

**PHYSICS**

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**COLLEGE OF SCIENCE**

**Ali, Naushad**, Professor, Ph.D., University of Alberta, Canada, 1984; 1986.

**Aouadi, Samir**, Assistant Professor, Ph.D., University of British Columbia, 1994; 2002.

**Byrd, Mark**, Assistant Professor, Ph.D., University of Texas at Austin, 1999; 2003.

**Calbi, Maria de las Mercedes**, Assistant Professor, Ph.D., University of Buenos Aires, Argentina, 1999; 2003.

**Cutnell, John D.**, Professor, *Emeritus*, Ph.D., University of Wisconsin, 1967; 1968.

**Gaitan, Frank**, Associate Professor, Ph.D., University of Illinois at Urbana-Champaign, 1992; 1999.

**Gruber, Bruno J.**, Professor, *Emeritus*, Ph.D., University of Vienna, Austria, 1961; 1972.

**Henneberger, Walter C.**, Professor, *Emeritus*, Ph.D., Gottingen University, Germany, 1959; 1963.

**Johnson, Kenneth W.**, Professor, *Emeritus*, Ph.D., Ohio State University, 1967; 1970.

**Kolmakov, Andrei A.**, Assistant Professor, Ph.D., Kurchatov Institute, Moscow, Russia, 1996; 2005.

**Malhotra, Vivak**, Professor, Ph.D., Kanpur University, India, 1978; 1984.

**Malik, F. Bary**, Professor, *Emeritus*, Ph.D., Gottingen University, 1958; 1980.

**Masden, J. Thomas**, Associate Professor, Ph.D., Purdue University, 1983; 1984.

**Migone, Aldo D.**, Professor and *Chair*, Ph.D., Pennsylvania State University, 1984; 1986.

**Sanders, Frank C., Jr.**, Associate Professor, *Emeritus*, Ph.D., University of Texas, 1968; 1969.

**Saporoschenko, Mykola**, Professor, *Emeritus*, Ph.D., Washington University, 1958; 1965.

**Silbert, Leonardo**, Assistant Professor, Ph.D., University of Cambridge, 1998; 2006.

**Stadler, Shane**, Assistant Professor, Ph.D., Tulane University, 1998; 2001.

**Tsige, Mesfin**, Assistant Professor, Ph.D., Case Western Reserve University, 2001; 2005.

**Talapatra, Saikat**, Assistant Professor, Ph.D., Southern Illinois University, Carbondale, 2002; 2007.

**Watson, Richard E.**, Professor, *Emeritus*, Ph.D., University of Illinois, 1938; 1958

The Department of Physics offers graduate programs leading to the Master of Science degree with a major in physics and to the Doctor of Philosophy degree in Applied Physics.

This program requires a \$50.00 application fee that must be submitted with the application for Admissions to Graduate Study in Physics. Applicants may pay this fee by credit card if applying electronically. Applicants submitting a paper application must pay by personal check, cashier's check, or money order made out to SIU, and payable to a U.S. Bank.

**Master of Science**

In order to be considered for admission into the Master of Science program, students must have a baccalaureate degree in Physics, or equivalent. Applicants for admission to the Master's degree program are strongly encouraged to submit GRE scores together with other application materials.

In addition to the general requirements of the Graduate School for the Master of Science degree, the student must complete PHYS 500a (or mathematics equivalent), 510, 520a, b, and 530a, b.

Other specific requirements for the Master's degree are as follows:

A thesis is required, based upon not more than six nor less than three semester hours of 599- level credit. The 599 credit requirement is in addition to the minimum of 15-hour requirement at the 500 level as stated in this catalog and should be distributed preferably over several terms of enrollment.

Each candidate for an M. S. degree is required to pass an examination, written or oral or both, covering graduate work including the thesis; the examination is administered by the student's thesis committee.

Each candidate for an M.S. degree is required to earn one credit in PHYS 581 by lecturing in the graduate seminar. An oral thesis defense satisfies this requirement.

**Doctor of Philosophy in Applied Physics**

Program Description and Objectives:

The Department of Physics offers a graduate program at the doctoral level leading to the Ph.D. degree in Applied Physics. The Applied Physics doctoral program is designed to provide advanced studies both in the application of the concepts and methods of physics to various research areas, including: materials, nanoscience and nanotechnology, quantum computing, computational physics, condensed matter physics, magnetism, thin films, and in the application of the methods and techniques of physics to the study of industrial processes and products. The Applied Physics Ph.D. provides students with broad, in-depth knowledge of the fundamentals of those areas of physics relevant to applications, as well as with advanced specialized knowledge in applied areas. The ultimate goal of this program is to produce graduates that are competent scientific researchers in Applied Physics, i.e., researchers that are capable of initiating and completing an independent investigation in a specific

sub-field of Applied Physics. The graduates of this program will be able to fill the needs of academia, industry and government in the area of Applied Physics.

### Admissions

Applicants will be admitted into the Applied Physics Ph.D. following one of three routes:

1. Direct admission: this option requires the applicant to have completed a Bachelor's degree in Physics (or its equivalent) with a grade point average of at least 3.25 (in exceptional cases the Department may solicit the Graduate School to waive this requirement).
2. Accelerated admission: students are admitted into the Masters' degree program and after one semester they can be considered for admission into the doctoral program if they show exceptional research potential and have accumulated a GPA of 3.25.
3. Regular admission: for students who have completed a Master's degree in Physics or equivalent and have accumulated a GPA of 3.25 in graduate level courses (in exceptional cases the Department may solicit the Graduate School to waive this requirement). The students obtaining their Masters' degree at SIUC will have satisfied most of the core course requirements for the Applied Physics Ph.D.

All applicants for admission to the doctoral program in Applied Physics must submit Graduate Record Examination scores together with other required application materials.

### Course Requirements

In addition to the general requirements of the Graduate School, the student must complete a sequence of Required Basic Core Courses that includes:

- Physics 510 (Classical Mechanics);
- Physics 520 A (Electromagnetic Theory);
- Physics 530 A (Quantum Mechanics);
- Physics 545 A (Statistical Mechanics);
- Physics 565 (Solid State Physics);

In addition, students are required to complete *one* additional course from those in the following list:

- Physics 550 (Computational Physics);
- Science 501 (Scanning Electron Microscopy);
- Science 502 (Transmission Electron Microscopy);
- Physics 575 (Special Topics in Physics: Magnetism and Magnetic Materials);
- Physics 575 (Special Topics in Physics);
- Physics 575 (Special Topics in Physics: Spectroscopy of Materials);
- Physics 575 (Special Topics in Physics: Surface Science);
- Physics 575 (Special Topics in Physics: Quantum Computing);
- Physics 575 (Special Topics in Physics: Hybrid Materials);
- Physics 575 (Special Topics in Physics: Advanced Optics).

After completing the Required Basic Core courses, doctoral students in the Applied Physics Ph.D. will be required to complete another 9-credit hours of 500-level elective courses that are to be selected from a list of electives approved by the Department. The following courses are not allowed to count as electives: Physics 599 (Thesis), 600 (Dissertation), and 601 (Continuing Enrollment).

Starting no later than the beginning of the third semester in the program, students will be required to enroll for two consecutive semesters in Physics 570, a 3-credit hour per semester Special Project course.

In addition to the above-described course-work, while working on their dissertation, the students must complete 24 credit hours of Physics 600 (Dissertation) in no less than two academic years of full-time work.

#### *Admission to Candidacy:*

- i. To be admitted to candidacy, the prospective doctoral candidate must have completed the basic core curriculum in Applied Physics with a grade point average of at least 3.25 (out of 4).
- ii. To be admitted to candidacy, the prospective doctoral candidate must pass a Qualifying Examination. Students are expected to take the Qualifying Examination by the end of their third semester in the program. The Qualifying Examination includes written examinations in Quantum Mechanics, Classical Mechanics, Statistical Mechanics, and Electromagnetic Theory. Upon successful completion of these exams, the Department will request the Graduate School to admit the student to candidacy for the doctoral degree.

The Qualifying Examination is prepared by an examination committee appointed by the Chair. The examination committee prepares and administers the Qualifying Examination for all doctoral students on a regular schedule. If the candidate is unsuccessful in the Qualifying Examination, the committee, following the criteria listed below, will decide whether to allow the candidate to repeat the entire examination or any part of it. In arriving at their decision, committee members will take into consideration the overall performance of the student in the courses he/she has taken up to the time of the Qualifying Examination, the performance in the

Qualifying Examination itself (i.e., how poor was the student's performance), and they will get input from the student's research advisor (if he/she has one at the time of the exam) to evaluate what is the likelihood that the student will successfully complete doctoral work. If a student gets a score below 40% in the Qualifying Examination, and has below average results, in the committee's estimation, in the other two indicators (courses and research activity), that student will not be allowed to repeat the Qualifying Examination.

In any case, the Qualifying Examination, in whole or in part, may not be taken more than two times. The one exception to the above rule is that students who so desire can have a "free try" at the Qualifying Examination by taking it at the beginning of their first semester in the program, without this instance counting as one of the two allowed opportunities to take the exam. Should they pass, such students could not be admitted to candidacy until the Graduate School's twenty-four (24) hour residency requirement is met.

*Dissertation Committee and Dissertation Examination.* No later than six months after admission to candidacy, the student will request the appointment of a dissertation committee to supervise the student's dissertation. This committee will include five faculty members, with at least one from outside the Department of Physics, at least one doing research in theoretical physics, and at least one doing research in experimental physics. The majority of the committee shall consist of faculty members from the Department of Physics. The committee will be chaired, in most cases, by the student's dissertation supervisor. The committee will meet within two months after its formation to determine if any specific course-work, beyond the core curriculum, is to be required of the student, and to determine if any special requirements might be appropriate for the student's particular research area. At this time (i.e., no later than eight months after admission to candidacy), the committee will be given a formal, written dissertation proposal and an oral presentation on the proposed research by the student.

*Dissertation Defense.* Upon completion of a dissertation demonstrating the student's ability to conduct independent research, the dissertation committee will administer a final oral examination. This oral examination shall consist of a defense of the dissertation. Upon the satisfactory completion of both the dissertation and the final examination, the committee will recommend the student for the doctoral degree.

### Courses (PHYS)

**410-3 Mechanics II.** Gravitation, continuous media, transformation properties, Lagrangian and Hamiltonian formalisms. Prerequisite: 310 with grade of C or better.

**420-3 Electricity and Magnetism II.** Induced electromotive force, quasisteady currents and fields, Maxwell's equations, electromagnetic waves and radiation, with applications. Prerequisite: 320 with grade of C or better.

**424-4 Electronics for Scientists.** Coordinated two-hour lecture and four-hour laboratory study of electronics. Emphasis is on overall modern electronics and its applications in the experimental research laboratory setting. Topics include DC and AC circuit theory, measurement techniques, semiconductor active devices, operational amplifiers and feedback, digital circuits, Boolean algebra, microprocessors and large scale integration, digital to analog and analog to digital conversion, and data acquisition. Prerequisite: 203b or 205b and Mathematics 111 with grade of C or better.

**425-3 Solid State Physics I.** Structure of a crystalline solid; lattice vibrations and thermal properties; electrons in metals; band theory; electrons and holes in semiconductors; opto-electronic phenomena in solids; dielectric and magnetic properties; superconductivity. Prerequisite: 310, 320, 345 and 430 with grade of C or better.

**428-3 Modern Optics and Lasers.** Properties of electromagnetic waves in space and media, polarization and interference phenomena and devices, electro- and magneto-optic effects, optical gain and lasers. Prerequisite: 420 with grade of C or better.

**430-3 Quantum Mechanics I.** An introduction to quantum mechanics including its experimental basis and application in atomic physics. Prerequisite: 205c, 310 and 320 with grade of C or better. Prior or concurrent enrollment in 410 and 420 is desirable.

**431-3 Atomic and Molecular Physics I.** Atomic spectra and structure; molecular spectra and structure. Prerequisite: 430 with grade of C or better.

**432-3 Nuclear Physics I.** Basic nuclear properties and structure; radioactivity, nuclear excitation, and reactions, nuclear forces; fission and fusion. Prerequisite: 430 with grade of C or better.

**445-3 Thermodynamics and Statistical Mechanics.** Laws of thermodynamics; principles and applications of classical and quantum statistical mechanics; introduction to kinetic theory of matter. Prerequisites: Physics 205c and 301 both with a grade of C or better; Math 251 with grade of C or better.

**450-1 Modern Physics Laboratory.** Introduces students to experimental research and encourages them to develop and carry out experiments. Prerequisite: 205c with grade of C or better.

**458-2 Laser and Optical Physics Laboratory.** Properties of laser beams and resonators, fluorescence and two photon spectroscopy, diffraction, Fourier transformation and frequency filtering, electro- and magneto-optic modulation, fiber propagation and related experiments. Prerequisite: 428 with a grade of C or better.

**470-1 to 3 Special Projects.** Each student chooses or is assigned a definite investigative project or topic. Prerequisite: 310, 320 or consent of instructor.

**500-6 (3,3) Mathematical Methods in Physics.** Vector spaces and operators in physics. Hilbert spaces and complete orthonormal sets of functions. Elements and applications of the theory of analytic functions. Methods

for the solution of partial differential equations of physics. Prerequisite: Mathematics 407 or equivalent, consent of instructor.

**510-4 Classical Mechanics.** Generalized coordinates and forces. Lagrangian, Hamiltonian, and variational formulations of mechanics. Central forces, oscillations; normal modes of molecular systems. Prerequisite: 410.

**520-6 (3,3) Electromagnetic Theory.** Determination of static, electrostatic, and magnetostatic fields. Microscopic and macroscopic theory of insulators and conductors. Maxwell's equations; radiation, propagation and scattering of electromagnetic waves. Electrodynamics and special theory of relativity. Selected topics. Prerequisite: 420.

**530-6 (3,3) Quantum Mechanics II.** Basic principles; the harmonic oscillator and the hydrogen atom; scattering; approximation and perturbation methods; spin, statistics. Prerequisite: Mathematics 406 or consent of instructor; 500 desirable.

**531-6 (3,3) Advanced Quantum Mechanics.** Quantum theory of radiation; applications of field theory to elementary particles; covariant quantum electrodynamics; renormalization; special topics. Content varies somewhat with instructor. Prerequisite: 530 and consent.

**535-6 (3,3) Atomic and Molecular Physics II.** Recent experimental methods in atomic and molecular spectroscopy with applications. Detailed quantum mechanical and group theoretical treatment of atomic and molecular systems. Reactions between atomic systems. Prerequisite: consent of instructor.

**545-6 (3,3) Statistical Mechanics II.** Principles of classical and quantum equilibrium statistics; fluctuation phenomena; special topics in equilibrium and non-equilibrium phenomena. Prerequisite: 445.

**550-3 Computational Physics.** Using modern computers to solve physics problems. Integration of ordinary and partial differential equations, interpolation and extrapolation, finite element analysis, linear and nonlinear equations, eigensystems, optimization, root finding, Monte Carlo simulations, etc. Prerequisite: Mathematics 305, computer language FORTRAN or C, or consent of instructor.

**560-6 (3,3) Nuclear Physics II.** Fundamental properties and systematics of nuclei, scattering theory, nuclear two-body problem, nuclear models, nuclear many-body problem, electromagnetic properties of nuclei, radioactivity, nuclear reactions. Prerequisite: 530 and consent of instructor.

**565-6 (3,3) Solid State Physics II.** Fundamental concepts in solid state physics. Lattice vibrations, band theory of solids, the Fermi surface, dynamics of electrons. Transport, cohesive, optical, magnetic and other properties of solids. Prerequisite: consent of instructor.

**570-1 to 36 Special Projects in Physics.** Each student works on a definite investigative topic under the supervision of a faculty sponsor. The projects are taken from the current research in the department. Resourcefulness and initiative are required. Graded *S/U* only. Prerequisite: consent of instructor.

**571-6 (3,3) X-Ray Diffraction and Electron Microscopy.** (See Mechanical Engineering 504.)

**575-1 to 12 (1 to 4 per topic for a maximum of three topics) Special Topics in Physics.** The courses reflect special research interests of the faculty and current developments in physics. They are offered as the need arises and interest and time permit. Students are required to give presentations. Prerequisite: consent of instructor.

**581-1 to 3 (1,1,1) Graduate Seminar.** Lectures on special topics by students, faculty, or invited scholars; participation is required of all graduate students. For credit each student may present a seminar in the form of a lecture on a theoretical or experimental topic, a demonstration experiment or apparatus critique. Prerequisite: lecturing experience or concurrent teaching. Graded *S/U* only.

**598-1 to 50 (1 to 12 per semester) Research.** Maximum credit 50 hours. Graded *S/U* only. Prerequisite: consent of instructor.

**599-1 to 6 Thesis.**

**600-1 to 30 Dissertation.** Minimum 24 credit hours required for Ph.D degree. Prerequisite: consent of instructor.

**601-1 per semester Continuing Enrollment.** For those graduate students who have not finished their degree programs and who are in the process of working on their dissertation, thesis, or research paper. The student must have completed a minimum of 24 hours of dissertation research, or the minimum thesis, or research hours before being eligible to register for this course. Concurrent enrollment in any other course is not permitted. Graded *S/U* or *DEF* only.

**699-1 Postdoctoral Research.** One credit hour per semester. Concurrent enrollment in any other course is not permitted. Prerequisite: must be a Postdoctoral Fellow.