DEPARTMENT OF PHYSICS

Chair
- Edward Blucher

Professors
- Edward C. Blucher
- Marcela Carena
- John Eric Carlstrom, Astronomy & Astrophysics
- Henry J. Frisch
- Philippe M. Guyot Sionnest, Chemistry
- Jeffrey A. Harvey
- Eric Isaacs
- Heinrich Martin Jaeger
- Woowon Kang
- Kwang Je Kim
- Young Kee Kim
- David Kutasov
- Kathryn Levin
- Zheng Tian Lu
- Emil J. Martinec
- Gene F. Mazenko
- Frank S. Merritt
- Stephan Meyer, Astronomy & Astrophysics
- Sidney R. Nagel
- Pier Oddone
- Mark J. Oreglia
- James E. Pilcher
- Paolo Privitera
- Thomas F. Rosenbaum
- Jonathan L. Rosner
- Robert Rosner, Astronomy & Astrophysics
- Guy Savard
- Melvyn J. Shochet
- Michael Turner, Astronomy & Astrophysics
- Carlos E.M. Wagner
- Yau Wai Wah
• Robert M. Wald
• Paul B. Wiegmann
• Thomas A. Witten

Associate Professors
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• Florencia Canelli
• Cheng Chin
• Ilya Gruzberg
• Savdeep Sethi
• Scott Wakely
• Wendy Zhang

Assistant Professors
• David Biron
• Margaret Gardel
• Daniel Holz
• Richard Hill
• William Irvine
• LiangTao Wang

Emeritus Faculty
• Isaac D. Abella
• Albert V. Crewe
• James W. Cronin
• Dean Eastman
• Peter G.O. Freund
• Robert P. Geroch
• Roger H. Hildebrand
• Leo P. Kadanoff
• Riccardo Levi Setti
• Dietrich Müller
• Yoichiro Nambu
• Eugene Parker
• John P. Schiffer
• S. Courtney Wright

The Department of Physics offers advanced degree opportunities in many areas of experimental and theoretical physics, supervised by a distinguished group of research faculty. Applications are accepted from students of diverse backgrounds and institutions: graduates of research universities or four year colleges, from the
U.S. and worldwide. Most applicants, but not all, have undergraduate degrees in physics; many have had significant research experience. Seeking to identify the most qualified students who show promise of excellence in research and teaching, the admissions process is highly selective and very competitive.

**DOCTOR OF PHILOSOPHY**

During the first year of the doctoral program, a student takes introductory graduate physics courses and usually serves as a teaching assistant assigned to one of the introductory or intermediate undergraduate physics courses. Students are encouraged to explore research opportunities during their first year. Students are also encouraged to take the candidacy examination as soon as they feel that they are prepared for it. After passing the candidacy exam and identifying a research sponsor, the student begins dissertation research while completing course requirements. Within a year after research begins, a Ph.D. committee is formed with the sponsor as chairman. A student continues research, from time to time consulting with the members of the committee, until completion of the dissertation. The average length of time for completion of the Ph.D. program in physics is about six years. In addition to fulfilling University and divisional requirements, a candidate for the degree of Doctor of Philosophy in physics must:

1. Pass the candidacy examination. This examination on basic physics covers fundamental material usually studied in upper division undergraduate courses (mechanics, electricity and magnetism, special relativity, statistical mechanics, and quantum mechanics) and requires some knowledge of particles and fields and of the structure of matter. The candidacy examination is given every September and March and must be passed by the autumn quarter of the student’s third year after matriculation.

2. Fulfill the experimental physics requirement by completing PHYS 33400 Adv Experimental Physics or PHYS 33500 Adv Experimental Physics Project.

3. Pass four post candidacy advanced graduate courses devoted to the broad physics research areas of (A) Condensed Matter Physics, (B) Particle Physics, (C) Large Scale Physics (i.e. Astrophysics and/or Cosmology related), and (D) Intermediate Electives. The four courses selected must include at least one from each of the categories (A), (B), and (C).

4. Pass two other advanced (40000 level) courses either in physics or in a field related to the student's Ph.D. research. The latter requires department approval.

5. Within the first year after beginning research, convene a first meeting of the Ph.D. committee to review plans for the proposed thesis research and for fulfilling the remaining Ph.D. requirements.

6. One to two quarters prior to the defense of the dissertation, hold a pre-oral meeting at which the student and the Ph.D. committee discuss the research project.

7. Defend the dissertation before the Ph.D. committee.
8. Submit for publication to a refereed scientific journal the thesis which has been approved by the Ph.D. committee or a paper based on the thesis. A letter from the editor acknowledging receipt of the thesis must be provided to the department office.

Consult a department adviser for more details.

**MASTER OF SCIENCE**

The graduate program of the Department of Physics is oriented toward students who intend to earn a Ph.D. degree in physics. Therefore, the department does not offer admission to students whose goal is the Master of Science degree. However, the department does offer a master’s degree to students who are already in the physics Ph.D. program or other approved graduate programs in the University. Normally it takes one and a half years for a student to complete the master’s program. A master’s degree is not required for continued study toward the doctorate.

In addition to fulfilling University and Divisional requirements, a candidate for the degree of Master of Science in physics must:

1. Demonstrate a satisfactory level of understanding of the fundamental principles of physics by either (a) passing the Ph.D. candidacy examination at the master’s level or higher or (b) passing nine approved courses with a minimum grade point average of 2.5. Six of the nine courses must be:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 31600</td>
<td>Advanced Classical Mechanics</td>
<td>100</td>
</tr>
<tr>
<td>PHYS 33000</td>
<td>Mathematical Methods of Physics</td>
<td>100</td>
</tr>
<tr>
<td>PHYS 34100</td>
<td>Advanced Quantum Mechanics I</td>
<td>100</td>
</tr>
<tr>
<td>PHYS 34200</td>
<td>Advanced Quantum Mechanics II</td>
<td>100</td>
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<tr>
<td>PHYS 32200</td>
<td>Advanced Electrodynamics I</td>
<td>100</td>
</tr>
<tr>
<td>PHYS 35200</td>
<td>Statistical Mechanics</td>
<td>100</td>
</tr>
</tbody>
</table>

2. Complete the Experimental Physics requirement (PHYS 33400 Adv Experimental Physics or PHYS 33500 Adv Experimental Physics Project).

**TEACHING OPPORTUNITIES**

Part of the training of graduate students is dedicated to obtaining experience and facility in teaching. Most first year students are supported by teaching assistantships, which provide the opportunity for them to engage in a variety of teaching related activities. These may include supervising undergraduate laboratory sections, conducting discussion and problem sessions, holding office hours, and grading written work for specific courses. Fellowship holders are invited to participate in these activities at reduced levels of commitment to gain experience in the teaching of physics. During the Autumn quarter first year graduate students attend the weekly workshop, Teaching and Learning of Physics, which is an important element in their training as teachers of physics.
**Teaching Facilities**

All formal class work takes place in the modern lecture halls and classrooms and instructional laboratories of the Kersten Physics Teaching Center. This building also houses special equipment and support facilities for student experimental projects, departmental administrative offices, and meeting rooms. The center is situated on the science quadrangle near the John Crerar Science Library, which holds over 1,000,000 volumes and provides modern literature search and data retrieval systems.

**Research Facilities**

Most of the experimental and theoretical research of Physics faculty and graduate students is carried out within the Enrico Fermi Institute, the James Franck Institute and the Institute for Biophysical Dynamics. These research institutes provide close interdisciplinary contact, crossing the traditional boundaries between departments. This broad scientific endeavor is reflected in students’ activities and contributes to their outlook toward research.

In the Enrico Fermi Institute, members of the Department of Physics carry out theoretical research in particle theory, string theory, field theory, general relativity, and theoretical astrophysics and cosmology. There are active experimental groups in high energy physics, nuclear physics, astrophysics and space physics, infrared and optical astronomy, and microwave background observations. Some of this research is conducted at the Fermi National Accelerator Laboratory, at Argonne National Laboratory (both of these are near Chicago), and at the European Organization for Nuclear Research (CERN) in Geneva, Switzerland.

Physics faculty in the James Franck Institute study chemical, solid state, condensed matter, and statistical physics. Fields of interest include chaos, chemical kinetics, critical phenomena, high Tc superconductivity, nonlinear dynamics, low temperature, disordered and amorphous systems, the dynamics of glasses, fluid dynamics, surface and interface phenomena, nonlinear and nanoscale optics, unstable and metastable systems, laser cooling and trapping, atomic physics, and polymer physics. Much of the research utilizes specialized facilities operated by the institute, including a low temperature laboratory, a materials preparation laboratory, x-ray diffraction and analytical chemistry laboratories, laser equipment, a scanning tunneling microscope, and extensive shop facilities. Some members of the faculty are involved in research at Argonne National Laboratory.

The Institute for Biophysical Dynamics includes members of both the Physical Sciences and Biological Sciences Divisions, and focuses on the physical basis for molecular and cellular processes. This interface between the physical and biological sciences is an exciting area that is developing rapidly, with a bi-directional impact. Research topics include the creation of physical materials by biological self assembly, the molecular basis of macromolecular interactions and cellular signaling, the derivation of sequence structure function relationships by computational means, and structure function relationships in membranes.
In the areas of chemical and atomic physics, research toward the doctorate may be done in either the physics or the chemistry department. Facilities are available for research in crystal chemistry; molecular physics; molecular spectra from infrared to far ultraviolet, Bose Einstein condensation, and Raman spectra, both experimental and theoretical; surface physics; statistical mechanics; radio chemistry; and quantum electronics.

Interdisciplinary research leading to a Ph.D. degree in physics may be carried out under the guidance of faculty committees including members of other departments in the Division of the Physical Sciences, such as Astronomy & Astrophysics, Chemistry, Computer Science, Geophysical Sciences or Mathematics, or related departments in the Division of the Biological Sciences.

**ADMISSION AND STUDENT AID**

Most students entering the graduate program of the Department of Physics of the University of Chicago hold a bachelor’s or master’s degree in physics from an accredited college or university.

December 28 is the deadline for applications for admission in the following autumn quarter. The Graduate Record Examination given by the Educational Testing Service is required of all applicants. Applicants should submit recent scores on the verbal, quantitative, and analytic writing tests and on the advanced subject test in physics. Arrangements should be made to take the examination no later than early December in order that the results be available in time for the department’s consideration. Applicants from non English speaking countries must provide the scores achieved on the TOEFL or the IELTS.

All full time physics graduate students in good standing receive financial aid. Most graduate students serve as teaching assistants in their first year.

For information regarding application for admission, e-mail physics@uchicago.edu or write to: Graduate Affairs, Department of Physics, University of Chicago, 5720 South Ellis Avenue, Chicago, IL 60637-1434. A departmental counselor will be glad to answer questions. Use URL http://physics.uchicago.edu/ to access the department’s World Wide Web home page for further information.

**PHYSICS COURSES**

**PHYS 31600. Advanced Classical Mechanics. 100 Units.** Edit Course Data - default This course begins with variational formulation of classical mechanics of point particles, including discussion of the principle of least action, Poisson brackets, and Hamilton-Jacobi theory. These concepts are generalized to continuous systems with infinite number of degrees of freedom, including a discussion of the transition to quantum mechanics. 

Terms Offered: Autumn 
Prerequisite(s): PHYS 18500
**PHYS 32200-32300. Advanced Electrodynamics I-II.** Edit Course Data - default
This two-quarter sequence covers electromagnetic properties of continuous media, gauge transformations, electromagnetic waves, radiation, relativistic electrodynamics, Lorentz theory of electrons, and theoretical optics. There is considerable emphasis on the mathematical methods behind the development of the physics of these problems.

**PHYS 32200. Advanced Electrodynamics I. 100 Units.** Edit Course Data - default
Terms Offered: Winter
Prerequisite(s): PHYS 22700 and 23500

**PHYS 32300. Advanced Electrodynamics II. 100 Units.** Edit Course Data - default
Terms Offered: Spring
Prerequisite(s): PHYS 32200

**PHYS 33000. Mathematical Methods of Physics. 100 Units.** Edit Course Data - default
Topics include complex analysis, linear algebra, differential equations, boundary value problems, and special functions.
Terms Offered: Autumn
Prerequisite(s): PHYS 22700

**PHYS 33400. Adv Experimental Physics. 100 Units.** Edit Course Data - default
For course description contact Physics.

**PHYS 34100-34200. Advanced Quantum Mechanics I-II.** Edit Course Data - default
This two-quarter sequence covers wave functions and their physical content, one-dimensional systems, WKB method, operators and matrix mechanics, angular momentum and spin, two- and three-dimensional systems, the Pauli principle, perturbation theory, Born approximation, and scattering theory.

**PHYS 34100. Advanced Quantum Mechanics I. 100 Units.** Edit Course Data - default
Terms Offered: Autumn
Prerequisite(s): PHYS 23500, and PHYS 22100 or MATH 20500

**PHYS 34200. Advanced Quantum Mechanics II. 100 Units.** Edit Course Data - default
Terms Offered: Winter
Prerequisite(s): PHYS 34100
PHYS 35200. Statistical Mechanics. 100 Units. Edit Course Data - default
This course covers principles of statistical mechanics and thermodynamics, as well as their applications to problems in physics and chemistry.
Terms Offered: Winter
Prerequisite(s): PHYS 19700 and 23500