Physics

To obtain specific admissions requirements on how to apply to Graduate School, prospective students should visit this page: https://www.uab.edu/cas/physics/graduate

Degree Offered:	Ph.D., M.S.
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Website:	http://www.uab.edu/cas/physics/graduate

Program Information

Students in the M.S. and Ph.D. programs may specialize in any of the areas of interest to the faculty, including experimental physics and theoretical and computational physics.

Admission

Admission into the physics graduate program is by recommendation of the graduate admission committee of the Department of Physics. The committee takes into consideration prior academic performance, personal statement, prior research experiences, GRE General Test scores (optional), and the letters of evaluation, usually from former instructors and research supervisors.

Beginning the Program

All students must take a placement examination on basic physics concepts before registering for any courses. Upon arrival at UAB, international students may be required to take English as a Second Language course or Scientific Communication courses at UAB during their first year of study.

Web http://www.uab.edu/cas/physics/graduate

M.S. Program

Plan I

The student must successfully complete at least 30 semester hours of coursework, including at least four core courses selected from PH 635**,** PH 650, PH 660, and PH 671 and 6 semester hours of Thesis Research PH 699. Equivalent directed reading course or courses may be substituted if approved by the graduate faculty. In addition, all students must complete the appropriate Responsible Conduct in Research Training before being admitted to candidacy. The student must also write and complete a successful oral defense of a thesis under the direction of a graduate faculty member. Additional coursework should be selected with the advice of the student's graduate study committee to meet the particular needs of the student.

A detailed timeline for admission to candidacy and the appropriate forms for Plan I students may be found at the Graduate School website.

Deadlines for the Application for Degree and appropriate forms may be found here.

Additional general information about the steps to a degree and graduate school requirements may be found here.

Plan II

With approval of the physics graduate program director, a non-thesis option (Plan II) is available for all tracks in the Masters program. In this case, the graduate study committee requires the same total credit hours as for Plan I, but does not require 6 semester hours of Thesis Research (PH 699). The committee gives the student an M.S.-degree exit examination upon successful completion of the coursework.

Deadlines for Application for Degree and appropriate forms may be found at the Graduate School website.

M.S. Concentrations

M.S. Program in Physics Plan I (30 credit hours total)

Students have the option to choose from among three M.S. concentrations: (1) Concentration in Optics & Photonics, (2) Concentration in Materials Physics, or (3) Concentration in Computational Physics.

All entrants must have at least one semester of PH 445 (Electromagnetic Theory I), PH 450 (Introductory Quantum Mechanics I), and PH 432 (Statistical Thermodynamics I) or equivalent.

The following are requirements for the MS Concentrations*:

- Participation every semester in Physics Seminar (1 credit hour/semester); PH 791 (Physics Seminar I) in Fall and PH 792 (Physics Seminar II) in Spring
- For students on teaching assistantships, the following course must be taken: PH 590 (Preparations for Teaching).

* Note: Up to 6 credit hours are allowed for PH 698 (Non-Thesis Research) to satisfy the MS credit hours requirement, with approval of graduate committee.

Required Core Courses

Requirements		Hours
PH 671	Quantum Mechanics I	3
PH 660	Methods of Mathematical Physics	3
PH 793	Scientific Communications I	1
PH 794	Scientific Communications II	1
PH 699	Research for Thesis	6
Total Hours		**14**

Concentration in Optics & Photonics

Requirements		Hours
Required Courses		**6**
PH 525	Applications of Contemporary Optics I	
PH 581	Laser Physics I	
PH Elective Courses		**6**
PH 582	Laser Physics II	
PH 752	Light-Matter Interactions	
PH 653	Solid State Physics I	
Non-PH Elective Courses		
(if needed to satisfy M.S. credit hours requirement)		
BME 665	Computational Vision	
PH 497	Special Topics in Physics	
GBSC 714	Applications of Microscopy	

EE 623	Computer Vision	
Total Hours		**12**

Concentration in Materials Physics

Requirements		**Hours**
Required Courses		**6**
PH 551	Introductory Quantum Mechanics II	
PH 653	Solid State Physics I	
PH 635	Advanced Statistical Mechanics	
PH Elective Courses		**6**
PH 587	Nanoscale Science and Applications	
PH 635	Advanced Statistical Mechanics	
PH 518	Machine Learning Applications in Physics and Materials Science	
PH 653	Solid State Physics I	
PH 654	Solid State Physics II	
PH 655	Advanced Solid State Laboratory	
PH 551	Introductory Quantum Mechanics II	
Non-PH Elective Courses		
(if needed to satisfy M.S. credit hours requirement)		
MSE 513	Composite Materials	
MSE 565	Characterization of Materials	
MSE 565L	Characterization of Materials Laboratory	
MSE 602	Intro to Thermodynamics and Mechanics of Materials	
MSE 530	Polymeric Materials	
MSE 530L	Polymeric Materials Lab	
MSE 564	Metals and Alloys	
MSE 570	Ceramic Materials	
MSE 570L	Ceramic Materials Laboratory	
GBSC 714	Applications of Microscopy	
MSE 501	Materials Processing	
Total Hours		**12**

Concentration in Computational Physics

Requirements		**Hours**
Required Courses		**6**
PH 762	Computational Physics I	
PH 518	Machine Learning Applications in Physics and Materials Science	
PH Elective Courses		**6**
PH 635	Advanced Statistical Mechanics	
PH 650	Electromagnetic Theory I	
PH 551	Introductory Quantum Mechanics II	
PH 653	Solid State Physics I	
Non-PH Elective Courses		
(if needed to satisfy M.S. credit hours requirement)		
MA 560	Scientific Programming	
MA 566	Introduction to Optimization	
MA 660	Numerical Linear Algebra	
CS 663	Data Mining	
CS 667	Machine Learning	
CS 665	Deep Learning	
CS 685	Foundations of Data Science	
Total Hours		**12**

Ph.D. Program

All students are required to take the following core courses:

PH 760 Methods of Mathematical Physics I (3 CH, 1 semester)

PH 715 Advanced Statistical Mechanics (3 CH, 1 semester)

PH 750 Classical Electrodynamics I (3 CH, 1 semester)

PH 771 Quantum Mechanics I (3 CH, 1 semester)

PH 793-PH 794 Scientific Communications I, II 2 credit hours

In addition, GRD717, Responsible Conduct in Research, must be taken prior to admission to candidacy. Students are encouraged to take the course during their first summer semester in the PhD program.

A qualifying examination is given to test a student's competency in fundamental areas of Physics. This examination is divided into three sections: statistical mechanics, electromagnetic theory, and quantum physics. Each exam must be taken at the first offering following the completion of the related core course, PH 715, PH 750, and PH 771. PH 760 should be passed before any of the qualifying exams. The examination may not be taken more than twice. Scientific communications, PH 793 and PH 794, must be taken at the first offering following the completion of the qualifying examinations.

Following satisfactory completion of the core qualifying examinations and consultation with individual faculty members, the student selects a specific area for dissertation research under the supervision of an appropriate graduate faculty member. The student's Graduate Study Committee, chaired by the major advisor, will outline a program of study including graduate courses and appropriate tools of research, such as computer and/or foreign language competency. Also, the Graduate Study Committee will administer an oral selected topic examination to test the student's knowledge in the area of research. The student must pass this oral examination in no more than two attempts. Then, with direction from the major advisor, the student should focus on formulating and writing a formal research proposal that must be presented and defended before the Graduate Study Committee; this should lead to a recommendation from the committee for admission to candidacy. Dissertation research culminates in the successful oral defense of the dissertation.

A detailed timeline for admission to candidacy and the appropriate forms for Plan I students may be found at the Graduate School website.

Deadlines for the Application for Degree and appropriate forms may be found here.

Additional general information regarding steps to the degree and graduate school requirements may be found here.

The Physics Graduate program offers two tracks, the Physics Track and the Applied Physics Track.

Physics Track:

For students entering with a B.S. degree, the program requires a total of 72 credit hours distributed as follows:

- Fourteen semester hours of the core courses listed above
- PH 752 Light-Matter Interactions (3 credit hours)
- GRD 717 (3 credit hours)

- Three credit hours of elective courses approved by dissertation committee and/or graduate program director
- Participation every semester in Physics Seminar (1 credit hour/semester); PH 791 Physics Seminar I (Fall) and PH 792 Physics Seminar II (Spring).
- Directed and Dissertation Research (at least 2 semesters of dissertation research are required to graduate)

For information about transferring credits from a Masters of Science program, please contact the department (mezvanut@uab.edu).

Applied Physics Track:

For students entering with a B.S. degree, the program requires a total of 72 credit hours distributed as follows:

- Fourteen semester hours of the core courses listed above
- PH 746 Applied Physics Internship (3 credit hours)
- GRD 717 (3 credit hours)
- Participation every semester in Physics Seminar (1 credit hour/semester); PH 791 Physics Seminar I (Fall) and PH 792 Physics Seminar II (Spring).
- Three credit hours of elective courses approved by dissertation committee and/or graduate program director
- Directed and Dissertation Research (at least 2 semesters of dissertation research are required to graduate

For information about transferring credits from a Masters of Science program, please contact the department (mezvanut@uab.edu)

The following is a partial list of elective courses. Others may be suggested by the student or advisor. All electives must be approved by the graduate advisor and/or PhD committee.

Elective Courses for the Applied Physics Track

- PHY 792: Cell Interactions with Biomaterials. 3 credit hours
- PH 753-754: Advanced Solid State Physics. 6 credit hours
- MSE 743-744: Materials Characterization I and II. 6 credit hours
- PH 732-733: Growth and Characterization of Thin Films I, II. 6 credit hours
- BME 590: Tissue Engineering. 3 credit hours
- PH 587: Nanoscale Science and Applications. 3 credit hours
- PH 575-576: Introduction to Biophysics I, II. 6 credit hours
- PH 581-582: Laser Physics I, II. 6 credit hours
- PH 585: Laser Spectroscopy. 3 credit hours
- PH 525-526: Applications of Contemporary Optics I, II. 6 credit hours

The following doctoral fellowships are available to the graduate students enrolled in the PhD program in physics at UAB.

Blazer Graduate Research Fellowship in Physics

Applicants to the PhD program in Physics, who have demonstrated exceptional promise in research and scholarship, will be considered for the UAB Blazer Fellowship. *Fellowship recipients will receive a fellowship stipend as well as tuition and health insurance. Furthermore, they will be able to engage in research at the beginning of their first year with no teaching duties. It is expected that the Blazer Fellow will be able to commence PhD research and choose a research mentor by the end of their first year.*

For information about the application, contact the Physics Graduate Program director at catledge@uab.edu.

NASA-Alabama Space Grant Consortium Fellowships

Awards are up to $37,000 ($24K in student stipend, up to $12K for tuition/insurance and $1K for student travel allowance) and are made initially for one 12-month period and may be renewed annually for a maximum total award of 36 months (3 years) support. Must be a U.S. citizen, enrolled full-time in good academic standing with a GPA of at least 3.0 on a 4.0 scale at an Alabama Space Grant member university pursing any space-related field of graduate study (Masters or Doctoral level). Must conduct a specific faculty-mentored research project that has a NASA or aerospace relevance. Cannot receive funds from any source for work other than that defined by the student's approved proposed research and plan of study for which the award is made (supplements to the student's award may be made by the home university using funds from any source, provided the amount and source are disclosed in advance - see information booklet for more details). Awardees must also complete an extramural NASA experience sometime during the fellowship year. The details are to be worked out with the faculty advisor and NASA lab facility where the student plans to participate in a research activity. *It is advisable that a NASA contact be found prior to submission of the fellowship proposal.* Fellows are also expected to be involved in ASGC outreach activities and submit a final report at the end of the award period.

The online Graduate Fellowship Application is available through the department website.

Graduate Research Scholars Program

Graduate students working toward their PhD may compete for a research fellowship based on the quality of their present research and promise of future success through the the Graduate Research Scholars Program (GRSP). The GRSP is designed to strengthen and enhance the research capacity of member institutions of the Alabama Experimental Program to Stimulate Competitive Research (EPSCoR). Students submit a complete research proposal package to the UAB EPSCoR Coordinator in Spring each year, and successful recipients are announced in early Summer.

For up-to-date information about additional fellowships, please contact the Physics Graduate Program Director, catledge@uab.edu.

Additional Information

Deadline for Entry Term(s):	Each Fall semester
Deadline for All Application Materials to be in the Graduate School Office:	Six weeks before term begins
Number of Evaluation Forms Required:	Three
Entrance Tests:	TOEFL and TWE required for international applicants whose native language is not English.
Comments:	GRE General Test is optional

Courses

PH 502. Instructional Physical Science. 4 Hours.
Modern Physics for Teachers.

PH 502L. Instructional Physical Science Laboratory. 0 Hours.
Design of Physical Science Labs and Detailed Instructional Plans.

PH 505. Studies in Physics Teaching II. 3 Hours.
Development of new curricula, apparatus, and techniques of presentation of concepts in physics. Prerequisite: Permission of instructor.

PH 507. Physical Science for Teachers I. 3 Hours.
Concepts of physical science. Laboratory includes evaluation of experiments and equipment for lecture demonstrations. Prerequisite: Permission of instructor.

PH 508. Physical Science for Teachers II. 3 Hours.
Concepts of physical science. Laboratory includes evaluation of experiments and equipment for lecture demonstrations. Prerequisite: Permission of instructor.

PH 510. Physics of Fluids and Polymer Solutions. 3 Hours.
This course provides an overview of fluid mechanics and polymer physics appropriate for physics, engineering, chemistry, and biology majors. Topics include the concept of a fluid, the fluid as a continuum, properties of the velocity field, thermodynamic properties of a fluid, viscosity, pressure distribution in a fluid, basic physical laws of fluid mechanics, the Reynolds transport theorem, differential relations for a fluid particle, viscous flow, polymer solutions and thermodynamics, Brownian motion, diffusion equation, Fick's law, Stokes-Einstein equation and hydrodynamic radius of a polymer chain, and viscosity of polymer solutions.
Prerequisites: PH 221 [Min Grade: C] and MA 252 [Min Grade: C]

PH 518. Machine Learning Applications in Physics and Materials Science. 3 Hours.
This course covers interdisciplinary topics in material physics, computer science, and data science, with a focus on introducing first-principles software based on density-functional theory and data-driven machine-learning discoveries for applications in materials science and other physics domains.

PH 520. Introduction to Methods in Theoretical Physics I. 3 Hours.
Vector calculus. Curvilinear coordinate systems; commonly encountered ordinary differential equations and special functions; complex variables and contour integration partial differential equations, including solutions by Green function methods. Prerequisite: Permission of instructor.
Prerequisites: PH 222 [Min Grade: C] and MA 252 [Min Grade: C]

PH 524. Biomedical Optics. 3 Hours.
The objective of this class is to present an overview of applied optics, with an emphasis on biomedical optics.
Prerequisites: PH 222 [Min Grade: C]

PH 525. Applications of Contemporary Optics I. 3 Hours.
Applied geometrical optics. Refraction and reflection, paraxial optics, thick lens, matrix theory, optical aberrations, optical systems, and optical design using computer simulations.
Prerequisites: PH 222 [Min Grade: C]

PH 526. Applications of Contemporary Optics II. 3 Hours.
Applied wave optics. Fresnel equations, optical interference, optical interferometry, coherence, diffraction, lasers, and Gaussian beam propagation.
Prerequisites: PH 525 [Min Grade: C]

PH 527. Geometrical Optics. 4 Hours.
Properties of optical systems. Lenses, mirrors, and stops; aberrations; rays and wave fronts, optical instruments; aspheric components.
Prerequisites: PH 222 [Min Grade: C]

PH 527L. Geometrical Optics Lab. 0 Hours.
Geometrical Optics Lab.

PH 528. Physical Optics. 4 Hours.
Interference and diffraction phenomena; emission, propagation, and absorption of radiation; polarization and dispersion; stimulated emission.
Prerequisites: PH 527 [Min Grade: C]

PH 528L. Physical Optics Lab. 0 Hours.
Physical Optics Lab.

PH 529. Applications of Contemporary Optics III. 3 Hours.
Applied optical interactions with materials linear and nonlinear polarization phenomena, optical properties of materials, anisotropic optics, electro-optics, and nonlinear optics.
Prerequisites: PH 526 [Min Grade: C]

PH 532. Statistical Thermodynamics I. 3 Hours.
Statistical basis of laws of thermodynamics; ensembles and partition functions; quantum statistics of ideal gases, including photons and electrons; applications to solids, real gases, liquids, and magnetic systems; transport theory.
Prerequisites: PH 351 [Min Grade: C]

PH 533. Statistical Thermodynamics II. 3 Hours.
Statistical basis of laws of thermodynamics; ensembles and partition functions; quantum statistics of ideal gases, including photons and electrons; applications to solids, real gases, liquids, and magnetic systems; transport theory.
Prerequisites: PH 532 [Min Grade: C]

PH 545. Electromagnetic Theory I. 3 Hours.
Electromagnetic theory approached from standpoint of fields and using Maxwell's equations.
Prerequisites: PH 420 [Min Grade: C] or MA 444 [Min Grade: C]

PH 546. Electromagnetic Theory II. 3 Hours.
Electromagnetic theory approached from standpoint of fields and using Maxwell's equations.
Prerequisites: PH 545 [Min Grade: C]

PH 550. Introduction to Quantum Mechanics I. 3 Hours.
Principles of quantum mechanics; their application to particle waves, angular momentum, tunneling, radiation, and selection rules; perturbation and variational methods.
Prerequisites: PH 351 [Min Grade: C] and PH 562 [Min Grade: C]

PH 551. Introductory Quantum Mechanics II. 3 Hours.
Principles of quantum mechanics; their application to particle waves, angular momentum, tunneling, radiation, and selection rules; perturbation and variational methods.
Prerequisites: PH 550 [Min Grade: C]

PH 552. Introduction to Quantum Mechanics III. 2 Hours.

PH 553. Solid State Physics I. 3 Hours.
Properties of crystal lattices, lattice dynamics, lattice imperfections, and bonding energies; electronic properties of dielectrics, semiconductors, and metals; ferroelectric, magnetic, and optical properties of solids.
Prerequisites: PH 551 [Min Grade: C]

PH 554. Solid State Physics II. 3 Hours.
Properties of crystal lattices, lattice dynamics, lattice imperfections, and bonding energies; electronic properties of dielectrics, semiconductors, and metals; ferroelectric, magnetic, and optical properties of solids.
Prerequisites: PH 553 [Min Grade: C]

PH 557. Directed Reading in Quantum Physics. 3 Hours.
Tutorial studies in quantum physics offered by special arrangement.
Prerequisites: PH 351 [Min Grade: C] and PH 562 [Min Grade: C]

PH 558. Directed Reading in Physics. 3 Hours.
Directed Reading in Physics I. Tutorial studies in physics offered by special arrangement.

PH 561. Classical Mechanics I. 3 Hours.
Kinematics and dynamics, including central forces, rotating coordinate systems, and generalized coordinates; Lagrangian and Hamiltonian.
Prerequisites: PH 222 [Min Grade: C] and MA 252 [Min Grade: C]

PH 562. Classical Mechanics II. 3 Hours.
Kinematics and dynamics, including central forces, rotating coordinate systems, and generalized coordinates; Lagrangian and Hamiltonian.
Prerequisites: PH 561 [Min Grade: C]

PH 571. Atomic and Molecular Physics. 3 Hours.
Applications of quantum mechanics to structure and spectra of atoms and small molecules; use of symmetry in understanding and describing molecular vibrations and bonding.
Prerequisites: PH 551 [Min Grade: C]

PH 575. Intro to Biophysics I. 3 Hours.
Application of physical techniques and analytical methods of selected biological problems. Permission of instructor.
Prerequisites: PH 352 [Min Grade: C]

PH 576. Intro to Biophysics II. 3 Hours.
Application of physical techniques and analytical methods of selected biological problems. Permission of instructor.
Prerequisites: PH 575 [Min Grade: C]

PH 580. Directed Reading in Classical Physics. 3 Hours.
Tutorial studies in classical physics offered by special arrangement.
Prerequisites: PH 222 [Min Grade: C] and MA 252 [Min Grade: C]

PH 581. Laser Physics I. 3 Hours.
Physical principles of laser operation and design. Spontaneous and stimulated emission, population inversion, light amplification, laser resonators, Q-switching, mode-locking, pulse shortening techniques, spectral narrowing, and tunable lasers. Individual types of lasers will be considered. Practical applications of lasers will be treated in detail.
Prerequisites: PH 222 [Min Grade: C]

PH 582. Laser Physics II. 3 Hours.
Physical principles of laser operation and design. Spontaneous and stimulated emission, population inversion, light amplification, laser resonators, Q-switching, mode-locking, pulse shortening techniques, spectral narrowing, and tunable lasers. Individual types of lasers will be considered. Practical applications of lasers will be treated in detail.
Prerequisites: PH 581 [Min Grade: C]

PH 583. Atomic and Nuclear Physics. 3 Hours.
Prerequisites: PH 352 [Min Grade: C]

PH 584. Atomic and Nuclear Physics. 3 Hours.
Prerequisites: PH 583 [Min Grade: C]

PH 585. Laser Spectroscopy. 3 Hours.
Practical applications of lasers and modern techniques and instrumentation in laser spectroscopy.
Prerequisites: PH 222 [Min Grade: D]

PH 586. Semiconductor Materials in Modern Technology. 3 Hours.
Brief review of electronic materials with emphasis on traditional and cutting edge Si technology. Competing and complementary semiconductors covered in standard lecture and seminar style. Materials: compound and tertiary semiconductors, organic semiconductors, wide bandgap semiconductors. Applications: optical and chemical sensors, microwave electronics, high power electronics, lasers. Specific applications/ materials determined by student interest.
Prerequisites: PH 352 [Min Grade: C] or EE 351 [Min Grade: C] or CH 326 [Min Grade: C]

PH 587. Nanoscale Science and Applications. 3 Hours.
Nanoscale Science and Applications. Physics of electronic, mechanical, and biological properties of materials at the nanoscale level approaching one billionth of a meter. The applications of nanoscale materials in electronic, mechanical, and biomedical systems will be emphasized. Special tools in synthesis and characterization of nanomaterials will be discussed.

PH 589. Applications of Modern Physics. 3 Hours.

PH 590. Preparations for Teaching. 1-3 Hour.
This class is intended to help teaching assistants prepare for successful teaching experiences. The course will emphasize a foundation of practical knowledge related to expectations and duites shared by teachers in higher education, as well as an opportunity to read, reflect, and discuss current research related to teaching and learning at the university level.

PH 591. Advanced Physics Laboratory I. 1-4 Hour.
Laboratory investigation of topics of modern physics. Permission of instructor.

PH 592. Advanced Physics Laboratory II. 1-4 Hour.
Laboratory investigation of topics of modern physics. Permission of instructor.

PH 593. Advanced Physics Laboratory III. 1-4 Hour.
Laboratory investigation of topics of modern physics. Permission of instructor.

PH 594. Computers in Physics. 3 Hours.

PH 595. Computers in Physics. 3 Hours.

PH 597. Special Topics in Physics. 1-3 Hour.

PH 610. Classical Mechanics I. 3 Hours.
Applications of methods of LaGrange, Hamilton, Poisson, and Hamilton-Jacobi to such classical problems as central force, small oscillation, and rigid body motions.
Prerequisites: PH 562 [Min Grade: C]

PH 618. Computational Solid State Physics. 3 Hours.
This course covers interdisciplinary topics in material physics, computer science, and data science, with a focus on introducing first-principles software based on density-functional theory and data-driven machine-learning discoveries for applications in materials science and other physics domains.

PH 635. Advanced Statistical Mechanics. 3 Hours.
Applications of statistical laws to modern topics such as quantum fluids, critical phenomena, and nonequilibrium systems.
Prerequisites: PH 551 [Min Grade: B]

PH 650. Electromagnetic Theory I. 3 Hours.
Boundary value and Green function methods for solving potential problems; fields in dielectric, magnetic media, and radiation fields.
Prerequisites: PH 546 [Min Grade: B]

PH 651. Electromagnetic Theory II. 3 Hours.
Boundary value and Green function methods for solving potential problems; fields in dielectric, magnetic media, and radiation fields.
Prerequisites: PH 650 [Min Grade: C]

PH 652. Electromagnetic Theory III. 3 Hours.
Electromagnetic Theory.

PH 653. Solid State Physics I. 3 Hours.
Structure and dynamics of solids; optical, magnetic, and transport properties.
Prerequisites: PH 551 [Min Grade: C]

PH 654. Solid State Physics II. 3 Hours.
Structure and dynamics of solids; optical, magnetic, and transport properties.
Prerequisites: PH 653 [Min Grade: C]

PH 655. Advanced Solid State Laboratory. 1-3 Hour.
Thin film X-ray diffraction, Raman spectroscopy in materials characterization, electron paramagnetic resonance, and thin film deposition.
Prerequisites: PH 653 [Min Grade: C] and PH 654 [Min Grade: C]

PH 660. Methods of Mathematical Physics. 3 Hours.
Vector and tensor analysis; differential and integral equations; Green functions; variational techniques; linear operator theory; Fourier and Laplace transforms.
Prerequisites: PH 520 [Min Grade: B]

PH 671. Quantum Mechanics I. 3 Hours.
Discrete and continuous spectra; central force problems; angular momentum and spin; systems of identical particles; perturbation theory; scattering theory.
Prerequisites: PH 546 [Min Grade: B] and PH 551 [Min Grade: B]

PH 672. Quantum Mechanics II. 3 Hours.
Discrete and continuous spectra; central force problems; angular momentum and spin; systems of identical particles; perturbation theory; scattering theory.
Prerequisites: PH 671 [Min Grade: C]

PH 673. Applications of Quantum Mechanics. 3 Hours.
Scattering theory, density matrix, and polarization; applications to atomic and nuclear reactions.
Prerequisites: PH 671 [Min Grade: C] and PH 672 [Min Grade: C]

PH 695. Directed Reading. 2-3 Hours.
Tutorial studies in physics offered by special arrangement. Permission of instructor.

PH 696. Directed Reading in Classical Physics. 3 Hours.
Tutorial studies in classical physics offered by special arrangement.
Prerequisites: PH 562 [Min Grade: C]

PH 697. Special Topics in Physics. 1-12 Hour.
Topics of current interest, such as theoretical physics, computational physics, experimental techniques. May be repeated for credit. 1-12 hours.

PH 698. Nonthesis Research. 1-12 Hour.
May be repeated for credit.

PH 699. Research for Thesis. 1-12 Hour.
May be repeated for credit. Prerequisite: Admission to candidacy. 1-12 hours.
Prerequisites: GAC M

PH 710. Advanced Classical Mechanics I. 3 Hours.
Analysis of dynamics, including rigid body motion, featuring the LaGrange formulation, introduction to the Hamiltonian, formulation, Poisson brackets, analyses in nonrelativistic applications.
Prerequisites: PH 562 [Min Grade: C]

PH 711. Advanced Classical Mechanics II. 3 Hours.
Analysis of dynamics, including rigid body motion, featuring the LaGrange formulation, introduction to the Hamiltonian, formulation, Poisson brackets, analyses in nonrelativistic applications.
Prerequisites: PH 710 [Min Grade: C]

PH 715. Advanced Statistical Mechanics. 3 Hours.
Applications of statistical laws to modern topics such as quantum fluids, critical phenomena, and nonequilibrium systems.
Prerequisites: PH 532 [Min Grade: B] and PH 551 [Min Grade: B]

PH 716. Advanced Statistical Mechanics. 3 Hours.
Applications of statistical laws to modern topics such as quantum fluids, critical phenomena, and nonequilibrium systems.
Prerequisites: PH 715 [Min Grade: C]

PH 718. Machine Learning Applications in Physics and Materials Science. 3 Hours.
This course covers interdisciplinary topics in material physics, computer science, and data science, with a focus on introducing first-principles software based on density-functional theory and data-driven machine-learning discoveries for applications in materials science and other physics domains.

PH 732. Growth and Characterization of Thin Films I. 3 Hours.
Basics of vacuum science. Methods of thin film deposition. Nucleation, evolution of microstructure and surface morphology of thin films. Simulation of growth processes. Thin film characterization techniques (SEM/SIM, TEM, SPM, SPS/AES, XRD, optical and and mechanical measurements). Demonstrations on thin-film deposition and basic characterization of tilm microstructure and properties. Prerequisites: PH 553/653 and PH554/654 or permission of instructor. Lecture and demonstration. 3 semester hours.
Prerequisites: (PH 453 [Min Grade: C] or PH 553 [Min Grade: C]) and (PH 454 [Min Grade: C] or PH 554 [Min Grade: C])

PH 733. Growth and Characterization of Thin Films II. 3 Hours.
Basics of vacuum science. Methods of thin film deposition. Nucleation, evolution of microstructure and surface morphology of thin films. Simulation of growth processes. Thin film characterization techniques (SEM/SIM, TEM, SPM, XPS/AES, XRD, optical and mechanical measurements). Demonstrations on thin-film deposition and basic characterization of film microstructure and properties. Prerequisites: PH553/653 and PH554/654 or permission of instructor. Lecture and demonstrations. 3 semester hours.
Prerequisites: (PH 453 [Min Grade: C] or PH 553 [Min Grade: C]) and (PH 454 [Min Grade: C] or PH 554 [Min Grade: C])

PH 745. Molecular Spectroscopy. 3 Hours.
Infrared, Raman, and ultraviolet techniques applied to study of molecular properties, including rotation-vibration spectra and spectra of crystalline solids.

PH 746. Applied Physics Internship. 3 Hours.
Practical research outside UAB or, upon approval of the graduate program director, at a UAB laboratory other than that of the student's advisor. The internship is intended to supplement proposed or ongoing dissertation research.

PH 747. Theoretical Nuclear Physics. 3 Hours.

PH 750. Classical Electrodynamics I. 3 Hours.
Static and time-varying fields in vacuum and in matter, radiation fields, solutions and implications of Maxwell's equation utilizing advanced mathematical methods.
Prerequisites: PH 546 [Min Grade: B] and PH 760 [Min Grade: B]

PH 751. Classical Electrodynamics II. 3 Hours.
Static and time-varying fields in vacuum and in matter, radiation fields, solutions and implications of Maxwell's equation utilizing advanced mathematical methods.
Prerequisites: PH 750 [Min Grade: C]

PH 752. Light-Matter Interactions. 3 Hours.
Quantized Electromagnetic Fields; Photons; Quantum Optics; Coherence; Nonlinear optics; Quantum excitations in solids.
Prerequisites: PH 750 [Min Grade: B] and PH 771 [Min Grade: B]

PH 753. Solid State Physics I. 3 Hours.
Properties of electrons and photons in crystal lattices; electromagnetic interactions with solids; lattice defects.

PH 754. Solid State Physics II. 3 Hours.
Properties of electrons and photons in crystal lattices; electromagnetic interactions with solids; lattice defects.
Prerequisites: PH 753 [Min Grade: C]

PH 755. Advanced Solid State Physics III. 2 Hours.
Advanced Solid State Physics II.
Prerequisites: PH 753 [Min Grade: C] and PH 754 [Min Grade: C]

PH 760. Methods of Mathematical Physics I. 3 Hours.
Vector and tensor analysis; differential and integral equations; Green functions; variational techniques; linear operator theory; Fourier and Laplace transforms.
Prerequisites: PH 520 [Min Grade: B]

PH 761. Methods of Mathematical Physics II. 3 Hours.
Vector and tensor analysis; differential and integral equations; Green functions; variational techniques; linear operator theory; Fourier and Laplace transforms.

PH 762. Computational Physics I. 3 Hours.
Numerical techniques for solution of differential, integral, and matrix equations of physics; computer simulations of physical phenomena; optimization problems.
Prerequisites: PH 545 [Min Grade: C] and PH 551 [Min Grade: C] and PH 561 [Min Grade: C]

PH 771. Quantum Mechanics I. 3 Hours.
Discrete and continuous spectra; central force problems; angular momentum and spin; systems of identical particles; perturbation theory; scattering theory.
Prerequisites: PH 546 [Min Grade: B] and PH 551 [Min Grade: B]

PH 772. Quantum Mechanics II. 3 Hours.
Discrete and continuous spectra; central force problems; angular momentum and spin; systems of identical particles; perturbation theory; scattering theory.
Prerequisites: PH 771 [Min Grade: C]

PH 773. Applications of Quantum Mechanics. 3 Hours.
Scattering theory, density matrix, and polarization; applications to atomic and nuclear reactions.
Prerequisites: PH 771 [Min Grade: C] and PH 772 [Min Grade: C]

PH 791. Physics Seminar I. 1 Hour.
Topics of current interest in physics, presented by graduate students, faculty, and visitors. Required each term of all full-time graduate students.

PH 792. Physics Seminar II. 1 Hour.
Topics of current interest in physics, presented by graduate students, faculty, and visitors. Required each term of all full-time graduate students.

PH 793. Scientific Communications I. 1 Hour.
Scientific writing exercises and recent topics in physics presented by graduate students in order to provide experience in written and oral scientific communication.

PH 794. Scientific Communications II. 1 Hour.
Scientific writing exercises and recent topics in physics presented by graduate students in order to provide experience in written and oral scientific communication.
Prerequisites: PH 793 [Min Grade: C]

PH 795. Directed Reading. 2-3 Hours.
Tutorial studies in physics offered by special arrangement. Permission of instructor.

PH 797. Special Topics in Physics. 1-12 Hour.
Topics of current interest, such as group theory, medical physics, computational methods, biological physics, materials physics, optics, and space physics. May be repeated for credit.

PH 798. Non-Dissertation Research. 1-12 Hour.
Permission of instructor.

PH 799. Research for Dissertation. 1-12 Hour.
Admission to candidacy.
Prerequisites: GAC Z