PHYSICS AND ASTRONOMY

College of Natural Sciences and Mathematics

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Advisors:

Undergraduate: Jiyeong Gu
Credential: James Kisiel, Tim Williamson
Graduate: Andreas Bill

Administrative Support Coordinator: Irene Howard

Students desiring information should contact the Department Office for referral to one of the faculty advisors.

Career Possibilities

Physicist • Teacher • Medical Physicist • Astrophysicist • Computer Scientist • Electro-Optical Engineer • Computer Engineer • Meteorologist • Metallurgist • Industrial Health Engineer • Aerospace Engineer • Geophysicist • Financial Analyst • Technical Writer • Astronomer • Teacher • Oceanographer • Systems Analyst • Mathematician • Materials Researcher • Quality Control Specialist • Food and Drug Inspector • Scientific Apparatus Salesperson • Nuclear Engineer • Physicist Technician (Some of these, and other careers, require additional education or experience. For more information, see www.careers.csulb.edu and www.aps.org/careers.) Various entry-level trainee positions in business and industry are available for graduates regardless of academic discipline.

Degree Programs

The Bachelor of Science degree is designed for students interested in immediate employment in industry or wishing to continue on to a Master's or Ph.D. degree in physics or a related field. The Bachelor of Arts degree is appropriate for those preparing for teaching careers in the physical sciences at the secondary level as well as those whose goal is a liberal art education with an emphasis on physics.

The Department also offers graduate study leading to the Master of Science degree. This degree is available in both a general option and an option in applied physics. A limited number of teaching associateships and graduate assistantships are available to students working on the master's degree. Application should be made to the Chair of the Department.

Academic Advising and Facilitated Enrollment into Classes

All entering students who declare a major in a degree program offered by this department need to contact the College of Natural Sciences and Mathematics' (CNSM) Academic Advising Center (HSCI 164) and participate in the College's Science Safari to Success (for first time freshmen) or EONS (Enrollment and Orientation in the Natural Sciences and Mathematics for transfer students) Program. These programs are held in July for those starting in the Fall Semester and in January for those starting in the Spring Semester. Department advisors will be available to provide an overview of the students' chosen baccalaureate degree program, to assist with academic advisement, to provide information on the many career opportunities available, and to aid students in enrolling in classes. Contact the CNSM Academic Advising Center, Jensen Student Access to Sciences and Mathematics Center (HSCI 164), or department office for additional information.

All entering graduate students need to contact the graduate advisor of the department. An orientation for graduate students is held during the week prior to start of classes.

Concurrent and/or Summer Enrollment at Another College

Students who wish to take course work at a community college or another college or university to meet curricular requirements while enrolled as undergraduates in the College of Natural Sciences and Mathematics must petition the appropriate Department for prior approval to earn credit for specific courses. This policy applies to concurrent enrollment or summer enrollment. Please see "Concurrent Enrollment" and "Transfer of Undergraduate Credit" in this catalog. Courses not receiving prior approval will not be accepted for credit by the Department.

Undergraduate Programs

Bachelor of Science in Physics (120 units)

Requirements

Lower Division:

Take all of the following courses:

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151;
Prerequisite/Corequisite: MATH 123.

PHYS 254 Modern Physics and Light (3)
Prerequisite: PHYS 152 or EE 210;
Prerequisite/Corequisite: MATH 224.

PHYS 255 Laboratory on Light & Modern Physics (1)
Prerequisite/Corequisite: PHYS 254.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or MATH 222.

MATH 247 Introduction to Linear Algebra (3)
Prerequisite: MATH 123 or MATH 222.

Select one from the following three courses:

BIOL 200 General Biology (4)
Prerequisite: GE Foundation requirements.

Or

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

Or

CHEM 111A General Chemistry (5)
Prerequisites: A passing score on the Chemistry Placement Examination.
Corequisite: MATH 109 or higher.

NOTE: BIOL 111, BIOL 111L are required if courses were taken prior to catalog year 2010-11.

Upper Division:

Take the following courses:

MATH 364A Ordinary Differential Equations I (3)
Prerequisites: MATH 222 or MATH 224, and prerequisite or corequisite MATH 247.

Take one other upper-division mathematics course:

Note: students interested in completing a minor in mathematics or applied mathematics should consult the appropriate advisor.

Take all of the following:

PHYS 310 Analytic Mechanics (3)
Prerequisite: PHYS 151. Corequisite: MATH 364A or MATH 370A.

PHYS 320 Thermodynamics (3)
Prerequisite: PHYS 152. Prerequisite/Corequisite, PHYS 254.

PHYS 340A Electricity and Magnetism I (3)
Prerequisites: PHYS 152, PHYS 310. Prerequisite/Corequisite: MATH 370A or MATH 364A.

PHYS 340B Electricity and Magnetism II (3)
Prerequisite: PHYS 340A.

PHYS 350 Modern Physics (3)
Prerequisites: PHYS 310; MATH 370A or MATH 364A.

PHYS 360 Physics with Symbolic Algebra Software (3)
Prerequisite: PHYS 254. Prerequisite/Corerequisite: MATH 247.

PHYS 380 Electronics (4)
Prerequisite: PHYS 152.

PHYS 450 Quantum Physics I (3)
Prerequisites: PHYS 310, PHYS 340A, PHYS 350.

Take one laboratory course chosen from:
PHYS 445, PHYS 446, PHYS 476 and PHYS 480

6 units of upper-division physics electives

Grade Requirements

Physics majors must have a "C" average in the major. Physics students must achieve a grade of "C" or better in each required course in the major. The following schedule is typical for a major who is a full-time student.

Sophomore Year

Fall: PHYS 254, PHYS 255; MATH 224.
Spring: PHYS 360, PHYS 380; MATH 247.

Junior Year

Fall: PHYS 310, PHYS 320; MATH 364A.
Spring: PHYS 340A, PHYS 350; Upper division MATH elective.

Senior Year

Fall: PHYS 340B, PHYS 450.
Spring: Three upper division physics electives (one of which is a laboratory).

Bachelor of Arts in Physics (120 units)

Requirements

All required courses must be passed with a grade of "C" or better

Lower Division:

Take all of the following courses:

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

PHYS 254 Modern Physics and Light (3)
Prerequisite: PHYS 152 or EE 210; Prerequisite/Corequisite: MATH 224.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or MATH 222.

Upper Division:

Take the following:

A minimum of 24 units selected in consultation with Physics Department Undergraduate Advisor, at least 12 units of which must be in physics. The remaining units can be chosen from EDSS 300C, EDSS 300M, any courses in the College of Engineering, or any courses in the College of Natural Sciences and Mathematics.

Physics Concentration

The Physics Concentration meets the subject matter competence requirement for the Single Subject Teaching Credential in Physics. Prospective students should consult the Single Subject Science Education Advisor in the Department of Science Education early to plan their program.

Requirements

Lower Division:

Take all of the following:

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151;
Prerequisite/Corequisite: MATH 123.

PHYS 254 Modern Physics and Light (3)
Prerequisite: PHYS 152 or EE 210; Prerequisite/Corequisite: MATH 224.

PHYS 255 Laboratory on Light & Modern Physics (1)
Prerequisite/Corequisite: PHYS 254.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or MATH 222.

ASTR 100 Astronomy (3)
Corequisites: One course from General Education Category B.2 and ASTR 100L.

CHEM 111A General Chemistry (5)
Prerequisites: A passing score on the Chemistry Placement Examination.
Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)
Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 117 or MATH 119A or MATH 122 all with a grade of "C" or better.

GEOL 102 General Geology (3)
Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)
Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

GEOL 160 Introduction to Oceanography (3)
Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Introduction to Cell and Molecular Biology (4)
Prerequisites: Completion of BIOL 211 and CHEM 111A with grades of "C" or better.
Prerequisite/Corequisite: Chem 111B

BIOL 213 Introduction to Ecology and Physiology (4)
Prerequisites: BIOL 211, BIOL 212, CHEM 111B with a grade of "C" or better.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

Upper Division:

Take all of the following:

PHYS 310 Analytic Mechanics (3)
Prerequisite: PHYS 151. Corequisite: MATH 364A or MATH 370A.

PHYS 340A Electricity and Magnetism I (3)
Prerequisites: PHYS 152, PHYS 310. Prerequisite/Corequisite: MATH 370A or MATH 364A.

PHYS 476 Modern Optics Laboratory (1)
Prerequisite: PHYS 340A.

SCED 403 Integrated Science (3)
Prerequisites: Completion of all credential breadth requirements for the Single Subject Teaching Credential Program in Science, three-fourths of the credential specializations courses, and consent of instructor.

SCED 404 Nature of Science Scientific Reasoning (3)
Prerequisites: Minimum of 9 units of science (introductory level or higher) or consent of instructor.

EDSS 300C Introduction to Teaching - Science (3)
Prerequisite: Advanced sophomore or junior standing.

EDSS 450C Curriculum and Methods in Teaching Science (3)
Prerequisite: EDSS 300C; admission to the Single Subject Credential Program or permission of the Single Subject Credential Program University Coordinator. Required prior to student teaching.

EDSE 435 U.S. Secondary Schools: Interculture Educ (3)
Prerequisite: EDSS 300 (A, C, D, F, G, H, M, N, P, or S); or admission in the Single Subject Credential Program; or permission of University Coordinator of the Single Subject Credential Program. Required course in the Single Subject Credential Program.

EDSE 436 Curriculum, Instruction, Assessment and Classroom Management (3)
Prerequisite: EDSS 300 (A, C, D, F, G, H, M, N, P, or S); or admission in the Single Subject Credential Program; or permission of the University Coordinator of the Single Subject Credential Program. Required course in the Single Subject Credential Program.

EDSE 457 Reading & Writing in Secondary School (3)
Prerequisite: EDSS 300 (A, C, D, F, G, H, M, N, P, or S); or admission in the Single Subject Credential Program; or permission of the University Coordinator of the Single Subject Credential Program. Required course in the Single Subject Credential Program.

Select one course from each of the following pairs:

1. MATH 364A Ordinary Differential Equations I (3)
Prerequisites: MATH 222 or MATH 224, and prerequisite or corequisite MATH 247.

MATH 370A Applied Mathematics I (3)
Prerequisites: A grade of "C" or better in MATH 123. Not open to Freshmen.

2. PHYS 320 Thermodynamics (3)
Prerequisite: PHYS 152. Prerequisite/Corequisite, PHYS 254.

PHYS 422 Statistical Physics (3)
Prerequisites: PHYS 310, PHYS 320, PHYS 350.

3. PHYS 380 Electronics (3)
Prerequisite: PHYS 152.

PHYS 496 Special Problems in Physics (3)
Prerequisites: Consent of instructor and senior standing.

Single Subject Teaching Credential in Physics

In addition to meeting the subject matter competence requirement for the Teaching Credential, prospective Physics teachers are also required to complete 45 units of professional preparation in the Single Subject Credential Program, including student teaching. Students may begin the professional preparation courses as early as the junior year. With careful planning, it is possible to complete many of the credential program courses, except for student teaching, as an undergraduate. Courses may also be started as a post-baccalaureate student. Refer to the Single Subject Teacher Education section of this catalog or the Single Subject Credential Program website (www.ced.csulb.edu/single-subject) for a description of the professional preparation requirements, courses, and application procedures.

The Physics Subject Matter Program is being revised to meet new state standards. When the revised program has been approved by the Commission on Teacher Credentialing, the new course requirements will be in effect and supersede current requirements.

Minor in Physics

Requirements

The Minor in Physics is available to any non-Physics major. A minimum of 20 units which must include the following.

Lower Division:

Take all of the following:

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

PHYS 254 Modern Physics and Light (3)
Prerequisite: PHYS 152 or EE 210; Prerequisite/Corequisite: MATH 224.

Upper Division:

A minimum of 9 units in physics.

Graduate Programs

Master of Science in Physics

This is a comprehensive physics master's degree with options in General Physics or Computational Physics.

Prerequisites

1. A bachelor's degree with a major in physics; or
2. A bachelor's degree with at least 24 units of upper division physics. Students deficient in undergraduate preparation must take courses to remove these deficiencies without credit toward the degree at the discretion of graduate advisor.

Requirements

Take all of the following:

PHYS 510 Graduate Mechanics (3)
Prerequisite: PHYS 310.

PHYS 522 Statistical Physics (3)
Prerequisites: PHYS 310, PHYS 320, PHYS 350.

PHYS 540A Graduate Electrodynamics I (3)
Prerequisite: PHYS 340B.

PHYS 550A Quantum Mechanics I (3)
Prerequisite: PHYS 450.

PHYS 560A Mathematical Methods of Physics (3)
Prerequisites: MATH 370A,B or equivalent.

Take one of the following:

PHYS 595 Colloquium (1)
Prerequisite: Consent of instructor

PHYS 695 Colloquium (1)
Prerequisite: Graduate standing.

Take one of the following:

PHYS 545 Experimental Methods in Physics I (3)
Prerequisites: PHYS 254; PHYS 450 or consent of instructor.

PHYS 546 Experimental Methods in Physics II (3)
Prerequisites: PHYS 254; PHYS 450 or consent of instructor.

PHYS 575 Modern Optics (3)
Prerequisite: PHYS 340A or consent of instructor.

PHYS 580 Computer Interfacing in Experimental Physics (3)
Prerequisite: PHYS 380 or consent of instructor.

In addition, students may opt for one of two plans:

General Physics Plan

Take the following course:

PHYS 550B Quantum Mechanics II (3)
Prerequisite: PHYS 550A.

Take one of the following two choices after consultation with the graduate advisor:

1. Completion of at least 2 additional units of graduate-level PHYS courses, 6 units of PHYS 698, a written thesis approved by the student's thesis committee consisting of a thesis chair (a Physics/Astronomy faculty member) and at least two more members, one of which must be a member of the Department, and an oral presentation of the thesis research. Note: Students must be advanced to candidacy before enrolling in PHYS 698.
2. With the permission of the Graduate committee, an additional 8 units of 500-level PHYS courses, and satisfactorily complete a comprehensive examination.

Computational Physics Plan

Take the following courses:

PHYS 550B Quantum Mechanics II (3)
Prerequisite: PHYS 550A.

PHYS 562 Computational Methods in Theoretical Physics (3)
Prerequisite: PHYS 450

Take 6 units of the following:

PHYS 698 Thesis (6)
Prerequisite: Advancement to candidacy for the M.S. in Physics.

A written thesis approved by the student's thesis committee consisting of a thesis chair (a Physics/Astronomy faculty member) and at least two more members, one of which must be a member of the Department, and an oral presentation of the thesis research.

Note: Students must be advanced to candidacy before enrolling in PHYS 698.

Advancement to Candidacy

1. Students must fulfill the University requirements for advancement to candidacy.
2. A student must have a "B" average or better in six units of physics applicable toward the master's degree, of which at least three units are at the graduate level.
3. Recognizing that effective organization and verbal communication of physics are a necessary part of a successful graduate program, the Department of Physics and Astronomy normally requires that a graduate student serve at least one semester as a teaching associate or a graduate assistant as part of the M.S. program. Exceptions may be granted by the Graduate Advisor.
4. Approval of the degree program by the graduate advisor, the Department Chair, Associate Dean in the College of Natural Sciences and Mathematics or designee.

Option in Applied Physics

The Option in Applied Physics provides a master's degree program that emphasizes concepts and techniques particularly appropriate for applied physics. It is intended for students having a background in physics, engineering, or a related field.

Prerequisites

1. A bachelor's degree with a major in physics, or
2. A bachelor's degree with a major in engineering with upper division physics substantially equivalent to PHYS 310, PHYS 340A,B, and PHYS 450, as determined by the graduate advisor, or
3. A bachelor's degree with upper division physics and mathematics courses essentially equivalent to PHYS 310, PHYS 340B, PHYS 450; and MATH 370A,B; as determined by the graduate advisor.

Students deficient in undergraduate preparation must take courses to remove deficiencies as determined by the graduate advisor.

Requirements

Take all of the following:

PHYS 510 Graduate Mechanics (3)
Prerequisite: PHYS 310.

PHYS 522 Statistical Physics (3)
Prerequisites: PHYS 310, PHYS 320, PHYS 350.

PHYS 540A Graduate Electrodynamics I (3)
Prerequisite: PHYS 340B.

PHYS 550A Quantum Mechanics I (3)
Prerequisite: PHYS 450.

PHYS 560A Mathematical Methods of Physics (3)
Prerequisites: MATH 370A,B or equivalent.

PHYS 695 Colloquium (1)
Prerequisite: Graduate standing.

Take two courses of the following (one must be 545 or 546):

PHYS 545 Experimental Methods in Physics I (3)
Prerequisites: PHYS 254; PHYS 450 or consent of instructor.

PHYS 546 Experimental Methods in Physics II (3)
Prerequisites: PHYS 254; PHYS 450 or consent of instructor.

PHYS 576 Modern Optics with Laboratory (3)
Prerequisite: PHYS 340A.

PHYS 580 Computer Interfacing in Experimental Physics (3)
Prerequisite: PHYS 380 or consent of instructor.

Completion of the following:

Take 2 additional units of graduate-level PHYS course;

Take 6 units of the following:

PHYS 698 Thesis (6)
Prerequisite: Advancement to candidacy for the M.S. in Physics.

A written thesis approved by the student's thesis committee consisting of a thesis chair (a Physics/ Astronomy faculty member) and at least two more members, one of which must be a member of the Department. An oral presentation of the thesis research is also required.

Note: Students must be advanced to candidacy before enrolling in PHYS 698.

Advancement to Candidacy

1. Students must fulfill the University requirements for advancement to candidacy.
2. A student must have a "B" average or better in six units of physics applicable toward the master's degree, of which at least three units are at the graduate level.
3. Recognizing that effective organization and verbal communication of physics are a necessary part of a successful graduate program, the Department of Physics and Astronomy normally requires that a graduate student serve at least one semester as a teaching associate or a graduate assistant as part of the M.S. program. Exceptions may be granted by the Graduate Advisor.
4. Approval of the degree program by the graduate advisor, the Department Chair and Associate Dean in the College of Natural Sciences and Mathematics.

Master of Science in Professional Physics

This is a terminal physics master's degree intended for students pursuing industrial professional careers.

Prerequisites

1) A bachelor's degree with a major in physics; or
2) A bachelor's degree with at least 24 units of upper division physics. Students deficient in upper division undergraduate preparation must take courses to remove these deficiencies without credit toward the degree at the discretion of the graduate advisor.

Requirements

Take all of the following:

- PHYS 510 Graduate Mechanics (3)

Prerequisite: PHYS 310.

- PHYS 522 Statistical Physics (3)

Prerequisites: PHYS 310, 320, 350.

- PHYS 540A Graduate Electrodynamics I (3)

Prerequisite: PHYS 340B.

- PHYS 550A Quantum Mechanics I (3)

Prerequisite: PHYS 450.

- PHYS 560A Mathematical Methods of Physics (3)

Prerequisites: MATH 370A,B or equivalent.

- One elective from 500-level PHYS courses (3)

Take three of the following:

- NSCI 501 Project Management for Scientists (3)
- NSCI 502 Leadership and Management for Scientists (3)
- NSCI 503 Accounting and Finance for Scientists (3)
- NSCI 504 Introduction to Regulatory Science (3)
- NSCI 505 Professional Ethics (3)
- PHYS 692 Internship (3)

Take 4 units of the following:

- PHYS 699 Professional Project (4)

Prerequisite: Advancement to candidacy for the MS in Professional Physics.

Culminating Experience:

The program culminates with a professional project. The professional project is a significant undertaking that aims to apply fundamental physics methods and business-professional skills to situations relevant to the industry environment. Students are to demonstrate professional attributes expected in industry and to communicate the findings to a diverse audience. The project plan must be prepared by the student before advancing to candidacy. The project plan includes a specific set of advanced skills to be demonstrated and a specific timeline for the activities that must be completed. Students will engage the equivalent of 4-units of work on the professional project. The project report must demonstrate core competencies developed through the curriculum and reflect how the student integrates this knowledge into a project in industry. The completed project will include a written project report and oral defense.

Advancement to Candidacy

1) Attainment of classified status as a student in a graduate program at CSULB;
2) Fulfillment of the Graduation Writing Assessment Requirement (GWAR);
3) Approval of the program of study by the Graduate Advisor, the Department Chair, and the Associate Dean in the College of Natural Sciences and Mathematics;
4) Completion with a minimum GPA of 3.0 of at least six units of courses required on the student's program of study;
5) A cumulative, graduate, grade-point average of at least 3.0 calculated on all upper-division and graduate-level coursework attempted by the student at CSULB after completion of a baccalaureate degree.

Single Subject Teaching Credential in Physics

For information, refer to the undergraduate section in this department.

Physics Courses (PHYS)

LOWER DIVISION

100A,B. General Physics (4,4) F,S

Prerequisite: PHYS 100A: MATH 109 or MATH 113 or MATH 119A or MATH 122.

PHYS 100B: PHYS 100A.

Year course in introductory physics. First semester considers properties of matter, mechanics, wave motion, and heat. Second semester considers electricity, light, and atomic and nuclear physics.

Letter grade only (A-F). (Lecture 3 hrs, laboratory 3 hrs.)

151. Mechanics and Heat (4) F,S

Prerequisite/Corequisite: MATH 122.

Kinematics, Newton's Laws, rotational motion, fluid statics, laws of thermodynamics.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

152. Electricity and Magnetism (4) F,S

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Mechanical waves, Coulomb's law, electrostatics, electric circuits, introductory electronics, magnetic fields, induction and Maxwell's equations.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

254. Applied Modern Physics (3) F,S

Prerequisite: PHYS 152 or EE 210; Prerequisite/Corequisite: MATH 224.

Geometrical and physical optics, models of atomic and condensed matter systems.

Not open for credit to students with a "C" or better in PHYS 153 or PHYS 154. Letter grade only (A-F). (Lecture 3 hrs.)

255. Laboratory on Modern Physics (1)

Prerequisite/Corequisite: PHYS 254.

Experimental work in optics and modern physics.

Not open for credit to students with a "C" or better in PHYS 153 or PHYS 155. PHYS 255 is equivalent to PHYS 155. Letter grade only (A-F). (Laboratory 3 hrs.)

UPPER DIVISION

310. Analytic Mechanics (3) F

Prerequisite: PHYS 151. Corequisite: MATH 364A or MATH 370A.

Kinematics and dynamics of mass points and systems of particles. Conservation laws. Harmonic motion. Central force problem. Noninertial frames of reference. Lagrangian and Hamiltonian formulation of laws of mechanics.

Letter grade only (A-F). (Lecture 3 hrs.)

320. Thermodynamics (3) F

Prerequisite: PHYS 152. Prerequisite/Corequisite, PHYS 254.

Laws of thermodynamics, thermodynamic potentials, kinetic theory methods, phase transitions, equilibrium ensembles and related formalism with applications to classical and quantum systems.

Letter grade only (A-F). (Lecture 3 hrs.)

340A. Electricity and Magnetism I (3) S

Prerequisites: PHYS 152, PHYS 310. Prerequisite/Corequisite: MATH 370A or MATH 364A.

Vector calculus, electrostatics, and magnetostatics. Formulation of Maxwell's equations in vector analytic form.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

340B. Electricity and Magnetism II (3) F

Prerequisite: PHYS 340A.

Special relativity. Applications of Maxwell's equations: Plane electromagnetic waves, guided waves, radiation, interaction of electromagnetic waves and matter.

(Lecture-discussion 3 hrs.)

350. Modern Physics (3) S

Prerequisites: PHYS 310; MATH 370A or MATH 364A.

Physical phenomena and models leading to development of quantum mechanics. Schroedinger equation, one-dimensional quantum mechanical problems, uncertainty principle, one-electron atoms, elementary applications of quantum mechanics.

(Lecture-discussion 3 hrs.)

360. Physics With Symbolic Algebra Software (3)

Prerequisite: PHYS 254. Prerequisite/Corerequisite: MATH 247.

Learning symbolic algebra programming (e.g. Mathematica) to enhance the problem-solving abilities of students in physics, engineering and mathematics. Interpolation and fitting of experimental data. Sophisticated graphics, animations, analytic calculations, and numerical solutions for a variety of physics problems.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

380. Electronics (4) S

Prerequisite: PHYS 152.

Network analysis and complex impedance, transistor circuits, operational amplifiers, active filters and oscillators, digital electronics, analog-digital interfacing, microprocessors.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

385. Materials Science (3)

Prerequisite: CHEM 111A and PHSY 152 and (CHEM 111B or PHYS 320), completion of CHEM 11B is strongly recommended.

Introduction to general principles of energy materials including catalytics, photovoltaic, and thermoelectric materials based on nanostructural and/or nanoporous systems. Students will be required to complete preparatory modules on Kinetics (reaction dynamics), Electrochemistry, Fermi statistics, and Diodes.

Letter grade only (A-F). Same course as CHEM 385. Not open for credit to students with credit in CHEM 385.

385L. Materials Science Laboratory (2)

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended

Introduction to synthesis, characterization methods, and property measurement of advanced materials

Letter grade only (A-F), Course fee may be required. (Laboratory 6 hours). Same course as CHEM 385L. Not open for credit to students with credit in CHEM 385L.

385C. Materials Science Colloquium (1)

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended.

Discussion of advances as reported in recent literature related to energy materials. Provides experience in library use, organization, presentation, and critical evaluation of the literature.

Letter grade only (A-F). Same course as CHEM 385C. Not open for credit to students with credit in CHEM 385C.

390. Exploring Physics Teaching (3)

Prerequisite: PHYS 151 and consent of instructor.

Exploration of teaching physics as a learning assistant in secondary physics classrooms and in the lower-level laboratories and tutorials of the college physics curriculum. An exploration of the profession of teaching physics at many levels.

(Lecture, 3 hrs)

410./515. Relativity (3)

Prerequisite: PHYS 340A. Prerequisite/Corequisite: MATH 370A or MATH 364A. (Undergraduates enroll in PHYS 410; graduates enroll in PHYS 515.)

Lorentz transformation, relativistic kinematics and dynamics, 4-vectors and tensors, transformation of electric and magnetic fields, covariant form of Maxwell's equations, introduction to general relativity.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

422./522. Statistical Physics (3) S

Prerequisites: PHYS 310, PHYS 320, PHYS 350. (Undergraduates enroll in PHYS 422; graduates enroll in PHYS 522.)

Entropy and temperature, Boltzmann distribution and Helmholtz free energy, thermal radiation, chemical potential, Gibbs distribution, ideal gas, Fermi and Bose gases, heat and work, Gibbs free energy and chemical reactions, phase transformations and kinetic theory.

Letter grade only (A-F). (Lec-discussion 3 hrs)

434./534. Astrophysics (3)

Prerequisites: PHYS 310, PHYS 320, and PHYS 340A or consent of the instructor. (Undergraduates enroll in PHYS 434; graduates enroll in PHYS 534.)

Topics in astrophysics. A particular semester schedule might include one or two topics from: Stellar interiors and evolution, radiative transfer and stellar atmospheres, relativistic cosmology, galaxy formation, accretion disk physics and quasars.

Letter grade only (A-F). (Lecture 3 hrs)

445./545. Experimental Methods in Physics I (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor. (Undergraduates enroll in PHYS 445; graduates enroll in PHYS 545.)

Modern physical measurement techniques including scanning probe microscopy and pulsed nuclear magnetic resonance. Noise and fluctuations in physical measurements. Low noise measurement techniques including lock-in amplifier, gated integrator and boxcar averager, bridge circuits, convolution, auto- and cross-correlation and FFT.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

446./546. Experimental Methods in Physics II (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor. (Undergraduates enroll in PHYS 446; graduates enroll in PHYS 546.)

Modern physical measurement techniques in condensed matter physics in high magnetic fields and low temperatures. Examples are temperature and magnetic field effects in magnetic materials, Meissner effect and superconducting transition temperature in superconductors, and mobility and Hall effect in semiconductors.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

450. Quantum Physics I (3) F

Prerequisites: PHYS 310, PHYS 340A, PHYS 350.

Schroedinger equation, atomic physics, harmonic oscillator, scattering, perturbation theory, Heisenberg and Dirac representations, spin, symmetries (angular momentum, time reversal, and parity), applications.

(Lec-discussion 3 hrs.)

451. Quantum Physics II (3)

Prerequisite: PHYS 450.

Measurement processes, atomic physics, identical particles, quantum statistics, numerical methods, many-body systems, density matrix, applications.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

470./569. Introduction to Solid State Physics (3)

Prerequisite: PHYS 450. (Undergraduates enroll in PHYS 470; graduates enroll in PHYS 569.)

Study of properties of solids from quantum theoretical viewpoint. Includes lattice vibratons, elastic constants, and thermal, electric, and magnetic properties.

Letter grade only (A-F). (Lecture 3 hrs.)

476./576. Modern Optics with Laboratory (3)

Prerequisite: PHYS 340A. (Undergraduates enroll in PHYS 476; graduates enroll in PHYS 576.)

Propagation of electromagnetic waves, optical resonators, laser spectroscopy and operation, optical phase conjugation, nonlinear optics and selected application. Experiments illustrating principles and techniques of electro-optics and laser physics. Applications include optical methods in communications, atomic spectroscopy, and nonlinear optics.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

480./580. Computer Interfacing in Experimental Physics (3)

Prerequisite: PHYS 380 or consent of instructor. (Undergraduates enroll in PHYS 480; graduates enroll in PHYS 580.)

Modern data acquisition and analysis methods using computer-based equipment and high level software. Physics experiments performed with standard personal computers, research-quality data acquisition hardware, and programmable instruments. Computer use as tool in execution and interpretation of experiments.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

490./590. Selected Topics in Physics (3)

Prerequisite: Consent of instructor. (Undergraduates enroll in PHYS 490; graduates enroll in PHYS 590.)

Physics topics selected from such areas as atomic and nuclear physics, astrophysics, physics of materials, low temperature physics, acoustics, and theoretical physics.

May be repeated to a maximum of 6 units. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.)

491A. Pedagogical Content Knowledge in Physics - Force and Motion (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Force and Motion.

Letter grade only (A-F). (Seminar 3 hrs)

491B. Pedagogical Content Knowledge in Physics - Energ and Momentum (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Energy and Momentum.

Letter grade only (A-F). (Seminar 3 hrs)

491C. Pedagogical Content Knowledge in Physics - Waves and Optics (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Waves and Optics.

Letter grade only (A-F). (Seminar 3 hrs)

491D. Pedagogical Content Knowledge in Physics - Electrcity and Magnetism (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Electricity and Magnetism.

Letter grade only (A-F). (Seminar 3 hrs)

491E. Pedagogical Content Knowledge in Physics - Nuclear and Thermal (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Nuclear, Thermal.

Letter grade only (A-F). (Seminar 3 hrs)

495./595. Colloquium (1)

Prerequisite: Consent of instructor.

Weekly meetings for presentation and discussion of current research in physics.

Credit /No credit grading only. (Seminar 1 hr) (Undergraduates enroll in PHYS 495; graduate students enroll in PHYS 595)

496. Special Problems in Physics (1-3)

Prerequisites: Consent of instructor and senior standing.

Physics problems selected by instructor for considered and mature analysis. Written and 10-minute oral reports required.

GRADUATE LEVEL

510. Graduate Mechanics (3) F

Prerequisite: PHYS 310.

Variational principles, Lagrange's equations, Hamilton's equations, canonical transformations, Hamilton-Jacobi theory, relativistic mechanics and small oscillation theory.

Letter grade only (A-F). (Lecture 4 hrs.)

515./410. Relativity (3)

Prerequisite: PHYS 340A. Prerequisite/Corequisite: MATH 370A or MATH 364A. (Undergraduates enroll in PHYS 410; graduates enroll in PHYS 515.)

Lorentz transformation, relativistic kinematics and dynamics, 4-vectors and tensors, transformation of electric and magnetic fields, covariant form of Maxwell's equations, introduction to general relativity.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

522./422. Statistical Physics (3) S

Prerequisites: PHYS 310, PHYS 320, PHYS 350. (Undergraduates enroll in PHYS 422; graduates enroll in PHYS 522.)

Entropy and temperature, Boltzmann distribution and Helmholtz free energy, thermal radiation, chemical potential, Gibbs distribution, ideal gas, Fermi and Bose gases, heat and work, Gibbs free energy and chemical reactions, phase transformations and kinetic theory.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

534./434. Astrophysics (3)

Prerequisites: PHYS 310, PHYS 320, and PHYS 340A or consent of the instructor. (Undergraduates enroll in PHYS 434; graduates enroll in PHYS 534.)

Topics in astrophysics. A particular semester schedule might include one or two topics from: Stellar interiors and evolution, radiative transfer and stellar atmospheres, relativistic cosmology, galaxy formation, accretion disk physics and quasars.

Letter grade only (A-F). (Lecture 3 hrs)

540A.Graduate Electrodynamics (3) S

Prerequisite: PHYS 340B.

Boundary-value problems, applications of special functions to electro/magnetostatics, Green's function techniques, multipole expansion of electrostatic field, dielectric media, Maxwell's equations, electromagnetic waves.

Letter grade only (A-F). (Lecture 3 hrs.)

545./445. Experimental Methods in Physics I (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor. (Undergraduates enroll in PHYS 445; graduates enroll in PHYS 545.)

Modern physical measurement techniques including scanning probe microscopy and pulsed nuclear magnetic resonance. Noise and fluctuations in physical measurements. Low noise measurement techniques including lock-in amplifier, gated integrator and boxcar averager, bridge circuits, convolution, auto- and cross-correlation and FFT.

Letter grade only (A-F). (Lecture 2 hrs, laboratory 3 hrs)

546./446. Experimental Methods in Physics II (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor. (Undergraduates enroll in PHYS 446; graduates enroll in PHYS 546.)

Modern physical measurement techniques in condensed matter physics in high magnetic fields and low temperatures. Examples are temperature and magnetic field effects in magnetic materials, Meissner effect and superconducting transition temperature in superconductors, and mobility and Hall effect in semiconductors.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

550A. Quantum Mechanics I (3) F

Prerequisite: PHYS 450.

Mathematical and postulational basis of quantum mechanics, one-dimensional problems, two-level systems, angular momentum, central potentials, time independent and time dependent perturbation theory.

Letter grade only (A-F). (Lecture 3 hrs.)

550B. Quantum Mechanics II (3) S

Prerequisite: PHYS 550A.

Scattering, rotation group and irreducible tensor operations, identical particles, semi-classical radiation theory, atoms, path integral formalism, and other selected topics.

Letter grade only (A-F). (Lecture 3 hrs.)

554. Nuclear Physics (3)

Prerequisite: PHYS 550A.

Deuteron problem, nucleon-nucleon potential, shell model, nuclear models, nuclear reactions, elementary particles, weak interactions, strong interactions.

Letter grade only (A-F). (Lecture 3 hrs.)

555. Elementary Particle Physics (3)

Prerequisites: PHYS 310, PHYS 340B, PHYS 450.

Feynman diagram language of scattering and decay, space-time symmetries, relativistic kinematics, hadron quantum numbers and quark models, QED, QCD and gluons, weak interactions.

Letter grade only (A-F). (Lecture 3 hrs.)

560A. Mathematical Methods of Physics (3,3)

Prerequisites: MATH 370A,B or equivalent.

Linear vector spaces, eigenvalue problem, functions of complex variable, special functions, properties and methods of solving partial differential equations of physics, integral equations, tensor analysis, and group theory.

Letter grade only (A-F). (Lecture 4,3 hrs.)

562. Advanced Computational Methods in Physics (3)

Prerequisite: PHYS 450

Computational methods applied to study advanced physics problems such as symbolic and numerical programming, and their applications in various fields (e.g. quantum mechanics, electrodynamics, statistical physics, condensed matter physics, astrophysics, atomic and subatomic physics, etc.)

Letter grade only (A-F). (Lecture 3 hrs.)

569./470. Introduction to Solid State Physics (3)

Prerequisite: PHYS 450. (Undergraduates enroll in PHYS 470; graduates enroll in PHYS 569.)

Study of the properties of solids from a quantum theoretical viewpoint. Topics include lattice vibrations, elastic constants, and thermal, electric and magnetic properties.

Letter grade only (A-F). (Lecture 3 hrs.)

576./476. Modern Optics with Laboratory (3)

Prerequisite: PHYS 340A. (Undergraduates enroll in PHYS 476; graduates enroll in PHYS 576.)

Propagation of electromagnetic waves, optical resonators, laser spectroscopy and operation, optical phase conjugation, nonlinear optics and selected application. Experiments illustrating principles and techniques of electro-optics and laser physics. Applications include optical methods in communications, atomic spectroscopy, and nonlinear optics.

Letter grade only (A-F). (Lecture 2 hrs laboratory 3 hrs)

580./480. Computer Interfacing in Experimental Physics (3)

Prerequisite: PHYS 380 or consent of instructor. (Undergraduates enroll in PHYS 480; graduates enroll in PHYS 580.)

Modern data acquisition and analysis methods using computer-based equipment and high level software. Physics experiments performed with standard personal computers, research-quality data acquisition hardware, and programmable instruments. Computer use as tool in execution and interpretation of experiments.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

590./490. Selected Topics in Physics (3)

Prerequisite: Consent of instructor. (Undergraduates enroll in PHYS 490; graduates enroll in PHYS 590.)

Physics topics selected from such areas as atomic and nuclear physics, astrophysics, physics of materials, low temperature physics, acoustics, and theoretical physics.

May be repeated to a maximum of 6 units. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.)

595./495. Colloquium (1)

Prerequisite: Consent of instructor

Weekly meetings for presentation and discussion of current research in physics. (Undergraduates enroll in PHYS 495; graduate students enroll in PHYS 595) Credit /No credit grading only. (Seminar 1 hr)

691. Directed Study (1)

Intensive study of advanced topics in physics.

May be repeated to a maximum of 2 units. Letter grade only (A-F).

692. Professional Physics Internship (1-4)

Prerequisite: Graduate standing in physics.

Internship in an industrial setting using advanced professional physics skills. An oral presentation is required. May be repeated to a maximum of 4 units in different semesters.

Credit/ No Credit grading only. (1-4 hours contact)

694. Seminar in Special Topics (1)

Prerequisite: Graduate standing.

Study of research papers and research methods in selected topics. If demand for more than one subject exists, multiple sections may be given in any one semester.

May be repeated to a maximum of 2 units; only 1 unit may be applied to the master's degree. Letter grade only (A-F). (Seminar 1 hr.)

695. Colloquium (1)

Prerequisite: Graduate standing.

Weekly meetings for presentation and discussion of current research in physics. Even though only 1 unit is for M.S. degree, graduate students are expected to attend each semester they are enrolled in University.

Credit/No Credit grading only. (Seminar 1 hr.)

697. Directed Research (1-3)

Theoretical and experimental problems in physics requiring intensive analysis.

Letter grade only (A-F).

698. Thesis (1-6)

Prerequisite: Advancement to candidacy for the M.S. in Physics.

Planning, preparation, and completion of acceptable thesis in partial fulfillment of requirements for master's degree. A half-hour seminar presenting and defending results of the thesis required. Credit obtained upon formal acceptance of thesis.

699. Professional Project (1-4)

Prerequisite: Advancement to candidacy in the Masters of Science in Professional Physics deree program.

A significant project undertaken to gain and demonstrate fluency with advanced methods of physics as it is used professionally. The project will demonstrate the acquisition of skills. An oral presentation is required.

Credit/No Credit grading only. May be repeated to a maximum 4 units in different semesters.

Astronomy Courses (ASTR)

LOWER DIVISION

100. Astronomy (3) F,S

Corequisites: One course from General Education Category B.2 and ASTR 100L.

Introductory course in astronomy. The earth moon system and the planets, the stars and their constitution. Survey of the methods of astronomical observation.

(Lecture 3 hrs.)

100L. Introductory Astronomy Laboratory (1) F,S

Prerequisites/Corequisites: One course from Category B.2 of GE requirements; ASTR 100.

Astronomical coordinates, star maps, magnitude, spectral classification, ages of stars, distance to star clusters.

Not open for credit to students with credit in ASTR 101. (Laboratory 3 hrs.)

UPPER DIVISION

370. Planetary Environments (3)

Prerequisites: GE Foundation requirements and GE B.1.b category; upper division standing.

Planets and moons analyzed as to surface geology, interiors, atmospheres, etc. Methodologies and scientific reasoning about nature and origins of features. Origin of terrestrial life, including role of extinction events, and probable requirements for life elsewhere in universe.

(Lecture 3 hrs.)

Physical Science Courses (PHSC)

LOWER DIVISION

112. Introduction to the Physical Sciences (3) F,S

Prerequisite/Corequisite: One course from Category B.2 of GE Foundation.

Selected processes which illustrate some basic principles used by scientists to interpret modern ideas of matter and energy in physical universe.

Not open for credit to majors in any of the physical sciences. (Lecture 2 hrs., laboratory 3 hrs.)