Physics

Associate Dean and Physics Program Director, Professor of Mathematics: Fisher
Professors: Dale, Forest, Shropshire
Research Professor: Spielman
Associate Professors: McNulty, Tatar
Assistant Professor: Stonaha
Lecturers: Bernabee, Hoskins
Adjunct Faculty: Fontenot-Durfee, Franckowiak, Millward
Affiliate Faculty: Khandaker, Wells
Professors Emeritus: Cole, Harmon, Parker

General Objectives of Graduate Programs

The objectives of our graduate degrees, which are the Doctor of Philosophy in Applied Physics and Master of Science in Physics, are to develop a core competence in the fundamental physical science that is appropriate for the level of the degree, to develop more generalized skills of quantitative reasoning that are applicable to any discipline, and to understand the nature and influence of physics in particular, and science in general, upon our society. Additional objectives for these students include the development of (1) broad, fundamental technical skills and knowledge, (2) strong communication skills, and (3) the capability to think critically and work independently. The expectations for each of these objectives have a “level” that is appropriate for the degree.

The learning objectives of the master's degree in physics are mastery of the “core” subjects of electromagnetism, non-relativistic quantum mechanics, and theoretical methods of classical physics (principally mechanics).

The communication objectives for these degrees are writing and speaking skills that are sufficient for students to represent themselves, their projects, and their organizations at regional, national, or international scientific meetings. Our expectations are that these students will obtain critical thinking skills and an ability to work independently at a level that will require minimal or no supervision by a more senior scientist or management.

The educational objectives of the doctoral degree in applied physics include all of those of the master's degree program, plus mastery of additional graduate-level classes of the student’s choosing, plus completion of an original doctoral research thesis project with the objective of mastery of planning, executing, and publishing original research in physics at the highest level of the discipline. The communication objectives at this level are writing and speaking skills that are sufficient to teach in higher education, attract interest and funding to their projects, and to represent themselves, their projects and their organizations at regional, national, or international scientific meetings. Our expectations are that these students will develop critical thinking skills and an ability to work independently such that they are capable of initiating and leading their own scientific projects, and can work at a level that requires no supervision.

Doctor of Philosophy in Applied Physics

Program Goals

- Prepare graduates to conduct and disseminate independent scholarly research in applied physics.
- Prepare graduates for careers in academia, industry, or government.

Program Objectives

- Increase the knowledge of graduates in their chosen field of applied physics.
- Enhance the ability of graduates to contribute to their chosen field of applied physics.
- Enhance effective written and oral communication skills of graduates.

The Ph.D. program in Applied Physics is an interdisciplinary program offered by that allows for a broad range of research topics. Areas of emphasis in the department include: nuclear physics applications, radiation effects in materials, accelerator physics and applications, materials science, homeland security applications, and other areas of applied nuclear science.

To attain a degree in this program, a student must demonstrate scholarly achievement and ability for independent investigation. The program will normally require approximately five years of full-time study beyond the bachelor’s degree (or three years beyond the master’s degree), including class work, research, and preparation of the dissertation.

Admission Requirements

All applicants must meet Idaho State University Graduate School admission requirements for doctoral programs. In addition, applicants must have attained a minimum of a bachelor’s degree in physics or a closely related field (engineering, applied physics, chemistry, etc.). The student’s course of study will be determined by consultation with the department chair or the department’s graduate advising committee. Students may be required to complete any missing course material that is required for the B.S. degree in physics at Idaho State University. Continued enrollment in the program is contingent upon maintaining a 3.0 grade point average and upon making satisfactory progress toward the degree.

A complete graduate application for classified status in the Idaho State University Physics Department Ph.D. program consists of:

1. GRE scores (normally, a minimum of 50th percentile on verbal, quantitative, or analytical is required for classified students);
2. An Idaho State University Graduate School application form, fee, and official copies of transcripts;
3. Three letters of recommendation;
4. A resume or CV; and
5. A statement of career goals.

General Requirements

The Ph.D. degree requires completion of at least 84 credits at the 500-course or greater. Of these, at least 32 credits, but no more than 44 credits, must be doctoral dissertation credits (PHYS 8850 Doctoral Dissertation). At least 4 must be graduate seminar (or equivalent, as determined by the department). The remaining required credits consist of electives and the required courses listed below. Students entering the program with a master’s degree may receive credit for up to 30 credits toward the Ph.D., subject to the department chair’s approval. Students should complete the required courses as listed below (or their equivalent, as determined by the department) at Idaho State University.

Program of Study

A departmental advisory committee consisting of graduate faculty will guide each student in establishing his or her program of course and laboratory study based upon the student’s background and research interest. The advisory committee has

the responsibility of ensuring that the student has adequate knowledge to support research in his or her area of research.

At the beginning of a full-time student's second year, the student will sit for a written Qualifying Examination. Exceptions to this schedule may be made when a student has academic deficits to make up, in which case the student will have an additional year. The student may take the exam as often as it is offered, but the student must pass the exam by the end of their second year of enrollment. The student will be admitted to candidacy upon passing the qualifying examination.

A dissertation committee of four departmental members and a Graduate Faculty Representative (GFR), chaired by the candidate's major professor, must be appointed within six months of passing the qualifying examination. Within one year of passing the qualifying exam, the full-time candidate, with guidance from the major professor, must satisfactorily complete the Preliminary Examination, which consists of an oral presentation and defense of a written proposal for dissertation research to the student's dissertation committee.

The research and dissertation preparation must be done under the close supervision of the committee and must include at least one full year of work performed under the supervision of a Idaho State University graduate faculty.

Dissertation Examination approval requires a public presentation of the dissertation and a satisfactory oral defense to the dissertation committee. Doctoral oral examinations are open to all regular members of the graduate faculty as observers. Further, oral presentations are open to the public until questioning by the dissertation committee begins.

Doctor of Philosophy in Engineering and Applied Science

A doctoral program in Engineering and Applied Science, administered through the College of Science and Engineering, is available to Physics students. The complete program description is provided in the Engineering and Applied Science (http://coursecat.isu.edu/graduate/scienceengineering/engineeringandappliedscience/) section of the Graduate Catalog.

Master of Science Programs

Admission Requirements

The student must apply to and meet all criteria for admission to the Graduate School. In addition to the general requirements of the Graduate School, the student must comply with departmental requirements.

A complete graduate application for classified status in the Idaho State University Physics Department consists of:

1. GRE aptitude scores;
2. An Idaho State University Graduate School Application form, fees, and official copies of transcripts;
3. Three letters of recommendation;
4. A resume or CV; and
5. A brief statement of career goals.

Applicants must hold the degree of Bachelor of Science or Bachelor of Arts in Physics, or a closely related field. The student's course of study will be determined by consultation with the chair and the student's major advisor. In some circumstances, a placement examination will be given. Students will normally be required to complete as deficiencies any courses required for the B.S. in Physics at Idaho State University that they have not already taken. Continued enrollment in the program is contingent upon maintaining a 3.0 grade point average and upon making satisfactory progress toward the degree.

Master of Science

Thesis Option:

A satisfactory score on physics examination(s) may be required before admission to candidacy. A total of 30 credits are required for the Master of Science Degree.

Code	Title	Credits
Required Courses		
PHYS 5525	Nuclear and Particle Physics I	3
PHYS 6602	Theoretical Methods of Physics	3
PHYS 6611	Electricity and Magnetism	3
PHYS 6621	Classical Mechanics	3
PHYS 6624	Quantum Mechanics	3
PHYS 6625	Quantum Mechanics	3
PHYS 6650	Thesis	6
Additional graduate-level credits approved by the student's advisor, department chair, and the Graduate School		12
Total Credits		**36**

A public presentation of the thesis is required, along with a satisfactory oral defense to the thesis committee consisting of two departmental members and one GFR.

Master of Science

Non-Thesis Option:

There are two mechanisms by which a student may attain a non-thesis M.S. degree. First, students in the Ph.D. program who do not pass the qualifying examination at the Ph.D. level after two attempts may complete a non-thesis M.S. degree. The required core courses for the non-thesis M.S. degree are the same as those for the Ph.D., i.e., those listed above. In addition, a non-thesis M.S. student must pass the qualifying examination at a level appropriate for the M.S. and he or she must complete an oral presentation and defense of a written proposal for research project to the student's graduate committee.

Second, students in the Ph.D. program who have completed all required courses for the Ph.D. and have passed both their qualifying examination and their oral presentation and defense of a written proposal for research project are eligible for a non-thesis M.S. degree.

Courses

PHYS 5503 Advanced Modern Physics: 3 semester hours.
Study of the elementary principles of quantum mechanics and an introduction to atomic, solid state and nuclear physics. Quantum mechanics will be used as much as possible. PREREQ: MATH 3360 and PHYS 3301.

PHYS 5504 Advanced Modern Physics: 3 semester hours.
Study of the elementary principles of quantum mechanics and an introduction to atomic, solid state and nuclear physics. Quantum mechanics will be used as much as possible. PREREQ: PHYS 5503.

PHYS 5505 Advanced Laboratory: 2 semester hours.
Experiments in radiation detection and measurement, nuclear spectroscopy including x-ray and gamma spectroscopies, neutron activation and ion beam methods. Available to Geology, Engineering, Health Physics, and Physics majors. PREREQ: Permission of instructor.

PHYS 5510 Science in American Society: 2 semester hours.
Observational basis of science; technology's historical influences on scientific developments; perceptions of science in contemporary America; tools/strategies for teaching science. Equivalent to GEOL 5510. PREREQ: Permission of instructor.

PHYS 5514 Electronic Instrumentation and Measurement: 3 semester hours.
Lecture course with laboratory requirements. Topics include: DC and AC electricial circuits, Analog pulses, Bipolar Transistors, Field Effect Transistors, Operational amplifiers. PREREQ: PHYS 2212, PHYS 2214, and MATH 3360.

PHYS 5515 Statistical Physics: 3 semester hours.
Topics covered may include kinetic theory, elementary statistical mechanics, random motion and the theory of noise. Choice of topics will depend upon the interest of the students and instructor. PREREQ: PHYS 2212 and MATH 3360.

PHYS 5516 Radiation Detection and Measurement: 3 semester hours.
Lecture/laboratory course emphasizing practical measurement techniques in nuclear physics. PREREQ: CHEM 1111, CHEM 1111L, CHEM 1112, CHEM 1112L, and either PHYS 1111 and PHYS 1113, or PHYS 2211 and PHYS 2213.

PHYS 5516L Radiation Detect/Measure Lab: 0 semester hours.

PHYS 5521 Electricity and Magnetism I: 3 semester hours.
Intermediate course in fundamental principles of electrical and magnetic theory. Free use will be made of vector analysis and differential equations. PREREQ: PHYS 2212 and MATH 3360.

PHYS 5522 Electricity and Magnetism: 3 semester hours.
Intermediate course in fundamental principles of electrical and magnetic theory. Free use will be made of vector analysis and differential equations. PREREQ: PHYS 5521.

PHYS 5525 Nuclear and Particle Physics I: 3 semester hours.
A course in Nuclear and Particle Physics with emphasis on structural models, radioactivity, nuclear reactions, particle interactions, fission and fusion, the standard model of particle physics, symmetries and conservation laws. PREREQ: Knowledge of elementary quantum mechanics and differential equations or permission of instructor.

PHYS 5526 Nuclear and Particle Physics II: 3 semester hours.
A course in Nuclear and Particle Physics with emphasis on structural models, radioactivity, nuclear reactions, particle interactions, fission and fusion, the standard model of particle physics, symmetries and conservation laws.

PHYS 5542 Solid State Physics: 3 semester hours.
Introduction to the field of solid state physics emphasizing the fundamental concepts. Topics usually covered are crystal structure, X-ray diffraction, crystal binding energies, free electron theory of solids, energy bands. PREREQ: PHYS 3301, PHYS 5583, and MATH 3360 or permission of instructor.

PHYS 5552 Intermediate Optics: 3 semester hours.
Wave theory, e/m waves, production of light, measurement of light, reflection, refraction, interference, diffraction, polarization, optical systems, matrix methods, Jones vectors, Fourier optics, propagation of e/m waves in materials, atmospheric optics. COREQ: MATH 3360. PREREQ: PHYS 2212.

PHYS 5553 Topics in Astrophysics: 2 semester hours.
Application of physics to astronomy or cosmology. May include lab exercise. PREREQ: Permission of instructor.

PHYS 5561 Introduction to Mathematical Physics I: 3 semester hours.
Introduction to the mathematics most commonly used in physics with applications to, and practice in, solving physical problems; includes vector analysis, ordinary and partial differential equations. PREREQ: PHYS 2212 and MATH 3360.

PHYS 5562 Introduction to Mathematical Physics: 3 semester hours.
Introduction to the mathematics most commonly used in physics with applications to, and practice in, solving physical problems; includes vector analysis, ordinary and partial differential equations. PREREQ: PHYS 5561.

PHYS 5583 Theoretical Mechanics: 4 semester hours.
Detailed study of the motion of particles, satellites, rigid bodies and oscillating systems. Develop and apply Langrangian and Hamiltonian methods. PREREQ: PHYS 2212 and MATH 3360.

PHYS 5592 Colloquium in Physics: 1 semester hour.
Faculty and student lectures in current research topics in physics. Open to upper division and graduate students in physics. May be repeated to a maximum of 4 credits.

PHYS 5598P Prof Development Workshop: 1-3 semester hours.

PHYS 5599 Experimental Course: 1-6 semester hours.
The content of this course is not described in the catalog. Title and number of credits are announced in the Class Schedule. Experimental courses may be offered no more than three times with the same title and content. May be repeated.

PHYS 6602 Theoretical Methods of Physics: 3 semester hours.
Calculus of variations, Lagrangian and Hamiltonian formalisms of classical mechanics, some classical scattering theory, methods of solving PDEs, Green's functions, functions of complex variables, vector and tensor analysis, matrix, group and operator theory, and numerical methods integrated throughout each topic.

PHYS 6603 Particle Physics: 3 semester hours.
Basic constituents of the standard model, experimental methods, particle interactions: weak, gravitational, strong and electromagnetic, conservation laws, hadron structure and interactions, unification of interactions, physics beyond the standard model. PREREQ: PHYS 6624 or permission of instructor.

PHYS 6609 Advanced Nuclear Physics: 3 semester hours.
Nucleon-nucleon interaction, bulk nuclear structure, microscopic models of nuclear structure, collective models of nuclear structure, nuclear decays and reactions, electromagnetic interactions, weak interactions, strong interactions, nucleon structure, nuclear applications, current topics in nuclear physics. PREREQ: PHYS 6624 or permission of instructor.

PHYS 6611 Electricity and Magnetism: 3 semester hours.
Maxwell's equations and methods of solution, plane wave propagation and dispersion, wave guides, antennas and other simple radiating systems, relativistic kinematics and dynamics, classical interaction of charged particles with matter, classical radiation production mechanisms.

PHYS 6612 Advanced Electricity and Magnetism: 3 semester hours.
Advanced topics in application of Maxwell's equations to wave guides, antennas and other simple radiating systems. Particular emphasis upon the relativistic interaction of charged particles with matter, energy loss, and classical radiation production and absorption mechanisms. PREREQ: PHYS 6611 or permission of instructor.

PHYS 6615 Activation Analysis: 3 semester hours.
Theory and use of neutron activation methods for quantitative chemical analysis of natural and synthetic materials. Applications in geologic systems will be emphasized. PREREQ: Permission of instructor.

PHYS 6621 Classical Mechanics: 3 semester hours.
Lagrange equations, small vibrations; Hamilton's canonical equations; Hamilton's principal, least action; contact transformation; Hamilton-Jacobi equation, perturbation theory; nonlinear mechanics. PREREQ: PHYS 5583, PHYS 5561and PHYS 5562, or permission of instructor.

PHYS 6624 Quantum Mechanics: 3 semester hours.
Schrodinger wave equation, stationary state solution; operators and matrices; perturbation theory, non-degenerate and degenerate cases; WKB approximation, non-harmonic oscillator, etc.; collision problems. Born approximation, method of partial waves. PREREQ: PHYS 5561, PHYS 5562, and PHYS 6621 or permission of instructor.

PHYS 6625 Quantum Mechanics: 3 semester hours.
Schrodinger wave equation, stationary state solution; operators and matrices; perturbation theory, non-degenerate and degenerate cases; WKB approximation, non-harmonic oscillator, etc.; collision problems. Born approximation, method of partial waves. PREREQ: PHYS 6624 or permission of instructor.

PHYS 6626 Advanced Quantum Mechanics: 3 semester hours.
Elementary quantum field theory and practical applications. Emphasis upon non-relativistic and relativistic quantum electrodynamics, radiative processes, bremsstrahlung, pair-production, scattering, photo-electric effect, emission and absorption. PREREQ: PHYS 6625 or permission of instructor.

PHYS 6630 Accelerator Physics: 3 semester hours.
The physics of direct voltage accelerators, betatrons, sychrotrons, linear induction acceleration; high current accelerators; electromagnetic particle optics, free electron lasers and synchrotron light sources. PREREQ: PHYS 6612, and PHYS 6624 or equivalent.

PHYS 6631 Accelerator Technology: 3 semester hours.
Topics will include high voltage and pulsed power techniques, wave guide and R.F. structures, ion and electron beam sources and beam measurements as applied to particle beam machines. PREREQ: PHYS 6612 or equivalent.

PHYS 6632 Particle Beam Laboratory: 1-4 semester hours.
Laboratory projects in particle beam and ion optics, radiation detectors, ion source operation, etc. May be repeated up to 4 credits. PREREQ: Permission of isntructor.

PHYS 6640 Statistical Mechanics: 3 semester hours.
Statistical ensembles; the Maxwell-Boltzmann law; approach to equilibrium, quantum statistical mechanics; application of statistical mechanics to thermodynamic processes. PREREQ: PHYS 5515 and PHYS 6621.

PHYS 6641 Field Theory Particles and Cosmology I: 3 semester hours.
Topics may include Dirac theory, group theory, Feynman diagrams, superstrings, supergravity, relativity and cosmology. PREREQ: Permission of instructor.

PHYS 6642 Field Theory Particles and Cosmology II: 3 semester hours.
A continuation of PHYS 6641. Topics may include Dirac theory, group theory, Feynman diagrams, superstrings, super gravity, relativity and cosmology. PREREQ: Permission of instructor.

PHYS 6643 Advanced Solid State Physics: 3 semester hours.
Electron many-body problem, crystal and reciprocal lattice, Bloch functions, pseudo potentials, semi-conductors, transition metals, crystal momentum and coordinate representations, electric and magnetic fields, impurities and defects in crystals and semi-conductors, radiation effects on solids, lattice vibrations, electron transport. PREREQ: PHYS 6624 or permission of instructor.

PHYS 6648 Special Topics in Physics: 1-3 semester hours.
Survey, seminar, or project (usually at an advanced level) in one area of physics. Content varies depending upon the desires of the students and faculty. May be repeated until 6 credits are earned. PREREQ: Permission of instructor.

PHYS 6649 Graduate Seminar: 1 semester hour.
Advanced seminar topics in currently-active areas of applied physics. Students will be required to provide presentations and may be required to submit a paper. Four credits required. May be repeated.

PHYS 6650 Thesis: 1-10 semester hours.
Thesis. May be repeated. Graded S/U.

PHYS 6699 Experimental Course: 1-6 semester hours.
The content of this course is not described in the catalog. Title and number of credits are announced in the Class Schedule. Experimental courses may be offered no more than three times with the same title and content. May be repeated.

PHYS 8850 Doctoral Dissertation: 1-12 semester hours.
Research toward and completion of the dissertation. Variable credits. May be repeated. Graded S/U.