Physics

The Department of Physics offers Master of Arts (AM) and Doctor of Philosophy (PhD) programs in Physics. Research in this department covers a wide area of experimental and theoretical physics and benefits from close contacts with nuclear and inorganic chemists in the chemistry department, planetary scientists in the earth and planetary sciences department, applied scientists in the McKelvey School of Engineering and the Institute of Materials Science & Engineering, and biological scientists both on the Danforth Campus and at the School of Medicine. The department is a major participant in the McDonnell Center for the Space Sciences and the Institute of Materials Science & Engineering.

Experimental research areas include the following:

• Astrophysics (observations of cosmic rays, gamma rays, X-rays, dark matter detection, high-precision tests of gravity)
• Space sciences (laboratory analysis of meteorites, stardust, interplanetary dust particles)
• Condensed matter and materials physics (graphene and other two-dimensional atomic crystals, quantum information and atomic physics with condensed matter devices, nanostructured materials, metallic glasses and liquids, magnetism and superconductivity, high-pressure physics, nuclear magnetic resonance)
• Biophysics (computational neurophysics, systems cell biology).

Theoretical research areas include the following:

• Biophysics (nonequilibrium dynamics in biological cells, theory of the microbiome)
• Condensed matter physics (strongly correlated electron systems, topological phases, excited states of many-electron systems, density functional theory and glasses)
• Elementary particle physics (astroparticle physics, dark matter, theoretical cosmology, strong interactions, non-Hermitian Hamiltonians, quark physics beyond the Standard Model)
• Nuclear theory (nuclear matter, correlations in nuclei).

Students are usually admitted to the PhD program rather than the AM program. They spend their first two years taking graduate courses, finding a dissertation adviser, and starting research. During that time, they receive a stipend and complete two semesters of mentored teaching experiences. After achieving the required course grades and passing an oral examination at the end of their second year, students are normally paid from research funds while working on their research and writing a dissertation. The PhD program typically takes between five and six years to complete.

Website: http://physics.wustl.edu/graduate

Faculty

Chair

Mark Alford (https://physics.wustl.edu/people/mark-g-alford/)
Professor
PhD, Harvard University
Nuclear/particle physics

Endowed Professors

Ramanath Cowsik (https://physics.wustl.edu/people/ramanath-cowsik/)
James S. McDonnell Professor of Space Sciences
PhD, University of Bombay
Astrophysics and space sciences

Kenneth F. Kelton (https://physics.wustl.edu/people/kenneth-f-kelton/)
Arthur Holly Compton Professor of Physics
PhD, Harvard University
Condensed matter and materials physics

Henric Krawczynski (https://physics.wustl.edu/people/henric-krawczynski/)
Wayman Crow Professor of Physics
PhD, University of Hamburg
Experimental high-energy astrophysics

Professors

James H. Buckley (https://physics.wustl.edu/people/james-h-buckley/)
PhD, University of Chicago
Experimental high-energy astrophysics

Anders E. Carlsson (https://physics.wustl.edu/people/anders-e-carlsson/)
PhD, Harvard University
Biophysics

Willem H. Dickhoff (https://physics.wustl.edu/people/willem-h-dickhoff/)
PhD, Free University, Amsterdam
Many-body theory

Martin H. Israel (https://physics.wustl.edu/people/martin-h-israel/)
PhD, California Institute of Technology
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PhD, University of California, Los Angeles
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PhD, Brown University
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PhD, Georgia Institute of Technology
Condensed matter and materials science

**Joint Professors**

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PhD, University of Toronto
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(Chemistry)
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PhD, University of California, Berkeley
Quantum information and materials

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PhD, Massachusetts Institute of Technology
Theoretical condensed matter physics

**Assistant Professors**

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Theoretical astro-particle physics & cosmology

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PhD, Universitat Autonoma de Barcelona
High-energy astrophysics, black holes, active galactic nuclei

Erik Henriksen (https://physics.wustl.edu/people/erik-henriksen/)
PhD, Columbia University
Condensed matter and materials science

Shankar Mukherji (https://physics.wustl.edu/people/shankar-mukherji/)
PhD, Massachusetts Institute of Technology/Harvard Medical School
Systems cell biology

James Mertens
PhD, Case Western Reserve University
Theoretical high-energy astrophysics

Johanna Nagy
PhD, Case Western Reserve University
Experimental astrophysics

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PhD, California Institute of Technology
Cosmochemistry, planetary science

Saori Pastore
PhD, Old Dominion University
Theoretical nuclear physics

Maria Piarulli
PhD, Old Dominion University
Theoretical nuclear physics

Sheng Ran
PhD, Iowa State University
Condensed matter, quantum materials

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Microbiome, microbial ecology and evolution

**Lecturer**

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PhD, Washington University

**Research Professors**

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PhD, Kobe University

Alexander Meshik (https://physics.wustl.edu/people/alex-meshik/)
PhD, Vernadsky Institute of Cosmochemistry

Michael Nowak
PhD, Stanford University

**Research Associate Professors**

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Professors Emeriti
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PhD, Harvard University

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PhD, Washington University

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PhD, University of Wisconsin-Madison

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Stuart A. Solin (https://physics.wustl.edu/people/stuart-solin-0/)
Charles M. Hohenberg Professor of Experimental Physics
PhD, Purdue University

Wai-Mo Suen (https://physics.wustl.edu/people/wai-mo-suen-0/)
PhD, California Institute of Technology

Clifford Will (https://physics.wustl.edu/people/clifford-m-will/)
PhD, California Institute of Technology

Degree Requirements
The information below summarizes the physics department's degree requirements. These requirements are in addition to those established by the Graduate School. For more information about requirements for doctoral degrees (http://bulletin.wustl.edu/grad/gsas/phd/academic/) or master's degrees (http://bulletin.wustl.edu/grad/gsas/masters/academic/) in the Graduate School, please visit the appropriate sections of this Bulletin.

Master of Arts in Physics

36-Unit Academic Credit Course Requirement

Courses that count toward academic credit are as follows:

• Any regular 400- or 500-level lecture courses in the physics department, including Physics 597/598 Supervised Teaching of Physics and Physics 582 Research Seminar
• Courses outside of the physics department, if approved by the master's program director
• Reading courses, for which students should register for Physics 589/590 Selected Topics in Physics
• Supervised research, for which students should register for Physics 593/594 Introduction to Methods in Physics (This can be used for a maximum of 6 units of academic credit.)
Students can take up to six 400-level physics classes toward their academic credit requirements without special permission from the graduate studies committee. However, they should discuss the merits of doing so with their adviser.

**Core Course Requirements**

For qualification, students must pass five core 500-level physics courses. In those courses, the student must maintain an average of a B (a grade-point average of 3.0), with no more than one grade lower than B-. A given core course may be taken only once. If more than five courses are taken, the average will be determined from the best five course grades.

**Students must take the following three courses:**

<table>
<thead>
<tr>
<th>Required</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical Electrodynamics I</td>
<td>3</td>
</tr>
<tr>
<td>Quantum Mechanics I</td>
<td>3</td>
</tr>
<tr>
<td>Statistical Mechanics</td>
<td>3</td>
</tr>
</tbody>
</table>

They must also take at least two of the following:

<table>
<thead>
<tr>
<th>Required</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical Physics</td>
<td>3</td>
</tr>
<tr>
<td>Classical Electrodynamics II</td>
<td>3</td>
</tr>
<tr>
<td>Classical Mechanics or Nonlinear Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>Quantum Mechanics II</td>
<td>3</td>
</tr>
</tbody>
</table>

**PhD in Physics**

**Outline of Requirements**

- Complete 36 units of academic credit (detailed below), maintaining an average grade of at least B (3.0 GPA).
- Pass the PhD qualification procedure. This must be done before a student can formally join a research group, and it is normally completed before the start of the third year.
- Complete the teaching requirements.
- Write a thesis (doctoral dissertation).
- Pass an oral dissertation defense examination.

**36-Unit Academic Credit Course Requirement**

Courses that count toward academic credit are as follows:

- Any regular 400- or 500-level lecture courses in the physics department, including Physics 597/598 Supervised Teaching of Physics and Physics 582 Research Seminar
- Courses outside of the physics department, if approved by the student’s adviser and the director of graduate studies
- Reading courses, for which students should register for Physics 589/590 Selected Topics in Physics
- Supervised research, for which students should register for Physics 593/594 Introduction to Methods in Physics (This can be used for a maximum of 6 units of academic credit.)

Students can take up to four 400-level physics classes toward their academic credit without special permission from the graduate studies committee. However, they should discuss the merits of doing so with their adviser.

**PhD Qualification: Course Requirements**

For qualification, students must pass six core 500-level physics courses. In those courses, the student must maintain an average of a B (3.0 GPA), with no more than one grade lower than B-. A given core course may be taken only once. If more than six core courses are taken, the average will be determined from the best six course grades.

**Students must take the following four courses:**

<table>
<thead>
<tr>
<th>Required</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical Physics</td>
<td>3</td>
</tr>
<tr>
<td>Classical Electrodynamics I</td>
<td>3</td>
</tr>
<tr>
<td>Quantum Mechanics I</td>
<td>3</td>
</tr>
<tr>
<td>Statistical Mechanics</td>
<td>3</td>
</tr>
</tbody>
</table>

They must also take at least two of the following:

<table>
<thead>
<tr>
<th>Required</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods of Theoretical Physics II</td>
<td>3</td>
</tr>
<tr>
<td>Classical Electrodynamics II</td>
<td>3</td>
</tr>
<tr>
<td>Classical Mechanics or Nonlinear Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>Quantum Mechanics II</td>
<td>3</td>
</tr>
</tbody>
</table>

These requirements can be modified or waived for students with previous graduate experience (e.g., a master's degree in physics).

**PhD Qualification: Oral Examination Requirement**

To qualify, the student must give a presentation to a committee of three physics faculty members (i.e., the prospective research adviser and two others). The student should demonstrate a basic understanding of a major topic of current research in the selected area of study, which will have been chosen in consultation with the student’s prospective thesis adviser. One week before the oral exam, the student must prepare a written paper (approximately 1500-3000 words) summarizing the content of the presentation and give it to the committee. The student’s responses to questions raised by the examination committee are graded as adequate or not. Students have a chance to answer inadequately answered questions in writing within 48 hours after the examination. The student is not allowed
to receive assistance in preparing the written response from any other individuals. The answers should either be given in person to the chair of the examination committee or emailed to the chair as a PDF file so that it is time stamped. The committee will determine whether the written answers are sufficient.

The committee must be chosen and approved by the department chairman by the end of a student's third semester (typically in December of the second year). The oral examination should be taken by the end of a student's fourth semester (typically in May of the second year). If the student fails the oral examination, they can take it again one additional time.

**Teaching Requirements**

These requirements must be completed before the student submits their doctoral dissertation to the Graduate School:

- **Complete L31 Physics 597:** Graduate students are required to take L31 Physics 597 Supervised Teaching of Physics prior to serving as an assistant in instruction. Students typically take Physics 597 during their first fall semester.

- **Complete at least two semesters of mentored teaching experiences**

- **Complete four hours of oral presentations:** Graduate students must complete a total of four hours of specialized oral presentations. Examples of such presentations include teaching a class (e.g., when substituting for a professor); giving seminars, such as the weekly graduate seminar; or giving oral presentations at conferences, journal clubs, and the like.

**Dissertation Requirements**