidass

Associate Professor, Pathology & Immunology
Associate Professor, Biomedical Engineering
MD, University of California, Irvine
PhD, University of California, Irvine

Jessie Sun

Assistant Professor, Psychological & Brain Sciences
PhD, University of California, Davis

Yevgeniy Vorobeychik

Associate Professor, Computer Science & Engineering
PhD, University of Michigan

Chenguang Wang

Assistant Professor, Computer Science & Engineering
PhD, Peking University

Yong Wang

Associate Professor, Electrical & Systems Engineering

Emily Willroth

Assistant Professor of Psychological & Brain Sciences
PhD, University of California, Berkeley

William Yeoh

Track Chair, Computational Methodologies
Associate Professor, Computer Science & Engineering
PhD, University of Southern California

Jeffrey Zacks

Track Chair, Psychological & Brain Sciences
Professor and Associate Chair, Psychological & Brain Sciences
PhD, Stanford University

Shen Zeng

Assistant Professor, Electrical & Systems Engineering
PhD, University of Stuttgart

Ning Zhang

Assistant Professor, Computer Science & Engineering
PhD, Virginia Polytechnic Institute and State University

Xuan Zhang

Assistant Professor, Electrical & Systems Engineering
PhD, Cornell University

Degree Requirements

Upon joining the PhD program, each student is assigned an initial advisor from the DCDS faculty. This advisor meets with the student to assess their background and to advise them on course selection.

All students complete a common core curriculum as well as a domain depth requirement in a social science area. The focus of the first year is on acquiring a common set of tools and an understanding of the ranges and types of problems students may work on as they progress through the program. The entire incoming cohort takes a unique two-semester seminar sequence solely for DCDS students, which includes both general topics and a series of data-driven dives into the types of research questions that may be encountered in each of the domain areas.

Curriculum

Required Core Courses

Please refer to the DCDS Doctoral Student Handbook for the most up-to-date core course requirements.

Domain Depth Tracks

Students will choose one of four focus tracks: Political Science, Psychological & Brain Sciences, Social Work & Public Health, or Computational Methodologies. Please refer to the DCDS Doctoral Student Handbook for the most up-to-date domain depth track requirements.

Further Requirements

Additional requirements for this program are as follows:

- A minimum of 72 credit units beyond the bachelor's level, with a minimum of 37 being course credits (including the core curriculum)
- A minimum of 24 credit units of doctoral dissertation research
- Students must maintain a cumulative average grade of B (3.0 grade-point average) for all 72 credit units.
- Required courses must be completed with no more than one grade below a B–.
- Up to 24 graduate credit units may be transferred with the approval of the Graduate Studies Committee, which is chaired by the director of graduate studies.

In addition to fulfilling the course and research credit requirements, students must do the following:

- Pass a qualifying exam.
- Successfully defend a thesis proposal.
- Present and successfully defend a dissertation.
- Complete a teaching requirement consisting of two semesters of mentored teaching experience.

Institute of Materials Science & Engineering

The Institute of Materials Science & Engineering (IMSE) at Washington University in St. Louis offers a unique, interdisciplinary PhD in Materials Science & Engineering that crosses traditional departmental and school boundaries. The field of materials science and engineering focuses on the study, development and application of new materials with desirable properties, with the goal of enabling new products and superior performance regimes. Disciplines in the physical sciences (e.g., chemistry, physics) play a central role in developing the fundamental knowledge that is needed to design materials for a variety of engineering applications (e.g., mechanical engineering, electrical engineering, biomedical engineering). Building on training that spans from fundamental to applied sciences, materials scientists and engineers integrate this fundamental knowledge to develop new materials and match them with appropriate technological needs.

The IMSE is well positioned to address the needs of a student seeking a truly interdisciplinary experience. The IMSE brings together a diverse group of faculty from departments in Arts & Sciences, the McKelvey School of Engineering, and the School of Medicine. The IMSE also oversees shared research and instrument facilities, develops partnerships with industry and national laboratories, and facilitates outreach activities.

Current focused areas of research and advanced graduate education within the IMSE include the following:

- Artificial intelligence in materials discovery and design
- Biomedical, bio-derived, and bio-inspired materials
- Materials for energy and environmental technologies
- Quantum and photonic materials and devices

Faculty

Director

Katharine M. Flores

Christopher I. Byrnes Professor, Mechanical Engineering & Materials Science
PhD, Stanford University

Professor Flores' primary research interest is the mechanical behavior of high-performance structural materials, with particular emphasis on understanding structure-processing-property relationships in bulk metallic glasses and their composites.

Professors

Jianjun Guan

Professor, Mechanical Engineering & Materials Science
PhD, Zhejiang University

Professor Guan's research interests are in biomimetic biomaterials synthesis and scaffold fabrication; bioinspired modification of biomaterials; injectable and highly flexible hydrogels; bioimageable polymers for MRI and EPR imaging and oxygen sensing; mathematical modeling of scaffold structural and mechanical properties; stem cell differentiation; neural stem cell transplantation for brain tissue regeneration; and bone and cardiovascular tissue engineering.

Marcus Foston

Professor, Energy, Environmental & Chemical Engineering
PhD, Georgia Institute of Technology

Professor Foston's research program seeks to develop innovative and novel routes to exploit and utilize lignocellulosic biomass by taking advantage of materials involved in industries such as agriculture, paper making, and forestry products.

Erik Henriksen

Professor, Physics
PhD, Columbia University

Professor Henriksen's lab research is centered on the properties of electrons confined to two dimensions. This remarkable system has yielded a tremendous amount of interesting and important physics over the past several decades, from the integer and fractional quantum Hall effects to the groundbreaking discoveries of graphene and other atomically thin crystals and especially to the recent realization of the topological nature of the electronic structure of a surprising number of materials both novel and familiar.

Song Hu

Professor, Biomedical Engineering
PhD, Washington University in St. Louis



Professor Hu's research focuses on the development of cutting-edge optical and photoacoustic technologies for high-resolution structural, functional, metabolic, and molecular imaging in vivo and their applications in neurovascular disorders, cardiovascular diseases, regenerative medicine, and cancer.

Vijay Ramani

Roma B. & Raymond H. Wittcoff Distinguished University Professor of Environment & Energy
PhD, University of Connecticut

Vijay Ramani's research interests lie at the confluence of electrochemical engineering, materials science and renewable and sustainable energy technologies. The National Science Foundation, Office of Naval Research, ARPA-E, and Department of Energy have funded his research, with mechanisms including an NSF CAREER award (2009) and an ONR Young Investigator Award (ONR-YIP; 2010).

Srikanth Singamaneni

The Lilyan & E. Lisle Hughes Professor, Mechanical Engineering & Materials Science
PhD, Georgia Institute of Technology

Professor Singamaneni's research interests include plasmonic engineering in nanomedicine (in vitro biosensing for point-of-care diagnostics, molecular bioimaging, nanotherapeutics); photovoltaics (plasmonically enhanced photovoltaic devices); surface-enhanced Raman scattering (SERS)-based chemical sensors, with particular emphasis on the design and fabrication of unconventional and highly efficient SERS substrates; hierarchical organic/inorganic nanohybrids as multifunctional materials; bioinspired structural and functional materials; polymer surfaces and interfaces; responsive and adaptive materials and scanning probe microscopy; and surface force spectroscopy of soft and biological materials.

Fuzhong Zhang

Professor, Energy, Environmental & Chemical Engineering
PhD, University of Toronto

Professor Zhang's research focuses on developing synthetic biology tools and systems for the sustainable production of structurally defined chemicals and high-performance materials. Current research projects include the following: (1) engineering microbial metabolic dynamics and heterogeneity; (2) engineering metabolic pathways to produce structure-defined biofuels and chemicals; and (3) developing microbial factories to produce high-performance materials.

Associate Professors

Peng Bai

Associate Professor, Energy, Environmental & Chemical Engineering
PhD, Tsinghua University, Beijing

Professor Bai's research focuses on the development of next-generation batteries. Knowledge and tools developed in the Bai Group also apply to and benefit the design of other electrochemical energy systems, like supercapacitors and fuel cells.

Mikhail Y. Berezin

Associate Professor, Radiology
PhD, Moscow Institute of Oil and Gas/Institute of Organic Chemistry

Dr. Berezin's lab focuses on the development of novel optically active probes ranging from small molecules to nanoparticles and the development of optical instrumentation for spectroscopy and imaging using knowledge of excited states. The lab's research interest lies in the investigation and application of molecular excited states and their reactions for medical imaging and clinical treatment.

Nathaniel Huebsch

Associate Professor, Biomedical Engineering
PhD, Harvard University

Professor Huebsch's research focus is in basic and translational stem cell mechanobiology, with specific focus on hydrogels to control cell-mediated tissue repair and three-dimensional, iPSC-based heart-in-a-dish models to study the influence of mechanical loading and genetics on arrhythmia and contractility.

Matthew Lew

Associate Professor, Electrical & Systems Engineering
PhD, Stanford University

Professor Lew and his students build advanced imaging systems to study biological and chemical systems at the nanoscale, leveraging innovations in applied optics, signal and image processing, design optimization, and physical chemistry. Their advanced nanoscopes (microscopes with nanometer resolution) visualize the activity of individual molecular machines inside and outside living cells. Examples of new technologies developed in the Lew Lab include (1) using tiny fluorescent molecules as sensors that can detect amyloid proteins; (2) designing new "lenses" to create imaging systems that can visualize how molecules move and tumble; and (3) new imaging software that minimizes artifacts in super-resolution images.

Xianglin Li

Associate Professor, Mechanical Engineering & Materials Science
PhD, University of Connecticut

Professor Li's research interests are in batteries and fuel cells, including direct methanol fuel cells, lithium-oxygen batteries and battery thermal management; transport phenomena in porous media; greenhouse gas emissions and full fuel cycle analysis of fossil fuels; and life cycle assessment and economic analysis of advanced energy techniques, among others.

Mark Meacham

Associate Professor, Mechanical Engineering & Materials Science
PhD, Georgia Institute of Technology

Professor Meacham's research interests include microfluidics, micro-electromechanical systems (MEMS) and associated transport phenomena, with application to design, development and testing of novel energy systems and life sciences tools, from scalable micro-/nanotechnologies for improved heat and mass exchangers to MEMS-based tools for manipulation and investigation of cellular processes.

He is also interested in the behavior of jets and/or droplets of complex fluids during ejection from microscopic orifices, which is critical to applications as disparate as biological sample preparation and additive manufacturing.

Rohan Mishra

Associate Professor, Mechanical Engineering & Materials Science
PhD, Ohio State University

Professor Mishra's research interest is to develop quantitative structure-property correlations in materials starting from the atomic scale. To develop such correlations, his group synergistically combines electronic structure calculations with atomic-resolution electron microscope imaging and spectroscopy. The end goal is the rational design of materials with properties tailored for electronic, optical, magnetic and energy applications. Current research topics include perovskite materials for photovoltaic and optoelectronic applications, novel electrocatalysts, oxidizers, and wide-bandgap semiconductors.

Jai Rudra

Associate Professor, Biomedical Engineering
PhD, Louisiana Tech University

Jai Rudra's lab is interested in the development of nanoscale biomaterials such as nanofibers, nanoparticles, virus-like particles, and hydrogels for engaging the immune system to induce protective antibody and cell-mediated immune responses against diseases such as tuberculosis, melanoma, and flavivirus infections (i.e., West Nile and Zika). He is also investigating the development of vaccines against drugs of addiction such as cocaine.

Chuan Wang

Associate Professor, Electrical & Systems Engineering
PhD, University of Southern California

Professor Wang's research focus is on two-dimensional semiconductor nanoelectronics and optoelectronics, stretchable electronics, printed electronics, and sensors and actuators.

Patricia Weisensee

Associate Professor, Mechanical Engineering & Materials Science
PhD, University of Illinois at Urbana-Champaign

Professor Weisensee's work focuses on understanding the interplay of fluid dynamics, heat transfer, and liquid-solid interactions of droplets and other multi-phase systems. Practical applications of interest are phase change heat transfer for thermal management, thermal storage, water harvesting, metallic additive manufacturing, and droplet interactions with biological and natural systems.

Assistant Professors

Sang-Hoon Bae

Assistant Professor, Mechanical Engineering & Materials Science
PhD, University of California, Los Angeles

Professor Bae's research group focuses on tackling the challenges in materials science with thermodynamics, kinetics, and solid-state physics.

Matthew Bersi**Christopher Cooper**

Assistant Professor, Energy, Environmental & Chemical Engineering
PhD, Stanford University

Christopher Cooper's research at WashU focuses on using dynamic polymers to create responsive, soft materials for applications in energy storage, environmental sustainability, and human health. Through advanced synthesis and characterization, his research group designs polymers with distinct molecular designs and reversible bonds for applications including wearable or implantable electronic devices, recyclable underwater adhesives, soft actuators, and upcycling of industrial plastics. Cooper has published more than 15 peer-reviewed journal articles and given numerous conference presentations and invited talks.

Francisco Lagunas Vargas**Mark Lawrence**

Assistant Professor, Electrical & Systems Engineering
PhD University of Birmingham

Professor Lawrence and his lab are harnessing breakthroughs in nanoscale engineering to push the limits of light-based technologies, targeting applications ranging from all-optical computing and quantum communication to metrology and biosensing.

Kelly Powderly

Assistant Professor of Chemistry
PhD, Princeton University

The Powderly Group seeks to develop and utilize new synthetic pathways to discover extended solids with magnetic, electronic, and non-trivial topological properties of interest in quantum information science and to explore new fundamental bonding in materials.

Sheng Ran

Assistant Professor, Physics
PhD, Iowa State University

Professor Ran's research aims to realize and understand exotic states of quantum materials using combined techniques of bulk crystal synthesis, electric and thermal transport measurements under extreme temperature, pressure and magnetic field conditions, and neutron and high-energy X-ray scattering.

Xi Wang

Assistant Professor, Physics
PhD, Florida State University

Xi Wang's lab utilizes cutting-edge magneto optical and optoelectronic microscopy and spectroscopy to probe and control excitons, electrons, phonons, magnons, and so on in quantum materials for applications in quantum simulation and quantum communication.

Chong Zu

Assistant Professor, Physics
PhD, Tsinghua University

Professor Zu's research interests lie at the interface between atomic, molecular, and optical physics; condensed matter physics; and quantum information.

Degree Requirements

To earn a PhD degree, students must complete the requirements of the McKelvey School of Engineering, along with program-specific requirements. Courses include the following:

- Four IMSE Core Courses (12 units)

Code	Title	Units
MEMS 5610	Quantitative Materials Science & Engineering	3
MEMS 5619	Thermodynamics of Materials *	3
<i>Hard Materials Track:</i>		
MEMS 5620	Kinetics of Materials	3
CHEM 5620	Solid-State and Materials Chemistry *	3
	or PHYSICS 5072 Solid State Physics	
<i>Soft Materials Track:</i>		
MEMS 5608	Introduction to Polymer Science and Engineering	3
MEMS 5614	Polymeric Materials Synthesis and Modification	3

* EECE 5020 Advanced Thermodynamics in EECE may be taken instead with permission of the Director of Graduate Studies.

- Three courses (9 units) from a preapproved list of Materials Science & Engineering electives
- IMSE 8991 IMSE First-Year Research Experience (6 units)
- A minimum of three graduate-level technical elective courses (9 units) in mathematics or any science or engineering department, to reach a total of at least 36 academic credit units
 - A maximum of 3 units of IMSE Journal Club will be permitted toward this requirement.
 - Any 4000-level courses not included on the preapproved list of Materials Science & Engineering electives must be approved by the Graduate Studies Committee.
- A maximum of 12 units of 4000-level courses may be applied toward the required 36 academic credit units. Undergraduate-only courses (below the 4000 level) are generally not permitted and may not be used to fulfill this requirement.
- IMSE 8997 IMSE Graduate Seminar every semester of full-time enrollment
- 18 to 36 units of IMSE 8998 Doctoral Research (Students must identify an IMSE faculty member willing and able to support their dissertation research on a materials-related topic.)
- Students must maintain a grade point average of at least 3.0 for all graded courses and have no more than one grade of B– or below in a core course or a Materials Science & Engineering elective.

Additional program requirements include the following:

- Pass the IMSE Qualifying Examination (oral and written components).
- Identify an IMSE graduate program faculty member willing and able to support the student's dissertation research on a materials-related topic.
- Maintain satisfactory research progress on a topic in materials science and engineering, as determined by the dissertation advisor and the mentoring committee.
- Successfully complete research ethics training by the end of the third semester.
- Successfully complete MTE requirements by the end of the third year.
- Successfully complete the dissertation proposal and presentation, with approval from the dissertation examination committee.
- Successfully complete and defend a PhD dissertation, with final approval from the dissertation examination committee.

Failure to meet these requirements will result in dismissal from the program.

Recommended Course Plan

Year 1

Fall Semester

- IMSE 8997 IMSE Graduate Seminar
- IMSE 8991 IMSE First-Year Research Experience
- MEMS 5610 Quantitative Materials Science & Engineering
- MEMS 5619 Thermodynamics of Materials
 - IMSE will allow EECE 5020 Advanced Thermodynamics in EECE in place of MEMS 5619 Thermodynamics of Materials with permission of the Director of Graduate Studies.
- Hard Materials Track: CHEM 5620 Solid-State and Materials Chemistry
 - An elective may be chosen if the student is taking PHYSICS 5072 Solid State Physics in the spring.
- Soft Materials Track: MEMS 5608 Introduction to Polymer Science and Engineering

Spring Semester

- Begin dissertation research
- IMSE 8997 IMSE Graduate Seminar
- IMSE 8991 IMSE First-Year Research Experience
- Hard Materials Track: MEMS 5620 Kinetics of Materials
- Soft Materials Track: MEMS 5614 Polymeric Materials Synthesis and Modification
- Elective

Summer

- Prepare for IMSE Qualifying Examination (typically taken in August):
 - Written document and oral presentation on research rotation
 - Oral examination on fundamentals from core courses

Years 2 and Beyond

- Complete remaining electives (discuss with dissertation advisor)
- IMSE 8997 IMSE Graduate Seminar
- IMSE 8998 Doctoral Research
- Teaching requirements (to be completed by the end of the third year):
 - Attend two McKelvey preparatory engagement workshops.
 - AI two times at 10 MER units for a total of 20 units.
- Regular meetings (at least once per year) with the mentoring committee
- Dissertation proposal and presentation (fifth semester)
- Dissertation and oral defense

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as the *MER*.

Mentored Experience Requirement (MER)

Philosophy of Teaching

Materials scientists and engineers work at the interface between the fundamental physical sciences and application-oriented disciplines. As such, they often need to translate between underlying physical principles governing the performance of a material and the design requirements of a system or device. This translation is inherently two-way; the emergent properties of novel materials enable new, potentially transformative applications, and new devices often require materials with unique (and challenging) property profiles. To facilitate this two-way translation, our PhD graduates must be able to communicate both fundamental and applied concepts to a variety of audiences, including supervisors, subordinates, clients, and co-workers, whose familiarity with the MSE field may range from novice

to expert. Moreover, mentored teaching experiences instill a sense of responsibility, professionalism, and ethical conduct, preparing students to navigate the complex landscape of academia, industry, government, or other research-oriented sectors with confidence and integrity.

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Two preparatory workshops are required:

1. McKelvey Teaching Orientation (Canvas Course)
2. McKelvey Teaching Workshop (Canvas Course)

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member*. An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

Students will AI two times at 10 MER units for a total of 20 units. Students work with their graduate supervisor on the timing and content of those assignments.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MER. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement

EGS 8010	Take two times
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Interdisciplinary Opportunities

Washington University offers courses through interdisciplinary programs that include studies in a variety of disciplines that cross traditional academic boundaries and support academic areas outside of the schools.

- **Interdisciplinary Courses**

Graduate students can speak with their advisors with regard to enrolling in individual courses available outside of their school that may advance their research or professional goals. An internal tuition agreement valid across the university's graduate and professional schools enables interdisciplinary study by allowing enrollment in classes outside of the student's home school. Many undergraduate and graduate courses are available for graduate student enrollment, subject to the following eligibility guidelines:

- The student must be enrolled full-time in a graduate degree program and have the approval of their faculty advisor or administrative officer to take a course outside of their home school.
- Courses will be open to students outside of the discipline only if those students have met the required prerequisites and have the approval of both their department/advisor and the course instructor.
- Finally, courses and students in part-time or "continuing" programs, including WashU Continuing & Professional Studies, are not part of this agreement. Courses that require individualized instruction and/or additional fees (e.g., independent studies, individual music lessons) are also excluded.
- **Teaching Citation — Center for Teaching and Learning**
The Teaching Citation is a professional-development program open to Washington University graduate students. The purpose of the program is to provide formalized pedagogical training to help graduate students prepare for careers that involve teaching. Graduate students who complete the program will participate in a learning community in which they will 1) develop knowledge of effective pedagogy, including evidence-based teaching methods, by completing one Foundations in Teaching and five advanced-level CTL workshops, 2) gain expertise with varied teaching methods by documenting three qualifying teaching experiences, and 3) develop, reflect on, and refine on their teaching approach by writing an engaging teaching philosophy statement. Documenting one's teaching experience includes demonstrating that the required number of teaching hours have been met, attaining faculty or CTL observation and student feedback on one's teaching activities, and writing a self-reflection. The qualifying teaching experiences that can be counted toward the Teaching Citation include, for example, include leading a weekly discussion or recitation subsection, leading regular review- or help-sessions, presenting course lectures, teaching a course independently, and mentoring a student in a research project. Teaching experiences must be approved by CTL staff.

- A limited opportunity for some Washington University students to enroll in courses at Saint Louis University and the University of Missouri–St. Louis is available through the Inter-University Exchange Program (p. 207).
- The Skandalaris Center (p. 208) offers cocurricular programming and practical, hands-on training and funding opportunities to students and faculty in all disciplines and schools.
- The McDonnell International Scholars Academy (p. 210) is an endowed fellowship program that offers generous financial support toward graduate and professional degree studies at Washington University in St. Louis.

Inter-University Exchange Program

The Inter-University Exchange (IE) program between Washington University, Saint Louis University (SLU), and the University of Missouri–St. Louis (UMSL) began in 1976 as an exchange agreement encouraging greater inter-institutional cooperation at the graduate level. Over time, this program has evolved to include undergraduate education. The basic provisions of the original agreement are still in place today, and participation continues to be at the discretion of each academic department or unit.

At Washington University, there are several schools that *do not participate* in this program (i.e., degree-seeking students in these schools are not eligible to participate in the IE program, and courses offered in these schools are not open to SLU and UMSL students attending Washington University through the IE program). They are the School of Law, the School of Medicine, the McKelvey School of Engineering, and the School of Continuing & Professional Studies. The Washington University schools that are open to participation in the IE program may have specific limitations or requirements for participation; details are available in those offices.

The following provisions apply to all coursework taken by Washington University students attending SLU or UMSL through the IE program:

- Such courses can be used for the fulfillment of degree or major requirements. (Students should consult with their dean's office for information about how IE coursework will count toward their grade-point average, units and major requirements.)
- Such courses are not regularly offered at Washington University.
- Registration for such courses requires preliminary approval of the student's major/department advisor, the student's division office or dean, and the academic department of the host university.
- Students at the host institution have first claim on course enrollment (i.e., a desired course at SLU or UMSL may be fully subscribed and unable to accept Washington University students).
- Academic credit earned in such courses will be considered as resident credit, not transfer credit.

- Tuition for such courses will be paid to Washington University at the prevailing Washington University rates; there is no additional tuition cost to the student who enrolls in IE coursework on another campus. However, students are responsible for any and all fees charged by the host school.
- Library privileges attendant on enrolling in a course on a host campus will be made available in the manner prescribed by the host campus.

Instructions

Washington University students must be enrolled full-time to participate in the IE program and have no holds, financial or otherwise, on their academic record at Washington University or at the host institution.

1. The student must complete the IE program application form. Forms are available from the Office of the University Registrar website.
2. The student must provide all information requested in the top portion of the form and indicate the course in which they wish to enroll.
3. The student must obtain the approval signature of the professor teaching the class or the department chair at SLU or UMSL, preferably in person.
4. The student also must obtain the approval signatures of their major advisor at Washington University and the appropriate individual in their dean's office.
5. Completed forms must be submitted to the Office of the University Registrar in the Women's Building a minimum of one week before the start of the term.

Course enrollment is handled administratively by the registrars of the home and host institutions. Washington University students registered for IE coursework will see these courses on their class schedule and academic record with the subject codes SLU and UMSL. Final grades are recorded when received from the host institution. The student does not need to obtain an official transcript from SLU or UMSL to receive academic credit for IE coursework at Washington University.

Contact:	Office of the University Registrar
Phone:	314-935-5959
Email:	registrar@wustl.edu
Website:	http://registrar.wustl.edu/student-records/registration/the-inter-university-exchange-program

Skandalaris Center for Interdisciplinary Innovation and Entrepreneurship

The Skandalaris Center for Interdisciplinary Innovation and Entrepreneurship is the hub of creativity, innovation, and entrepreneurship at Washington University. We believe everyone can be entrepreneurial. Skandalaris provides programming where anyone can explore their creative and entrepreneurial interests, develop an entrepreneurial mindset, and go from ideation to launch.

Mission

The Skandalaris Center fosters and empowers an inclusive community that finds opportunities in problems and transforms ideas into action. We build an ecosystem of education, research, and resources that engages all WashU students, faculty, alumni, and staff as entrepreneurial leaders and collaborators.

Who We Serve

We work with the best and brightest at WashU — the change-makers, thought leaders, and visionaries — to solve the world's problems and meet local needs through innovation and entrepreneurship. As an interdisciplinary center, our initiatives serve students, faculty, staff, and alumni from all levels and disciplines.

Our Initiatives

We develop programs for WashU entrepreneurs, creatives, innovators, and scholars. Our commitment to interdisciplinary innovation and entrepreneurship is motivated by the following beliefs:

- *Everyone can be creative.* We provide hands-on experiences and the creative means to solve problems.
- *Innovation is the backbone of entrepreneurship.* Our opportunities are designed to develop and share new ideas while connecting with other WashU entrepreneurs and innovators.
- *Good ideas are one opportunity away from success.* Our programs are created to help WashU entrepreneurs and innovators access the resources they need to take their ideas to the next level.
- *Knowledge and skills are key to innovation and entrepreneurship.* Our Center offers events and opportunities to help our community of WashU entrepreneurs, creatives, and innovators learn the ins and outs of innovation and entrepreneurship.

Programs and Resources

- **Experts on Call**

This program provides an opportunity for the WashU community to connect with experts in the Skandalaris Center or remotely, free of charge.

- **Honors in Innovation & Entrepreneurship**

Students who have shown exemplary involvement in innovation and entrepreneurship during their time at Washington University are recognized through this program. Honors are earned by accumulating points through a combination of curricular and cocurricular activities.

- **In-Residence Program**

This program provides WashU students, faculty, staff, and alumni with the opportunity to learn from and work with professionals with extensive industry experience.

- **PhD Citation in Entrepreneurship**

This program provides opportunities for PhD students who are interested in developing skills and experiences in the areas of entrepreneurship and innovation.

- **Pivot 314 Fellowship**

The Pivot 314 Fellowship is a year-long program presented by the Office of the Provost and the Skandalaris Center for Interdisciplinary Innovation and Entrepreneurship. Pivot 314 offers graduate students curated programming focused on professional development and on strengthening leadership and communications skills, as well as internship opportunities.

- **Resources**

The Skandalaris Center, Washington University, and external services and resources are available to support innovators and entrepreneurs.

- **Skandalaris Spaces**

Our collaboration space is available for hosting meetings or events. Requests should be made a week in advance.

- **Skandalaris Startup Webinars, Panel Discussions, and Workshops**

These webinars provide an exciting way for alumni to reconnect and share their experiences with entrepreneurship. We also offer free, noncredit workshops designed to encourage creativity, innovation, and entrepreneurship.

- **Startup Venture Promotion**

The Skandalaris Center is happy to help Washington University in St. Louis students, faculty, staff, and alumni with promoting their startup ventures.

- **Student Enterprise Program (StEP)**

StEP provides a unique opportunity for students to own and operate a business on campus that serves the WashU community. Student owners can supplement the valuable business and entrepreneurial skills they learn in the classroom while gaining real-world experience as they manage and lead their own businesses.

- **Student Groups**

There are many organizations that allow students to gain experience and make valuable interdisciplinary connections in the areas of creativity, innovation, and entrepreneurship.

- **Venture Development**

The WashU community is invited to set an appointment with a member of our team for help with ideas and businesses at any stage. We will work with these individuals to brainstorm ideas, strengthen financial models, draft business plans, perfect pitches, and more.

- **Washington University Entrepreneurship Courses**

Courses in entrepreneurship offered across the university are available to students at all levels and in all disciplines.

Competitions

- **IdeaBounce[®]**

IdeaBounce[®] is both an online platform and an event for sharing venture ideas and making connections. This is an opportunity for participants to pitch their ideas (no matter how "fresh"), get feedback on them, and make connections. In-person events happen frequently throughout the fall and spring semesters.

- **Skandalaris Venture Competition (SVC)**

The SVC provides expert mentorship to new ventures and startups to ready them for commercializing their ideas, launching, and pitching to investors. Teams will develop materials focused on explaining the ideas that they are working on to a broad audience.

- **Who Can Apply:** Current Washington University students and alumni (within one year of graduation) with an early-stage venture or idea
- **Award:** Up to \$22,500

- **Global Impact Award (GIA)**

The GIA awards WashU-affiliated ventures with inventions, products, ideas, and business models that will have a broad and lasting impact on society.

- **Who Can Apply:** WashU students, postdocs, residents, and alumni who have graduated within the last 10 years
- **Award:** Up to \$50,000

Learn More

Please contact the Skandalaris Center to sign up for our newsletter and for additional information about all programs.

Phone:	314-935-9134
Email:	sc@wustl.edu
Website:	http://skandalaris.wustl.edu

McDonnell International Scholars Academy

The McDonnell International Scholars Academy graduate fellowship program at WashU is dedicated to fostering a dynamic community of scholars chosen based on their ability to emerge as leaders and experts in their fields. The McDonnell Academy offers curated programming that includes a leadership seminar, cohort trips, and presentation skills development. This multifaceted approach cultivates leaders who embrace a global outlook and help drive positive change in their communities and beyond.

The McDonnell Academy provides both financial and programmatic support to enrich the WashU graduate experience. Meaningful participation and engagement are key components of the program. For more information about program benefits, eligibility, and admissions, please visit the Admissions page of the McDonnell International Scholars Academy website.

Website: <https://mcdonnell.wustl.edu/>

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