PHYSICS

Undergraduate Program Information
A bachelor’s degree in physics or engineering physics provides the basis for careers in industry, teaching, the military, government or for study toward advanced degrees in physics or engineering. It should also provide the skills that recipients of physics degrees have listed as among the most important in obtaining their current positions, including problem solving ability, computer skills, mathematical skills, and laboratory skills, as well as knowledge of physics.

Further information about the department may be found on the web at www.physics.nmsu.edu. All incoming (new or transfer) students must schedule an orientation meeting with the department head and/or the undergraduate program head before their first semester at NMSU. All students will be assigned a faculty advisor in the physics department to discuss course selection, career resources, internships and coops, and other topics.

Graduate Program Information
The Department of Physics offers programs in many areas of emphasis leading to the MS and Ph.D. degrees. Admission to these programs is competitive and selection of applicants is based on undergraduate and/or previous graduate grade-point averages, performance on the general and subject Graduate Record Examination, other evidence of prior academic and research accomplishments submitted by the applicant, and reference letters, as well as, in the case of applicants for the doctoral program, matching of the applicant’s research interests, as described by the student’s statement of purpose, to the Department’s research activities.

All degree-seeking graduate students must satisfy the relevant Graduate School requirements, successfully complete a 3-credit, 500-level laboratory, and demonstrate or develop knowledge of computer programming. All Ph.D. students and non-thesis Master’s students must pass a qualifying examination based on undergraduate physics courses at the 400 level. Additional course requirements are described below; courses taken S/U may not be used to satisfy any of the degree requirements, including the lab requirement for Master’s and Ph.D. students.

The qualifying and comprehensive examination outcomes are decided by vote of the entire faculty, based on the recommendations of the corresponding examination committees. For the qualifying examination, the faculty may decide that

- a student pass at the doctoral level;
- pass at the master’s level;
- be requested to retake the exam at the next available opportunity; or
- terminate graduate study.

For the written part of the comprehensive examination, the faculty may decide that

- a student be given an unconditional pass;
- be given a conditional pass, with the requirement that the student produce additional evidence of research accomplishments during the oral part of the exam before being granted admission to candidacy;
- repeat the written part the next time it is offered; or
- terminate graduate study.

In addition, the faculty may decide to discontinue financial support to a student based on the student’s performance on the qualifying or comprehensive examination. Students will receive written notification of the exam’s outcome from the Graduate Physics Program Head within 30 days of the exam. Appeals must be addressed to the Physics Department Head within 30 days of receiving written notification of the exam’s outcome and will be decided by the physics faculty.

A student granted an unconditional or conditional pass on the written part of the comprehensive examination must take the oral part in the same semester that the written part was taken; the student’s Ph.D. committee makes the final decision, following the oral part of the comprehensive examination, on admission of the student to the candidacy to the doctoral degree.

Students may choose areas of emphasis from a variety of experimental, theoretical and computational research programs in the department. The current major research areas of the department include atmospheric physics, condensed matter physics/materials science, geophysics, optics, particle and nuclear physics, physics education, and others. These research projects are supported by multimillion-dollar funding by various federal agencies and two national laboratories within the state of New Mexico: Los Alamos National Laboratory and Sandia National Laboratories. In addition to the in-house research, the department conducts collaborative research programs with

- The Brookhaven National Laboratory,
- The Center for Integrated NanoTechnologies,
- Los Alamos National Laboratory,
- Sandia National Laboratories,
- The Thomas Jefferson Laboratory,
- Fermilab,
- Air Force Research Laboratory and
- other national and international laboratories.

The MS in Physics with a concentration in Space Physics program provides students with a strong foundation in physics with an intensive focus on space physics. Graduate study in space physics at the master’s level prepares graduates for continued and specialized study toward the doctorate program in space-related fields as well as for challenges they will confront in space industrial and government settings.

The department is housed in a newly-renovated building which contains research laboratories, classrooms, offices and a computational laboratory.

**Degrees for the Department**

**Bachelor Degree(s)**

- Physics - Bachelor of Arts
- Physics - Bachelor of Science
- Physics (Applied Physics) - Bachelor of Science
- Physics (Computational Physics) - Bachelor of Science
- Physics (Geophysics) - Bachelor of Science
- Physics (Materials Sciences) - Bachelor of Science
Physics (Optics) - Bachelor of Science

Engineering Physics - Bachelor of Science in Engineering Physics

Master Degree(s)
Physics - Master of Science

Physics (Space Physics) - Master of Science - Master of Science

Doctoral Degree(s)
Physics - Doctor of Philosophy

Dual Degree
Physics - Bachelor of Science/Master of Science (scroll to bottom of the B.S. Page for more information)

Minors for the Department
Undergraduate
Physics - Undergraduate Minor

Graduate
Physics - Graduate Minor

Professor, Stefan Zollner, Department Head

Professor, Stephen Pate, Undergraduate Program Head

Professor, Vassili Papavassiliou, Graduate Program Head

Professor, Heinz Nakotte, Engineering Physics Program Head

Professors Ma. Burkardt, Engelhardt, Kiefer, Nakotte, Papavassiliou, Pate, Vasiliev, Zollner; Associate Professors Hearn, Urquidi; Assistant Professors Cooper, Schlegel, Waszek; College Professors Mi. Burkardt, DeAntonio; Emeritus Faculty Burleson, Gibbs, Goedecke, Kanim, Kyle, Liefeld, Ni.

Graduate Faculty S. Zollner, Department Head, Ph.D. (Stuttgart)– experimental condensed matter and applied physics; V. Papavassiliou, Graduate Program Head, Ph.D. (Yale)– nuclear and particle physics; C. W. Bruce, Ph.D. (New Mexico State)– applied optics; M. Burkardt, Ph.D. (Erlangen)– theoretical nuclear and particle physics; R. Cooper, Ph.D. (Michigan)– nuclear and particle physics; M. DeAntonio, Ph.D. (New Mexico State)– applied optics; M. Engelhardt, Ph.D. (Erlangen)– computational nuclear and particle physics; E. Fohtung, Ph.D. (Freiburg)– materials science, neutron and X-ray scattering; G. H. Goedecke, Ph.D. (Rensselaer)– theoretical physics, optics; T. M. Hearn, Ph.D. (Cal Tech)– seismic tomography, seismology, S. Kanim, Ph.D. (University of Washington)– Physics Education; B. Kiefer, Ph.D. (Michigan)– computational condensed matter physics, mineral physics; H. Nakotte, Ph.D. (Amsterdam)– materials science, neutron scattering; J. Ni, Ph.D. (Cornell)– geophysics, seismology; S. F. Pate, Ph.D. (Pennsylvania)– nuclear and particle physics; M. Schlegel, Ph.D. (Bochum)– theoretical nuclear and particle physics; J. Urquidi, Ph.D. (Texas Tech)– materials science, neutron and X-ray scattering; I. Vasiliev, Ph.D. (Minnesota)– computational materials science; L. Waszek, Ph.D. (Cambridge)– geophysics, seismology; P. T. Webster, Ph.D. (Arizona State)– materials science.

Geophysics Courses

GPHY 340V. Planet Earth
3 Credits (3)

GPHY 450. Selected Topics
1-3 Credits
Readings, discussions, lectures or laboratory studies of selected areas of geophysics. May be repeated for a maximum of 12 credits.
Prerequisite: consent of instructor.

GPHY 510. Geophysical Field Methods
1-3 Credits (3-9P)
Field collection, reduction, and interpretation of geophysical data; equipment operation.

GPHY 520. Selected Topics
1-3 Credits
Formal treatment of graduate topics not covered in regular courses. May be repeated for unlimited credit.
Prerequisites: graduate standing, consent of instructor, and selection of a specific topic prior to registration.

GPHY 560. Applied Inverse Theory
3 Credits (3)
Inversion of data with an emphasis on geophysical problems. Curve fitting, tomography, earthquake location, over determined and under determined problems, linear and nonlinear problems. Computing experience desirable. Consent of Instructor required.

GPHY 598. Special Research Problems
1-3 Credits
Individual investigations, either analytical or experimental. May be repeated for unlimited credit.

GPHY 599. Master's Thesis
1-15 Credits (1-15)
Thesis.

GPHY 620. Advanced Topics in Geophysics
3 Credits (3)
Advanced formal treatment of a topic or topics not covered in regular courses. May be repeated for unlimited credit.
Prerequisite: consent of instructor.

GPHY 700. Doctoral Dissertation
1-15 Credits (1-15)
Dissertation.

Physics Courses

PHYS 1111. Introductory Computational Physics
3 Credits (2+2P)
Introduction to computational techniques for the solution of physics-related problems.
Prerequisite(s): a C- or better in MATH 1220G or MATH 1250G or MATH 1511G.
PHYS 1112. Introductory Physics for the Health Sciences  
3 Credits (3)  
An algebra-level introduction to topics required for the Health Sciences, including basic mechanics (including sound, mechanical waves and fluids), heat and thermodynamics, electricity and magnetism, optics and electromagnetic waves, atomic and nuclear physics, and applications to medical imaging. Restricted to Community Colleges campuses only.  
Prerequisite(s): MATH 1215 or Equivalent. 

PHYS 1115G. Survey of Physics with Lab  
4 Credits (3+3P)  
Overview of the concepts and basic phenomena of physics. This course provides a largely descriptive and qualitative treatment with a minimum use of elementary mathematics to solve problems. No previous knowledge of physics is assumed. Includes laboratory. 

PHYS 1125G. Physics of Music  
4 Credits (3+2P)  
Introduction for non-science majors to basic concepts, laws, and skills in physics, in the context of a study of sound, acoustics, and music. 

PHYS 1230G. Algebra-Based Physics I  
3 Credits (3)  
An algebra-based treatment of Newtonian mechanics. Topics include kinematics and dynamics in one and two dimensions, conservation of energy and momentum, rotational motion, equilibrium, and fluids. 

PHYS 1230L. Algebra-Based Physics I Lab  
1 Credit (1)  
A series of laboratory experiments associated with the material presented in PHYS 1230G. 
Prerequisite(s)/Corequisite(s): PHYS 1230G. 

PHYS 1240G. Algebra-Based Physics II  
3 Credits (3)  
The second half of a two semester algebra-based introduction to physics. This course covers electricity, magnetism and optics. 
Prerequisite(s): a C- or better in PHYS 1230G or PHYS 2230G. 

PHYS 1240L. Algebra-Based Physics II Lab  
1 Credit (1)  
A series of laboratory experiments associated with the material presented in PHYS 1240G. 
Prerequisite(s)/Corequisite(s): PHYS 1240G. 

PHYS 1241. Problems in Algebra-Based Physics II  
1 Credit (1)  
This is a supplemental course for Algebra-based Physics II. 
Corequisite(s): PHYS 1240G. 

PHYS 1310G. Calculus-Based Physics I  
3 Credits (3)  
A calculus-level treatment of classical mechanics and waves, which is concerned with the physical motion concepts, forces, energy concepts, momentum, rotational motion, angular momentum, gravity, and static equilibrium. May be repeated up to 3 credits. 
Prerequisite(s): a C- or better in MATH 1511G or higher. 

PHYS 1310L. Calculus-Based Physics I Lab  
1 Credit (3P)  
A series of laboratory experiments associated with the material presented in Calculus-based Physics I. Students will apply the principles and concepts highlighting the main objectives covered in coursework for Calculus-based Physics I. 
Prerequisite(s)/Corequisite(s): PHYS 1310G. 

PHYS 1311. Problems in Calculus-Based Physics I  
0.5-1 Credits (.5-1)  
This is a supplemental course for Calculus-based Physics I. May be repeated up to 1 credits. 
Corequisite(s): PHYS 1310G. 

PHYS 1320G. Calculus -Based Physics II  
3 Credits (3)  
A calculus-level treatment of classical electricity and magnetism. It is strongly recommended that this course is taken at the same time as Calculus-based Physics II laboratory. May be repeated up to 3 credits. 
Prerequisite(s): A C- or better in PHYS 2110 or PHYS 1310G and MATH 1521G or higher. 

PHYS 1320L. Calculus -Based Physics II Lab  
1 Credit (3P)  
A series of Laboratory experiments associated with the material presented in Calculus-Based Physics II. Students will apply the principles and concepts highlighting the main objectives covered in coursework for Calculus-Based Physics II. 
Prerequisite(s)/Corequisite(s): PHYS 1320G. 

PHYS 1320G. Calculus -Based Physics II  
3 Credits (3)  
A calculus-level treatment of classical electricity and magnetism. It is strongly recommended that this course is taken at the same time as Calculus-based Physics II laboratory. May be repeated up to 3 credits. 
Prerequisite(s): A C- or better in PHYS 21100 or PHYS 1310G and MATH 1521G or higher. 

PHYS 1321. Problems in Calculus-Based Physics II  
0.5-1 Credits (.5-1)  
This is a supplemental course for Calculus-based Physics II. 
Corequisite(s): PHYS 1320G. 

PHYS 2110. Mechanics  
3 Credits (3)  
Newtonian mechanics. 
Prerequisite(s)/Corequisite(s): MATH 1511G or higher. 

PHYS 2110L. Experimental Mechanics  
1 Credit (3P)  
Laboratory experiments associated with the material presented in PHYS 2110. Science majors. 
Prerequisite(s)/Corequisite(s): PHYS 2110. 

PHYS 2111. Supplemental Instruction to PHYS 2110  
0.5-1 Credits (.5-1)  
This Optional workshop as a supplement to PHYS 2110. The tutorial sessions focus on reasoning and hands-on problem solving. May be repeated up to 1 credits. 
Corequisite(s): PHYS 2110. 

PHYS 2120. Heat, Light, and Sound  
3 Credits (3)  
Calculus-level treatment of thermodynamics, geometrical and physical optics, and sound. May be repeated up to 3 credits. 
Prerequisite(s): a C- or better in PHYS 2110 or PHYS 1310G, and MATH 1511G or higher. 

PHYS 2120L. Heat, Light, and Sound Laboratory  
1 Credit (3P)  
Laboratory experiments associated with the material presented in PHYS 2120. Science majors. 
Prerequisite(s)/Corequisite(s): PHYS 2120. 

PHYS 2121. Supplemental Instruction to PHYS 2120  
0.5-1 Credits (.5-1)  
This optional workshop supplements PHYS 2120 'Heat, Light, and Sound'. Students actively apply concepts and methods introduced in PHYS 2120 to problem solving and quantitative analysis. May be repeated up to 1 credits. 
Corequisite(s): PHYS 2120.
PHYS 2140. Electricity and Magnetism  
3 Credits (3)  
Charges and matter, the electric field, Gauss law, the electric potential, the magnetic field, Ampere's law, Faraday's law, electric circuits, alternating currents, Maxwell's equations, and electromagnetic waves. May be repeated up to 3 credits.  
Prerequisite(s)/Corequisite(s): MATH 1521G. Prerequisite(s): a C- or better in PHYS 2110 or PHYS 1310G, and MATH 1511G or higher.

PHYS 2140L. Electricity & Magnetism Laboratory  
1 Credit (3P)  
Laboratory experiments associated with the material presented in PHYS 2140.  
Prerequisite(s)/Corequisite(s): PHYS 2140. Prerequisite(s): a C- or better in PHYS 2110 or PHYS 1310G.

PHYS 2240G. General Physics for Life Science II  
3 Credits (3)  
This algebra-based introduction to general physics covers mechanics, waves, sound, and heat. Special emphasis is given to applications in the life sciences. This course is recommended for students in the life sciences and those preparing for the physics part of the MCAT. May be repeated up to 3 credits.  
Prerequisite(s): A C or better in MATH 1215 or higher.

PHYS 2240L. Laboratory to General Physics for Life Science II  
1 Credit (1)  
Optional workshop as a supplement to PHYS 2240. The tutorial sessions focus on reasoning and hands-on problem solving. May be repeated up to 1 credits.  
Corequisite(s): PHYS 2140.

PHYS 2230G. General Physics for Life Science I  
3 Credits (3)  
This algebra-based introduction to general physics covers mechanics, waves, sound, and heat. Special emphasis is given to applications in the life sciences. This course is recommended for students in the life sciences and those preparing for the physics part of the MCAT. May be repeated up to 3 credits.  
Prerequisite(s): A C- or better in MATH 1215 or higher.

PHYS 2230L. Laboratory to General Physics for Life Science I  
1 Credit (1)  
Laboratory experiments in topics associated with material presented in PHYS 2230G.  
Prerequisite(s)/Corequisite(s): PHYS 2230G. Restricted to Las Cruces campus only.

PHYS 2231. Supplemental Instruction to General Physics for Life Sciences I  
1 Credit (1)  
This optional workshop supplements Physics for Life Sciences I. The tutorial sessions focus on reasoning and hands-on problem solving. May be repeated up to 1 credits.  
Corequisite(s): PHYS 2230.

PHYS 2240G. General Physics for Life Science II  
3 Credits (3)  
This algebra-based course covers electricity, magnetism, light, atomic physics, and radioactivity. Special emphasis is given to applications in the life sciences. This course is recommended for students in the life sciences and those preparing for the physics part of the MCAT. May be repeated up to 3 credits.  
Prerequisite(s): a C- or better in PHYS 1230G or PHYS 2230G, and MATH 1220G or higher.

PHYS 2240L. Laboratory to General Physics for Life Science II  
1 Credit (1)  
Laboratory experiments in topics associated with material presented in PHYS 2240.  
Prerequisite(s)/Corequisite(s): PHYS 2240G. Restricted to Las Cruces campus only.

PHYS 2241. Supplemental Instruction to General Physics for Life Sciences II  
1 Credit (1)  
This optional workshop is a supplement to Physics for Life Science II. The tutorial sessions focus on reasoning and hands-on problem solving. May be repeated up to 1 credits.  
Corequisite(s): PHYS 2240G.

PHYS 2996. Special Topics  
1-3 Credits  
Topics to be announced in the Schedule of Classes. May be repeated for a maximum of 12 credits.

PHYS 2997. Independent Study  
1-3 Credits  
Individual analytical or laboratory studies directed by a faculty member. May be repeated for a maximum of 6 credits.  
Prerequisite: consent of instructor.

PHYS 303V. Energy and Society in the New Millennium  
3 Credits (3)  
Traditional and alternative sources of energy. Contemporary areas of concern such as the state of depletion of fossil fuels; nuclear energy, solar energy, and other energy sources; environmental effects; nuclear weapons; and health effects of radiation. Discussion of physical principles and impact on society. Focus on scientific questions involved in making decisions in these areas. No physics background required.

PHYS 304. Forensic Physics  
4 Credits (3+3P)  
Theories, laboratory, and field techniques in the area of forensic physics.

PHYS 305V. The Search for Water in the Solar System  
3 Credits (3)  
Examines the formation, abundance and ubiquity of water in our Solar System stemming from comets, Martian and Lunar poles, Earth's interior and into the outer reaches of the Solar System. Topics will include nuclear synthesis, Solar System formation, remote sensing, as well as past, present and future NASA missions for water.

PHYS 315. Modern Physics  
3 Credits (3)  
An introduction to relativity and quantum mechanics, with applications to atoms molecules, solids, nuclei, and elementary particles. May be repeated up to 3 credits.  
Prerequisite(s): a C- or better in MATH 2530G and PHYS 2140 or PHYS 1320G.

PHYS 315 L. Experimental Modern Physics  
4 Credits (3+3P)  
Elementary laboratory in modern physics which supports the subject matter in PHYS 315. Required for physics majors. May be repeated up to 3 credits.  
Prerequisite(s)/Corequisite(s): PHYS 315. Prerequisite(s): a C- or better in PHYS 2140L or 1320L.

PHYS 316. Supplemental Instructions to PHYS 315  
1 Credit (1)  
This optional workshop supplements PHYS 315 'Modern Physics'. Students actively apply concepts and methods introduced in PHYS 315 to problem solving and quantitative analysis.  
Corequisite(s): PHYS 315.
PHYS 325. Intermediate Experimental Physics
3 Credits (1+6P)
An exploration of a variety of experimental techniques in physics with
an emphasis on the proper determination of statistical and systematic
uncertainties. Students will work in teams and prepare professional
written and oral reports of their work.
Prerequisite(s)/Corequisite(s): PHYS 315. Prerequisite(s): a C- or better in
PHYS 2140L or PHYS 1320L.

PHYS 350. Special Topics
1-3 Credits
Lectures, demonstrations, and discussions on such topics as lasers and
holography, energy sources, clouds, and biophysics. May be repeated for
a maximum of 12 credits under different subtitles.

PHYS 380. Individual Study
1-3 Credits
Individual analytical or laboratory studies directed by a faculty member.
May be repeated for a maximum of 6 credits.
Prerequisite: consent of instructor.

PHYS 395. Intermediate Mathematical Methods of Physics
3 Credits (3)
Introduction to the mathematics used in intermediate-level physics
courses. Topics include vector calculus, curvilinear coordinates, matrices,
linear algebra, function spaces, partial differential equations, and special
functions. May be repeated up to 3 credits.
Prerequisite(s)/Corequisite(s): MATH 392. Prerequisite(s): a C- or better in
MATH 2530G.

PHYS 400. Undergraduate Research
1-3 Credits
May be repeated for a maximum of 6 credits.
Prerequisite: consent of instructor.

PHYS 420. Capstone Project I
3 Credits (3P)
Application of engineering physics principles to a significant design
project. Includes teamwork, written and oral communication and realistic
technical, economic and public safety requirements.

PHYS 421. Capstone Project II
3 Credits (3P)
Continuation of PHYS 420.

PHYS 450. Selected Topics
1-3 Credits
Readings, lectures or laboratory studies in selected areas of physics. May
be repeated for a maximum of 12 credits.

PHYS 451. Intermediate Mechanics I
3 Credits (3)
Newtonian mechanics, including an introduction to the Lagrangian
formulation. Topics include central force motion, rigid body motion,
noninertial reference frames, oscillating systems, and classical
scattering.
Prerequisite(s)/Corequisite(s): MATH 392. Prerequisite(s): a C- or better in
PHYS 2110 or PHYS 1310G, and MATH 2530G.

PHYS 454. Intermediate Modern Physics I
3 Credits (3)
Introduction to quantum mechanics, focusing on the role of angular
momentum and symmetries, with application to many atomic and
subatomic systems. Specific topics include intrinsic spin, matrix
representation of wave functions and observables, time evolution, and
motion in one dimension. May be repeated up to 3 credits.
Prerequisite(s)/Corequisite(s): MATH 392 and PHYS 395. Prerequisite(s):
a C- or better in PHYS 315.

PHYS 455. Intermediate Modern Physics II
3 Credits (3)
Continuation of subject matter of PHYS 454. Specific topics include
rotation and translation in three dimensions, solution of central potential
problems, perturbation theory, physics of identical particles, scattering
theory, and the interaction between photons and atoms. May be repeated
up to 3 credits.
Prerequisite(s): a C- or better in PHYS 454, MATH 392, and PHYS 395.

PHYS 461. Intermediate Electricity and Magnetism I
3 Credits (3)
The first part of a two-course sequence in classical electrodynamics.
Covered topics include static electric and magnetic fields, Laplace's and
Poisson's equations, electromagnetic work and energy, Lorentz force,
Gauss's, Biot-Savart, and Ampere's laws, Maxwell's equations, as well as
electric and magnetic fields in matter. May be repeated up to 3 credits.
Prerequisite(s)/Corequisite(s): MATH 392 and PHYS 395. Prerequisite(s):
a C- or better in PHYS 2140 or PHYS 1320G or equivalent and a C- or
better in MATH 2530G.

PHYS 462. Intermediate Electricity and Magnetism II
3 Credits (3)
Continuation of subject matter of PHYS 461. Covered topics include
Maxwell's equations and their applications, electromagnetic waves,
reflection, refraction, dispersion, radiating systems, interference
and diffraction, as well as Lorentz transformations and relativistic
electrodynamics. May be repeated up to 3 credits.
Prerequisite(s): a C- or better in PHYS 461, MATH 392, and PHYS 395.

PHYS 467. Nanoscience and Nanotechnology
3 Credits (3)
This is a lecture/laboratory course designed to present the basic
concepts, the techniques and the tools to synthesize and characterize
nanometer scale materials, and the latest achievements in current
and future nanotechnology applications in engineering, materials,
physics, chemistry, biology, electronics and energy. It is intended
for a multidisciplinary audience with a variety of backgrounds. This
course should be suitable for graduate students as well as advanced
undergraduates. Topics covered will include: nanoscience and
nanotechnology, nanofabrication, self-assembly, colloidal chemistry, sol-
gel, carbon nanotubes, graphene, thin film, lithography, physical vapor
deposition, chemical vapor deposition, quantum dots, lithium batteries,
X-ray diffraction, scanning electron microscopy, transmission electron
microscopy, nanoelectronics, nanophotonics and nanomagnetics, etc.
Crosslisted with: CHME 467.
Prerequisite(s): CHEM 1225G and (PHYS 1230G or PHYS 1310G) and
(EH&S Safety training to include the courses: (1) Employee & Hazard
Communication Safety (HazCom); (2) Hazardous Waste Management;
and (3) Laboratory Standard.

PHYS 471. Modern Experimental Optics
3 Credits (1+6P)
Cumulative experience course in optics related to the material presented
in PHYS 473 and PHYS 489.
Prerequisite(s): a C- or better in PHYS 315 and PHYS 315 L.
PHYS 473. Introduction to Optics
4 Credits (4)
The nature of light, geometrical optics, basic optical instruments, wave optics, aberrations, polarization, and diffraction. Elements of optical radiometry, lasers and fiber optics. May be repeated up to 4 credits. Crosslisted with: E E 473.
Prerequisite(s): PHYS 1320G or PHYS 2120.

PHYS 475. Advanced Physics Laboratory
3 Credits (3P)
Cumulative experience course involving experiments in atomic, molecular, nuclear, and condensed-matter physics.
Prerequisite(s): a C- or better in PHYS 315 and PHYS 315 L.

PHYS 476. Computational Physics
3 Credits (3)
Scientific visualization, numerical differentiation and interpolation, numerical integration, root finding, linear algebra, eigensystems, ODE's, boundary value problems, PDE's, Monte-Carlo calculations, data description and analysis, Fast Fourier Transforms, and applications to advanced physics problems. Recommended is the knowledge of a programming language.
Prerequisite(s): a C- or better in PHYS 1111 or equivalent and MATH 392.

PHYS 478. Fundamentals of Photonics
4 Credits (3+3P)
Prerequisite(s): PHYS 1320G or PHYS 2120.

PHYS 480. Thermodynamics
3 Credits (3)
Thermodynamics and statistical mechanics. Basic concepts of temperature, heat, entropy, equilibrium, reversible and irreversible processes. Applications to solids, liquids, and gases. May be repeated up to 3 credits.
Prerequisite(s): a C- or better in PHYS 2120, PHYS 315, and MATH 2530G.

PHYS 485. Independent Study
1-3 Credits
Individual analytical or laboratory studies directed by a faculty member. May be repeated for a maximum of 6 credits.
Prerequisite: consent of instructor.

PHYS 488. Introduction to Condensed Matter Physics
3 Credits (3)
Crystal structure, X-ray diffraction, energy band theory, phonons, cohesive energy, conductivities, specific heats, p-n junctions, defects, surfaces, and magnetic, optical, and low-temperature properties. May be repeated up to 3 credits.
Prerequisite(s): a C- or better in PHYS 315.

PHYS 489. Introduction to Modern Materials
3 Credits (3)
Structure and mechanical, thermal, electric, and magnetic properties of materials. Modern experimental techniques for the study of material properties. May be repeated up to 3 credits.
Prerequisite(s): a C- or better in PHYS 315.

PHYS 491. High Energy Physics I
3 Credits (3)
Prerequisite(s): a C- or better in PHYS 455.

PHYS 493. Experimental Nuclear Physics
3 Credits (1+6P)
Cumulative experience course in nuclear physics such as measurement of radioactivity, absorption of radiation, nuclear spectrometry. May be repeated up to 3 credits.
Prerequisite(s): a C- or better in PHYS 315 and PHYS 315 L.

PHYS 495. Mathematical Methods of Physics I
3 Credits (3)
Applications of mathematics to experimental and theoretical physics. Topics include vector analysis, Fourier series and transforms, Green's functions, special functions, complex variables, tensor algebra and analysis.
Prerequisite(s): a C- or better in MATH 392 and PHYS 395.

PHYS 500. Special Topics Seminar
1-2 Credits
Treatment of topics not covered by regular courses. Graded S/U. May be repeated.

PHYS 511. Mathematical Methods of Physics I
3 Credits (3)
Applications of mathematics to experimental and theoretical physics. Topics include vector analysis, Fourier series and transforms, Green's functions, special functions, complex variables, tensor algebra and analysis.

PHYS 520. Selected Topics
1-3 Credits
Formal treatment of graduate-level topics not covered in regular courses. May be repeated for a maximum of 9 credits.
Prerequisites: graduate standing, consent of instructor, and selection of a specific topic prior to registration.

PHYS 521. Individual Study
1-3 Credits
Individual analytical or laboratory studies directed by a faculty member. May be repeated for a maximum of 6 credits.
Prerequisites: graduate standing, consent of instructor, and selection of a specific topic prior to registration.

PHYS 528. Fundamentals of Photonics
4 Credits (3+3P)
Same as E E 528. Crosslisted with: E E528.

PHYS 551. Classical Mechanics
3 Credits (3)
Lagrangian and Hamiltonian formulation of dynamics. Advanced treatments of most topics listed under PHYS 451, plus canonical transformations and Hamilton-Jacobi theory. PHYS 451 strongly recommended.

PHYS 554. Quantum Mechanics I
3 Credits (3)

PHYS 555. Quantum Mechanics II
3 Credits (3)
Continuation of topics in PHYS 554.
Prerequisites: PHYS 554 or consent of instructor.
PHYS 561. Electromagnetic Theory I
3 Credits (3)
Detailed advanced treatments of most topics listed under PHYS 461, PHYS 462, plus multipole radiation, collisions of charged particles and bremsstrahlung, scattering, and radiation reaction. PHYS 461 and PHYS 462 strongly recommended.

PHYS 562. Electromagnetic Theory II
3 Credits (3)
Continuation of topics in PHYS 561.
Prerequisites: PHYS 561 or consent of instructor.

PHYS 568. Elements of X-ray Diffraction
3 Credits (3)
Same as PHYS 468, but additional work required. Crosslisted with: CHME 588.

PHYS 571. Advanced Experimental Optics
3 Credits (3)
Taught with PHYS 471 with additional work required at the graduate level. Consent of Instructor required.
Prerequisite(s): PHYS 473 or PHYS 562.

PHYS 575. Advanced Physics Laboratory
3 Credits (3P)
Selected experiments in atomic, molecular, nuclear and condensed-matter physics.

PHYS 576. Advanced Computational Physics I
3 Credits (3)
Advanced treatment of topics listed under PHYS 476 plus additional work. Applications of numerical methods to advanced physics problems. Recommended is the knowledge of a programming language.

PHYS 584. Statistical Mechanics
3 Credits (3)

PHYS 588. Condensed Matter Physics
3 Credits (3)
Same as PHYS 488, but additional work required. Prerequisite(s): PHYS 554 or consent of instructor.

PHYS 589. Modern Materials
3 Credits (3)
Same as PHYS 489 with differentiated assignments for graduate students. Prerequisite: PHYS 554 or consent of instructor.

PHYS 591. Advanced High-Energy Physics I
3 Credits (3)
Taught with PHYS 491 with additional work required at the graduate level. Prerequisite(s): PHYS 555 or consent of instructor.

PHYS 593. Advanced Experimental Nuclear Physics
3 Credits (1+6P)
Advanced experimental investigation of topics such as measurement of radioactivity, absorption of radiation, and nuclear spectrometry.

PHYS 597. Space Plasma Physics
3 Credits (3)
Same as PHYS 497 but with added requirements.

PHYS 599. Master’s Thesis
1-15 Credits (1-15)
Thesis.