PHYSICS (PHYS)

PHYS 501
Methods of Theoretical Physics I
Lecture: 3 Lab: 0 Credits: 3

PHYS 502
Methods of Theoretical Physics II
Lecture: 3 Lab: 0 Credits: 3

PHYS 505
Electromagnetic Theory
Lecture: 3 Lab: 0 Credits: 3

PHYS 508
Analytical Dynamics
Lecture: 3 Lab: 0 Credits: 3

PHYS 509
Quantum Theory I
Lecture: 3 Lab: 0 Credits: 3

PHYS 510
Quantum Theory II
Prerequisite(s): (PHYS 405 with min. grade of C and PHYS 406 with min. grade of C) or PHYS 509 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

PHYS 515
Statistical Mechanics
Lecture: 3 Lab: 0 Credits: 3

PHYS 518
General Relativity
Lorentz transformations, Minkowski space, 4D vectors and tensors, kinematics and dynamics of special relativity. Riemann geometry, Christoffel symbols, covariant derivatives, geodesics, curvature tensor, Einstein equations. Classical experiments of general relativity. Schwarzschild solution, physics of black holes. Cosmology, Big Bang theory, gravitational waves. Instructor permission required.
Lecture: 3 Lab: 0 Credits: 3
### PHY 520
**Bio-Nanotechnology**

In this multidisciplinary course, we will examine the basic science behind nanotechnology and how it has infused itself into areas of nanofabrication, biomaterials, and molecular medicine. This course will cover materials considered basic building blocks of nanodevices such as organic molecules, carbon nanotubes, and quantum dots. Top-down and bottom-up assembly processes such as thin film patterning through advanced lithography methods, self-assembly of molecular structures, and biological systems will be discussed. Students will also learn how bionanotechnology applies to modern medicine, including diagnostics and imaging and nanoscale, as well as targeted, nanotherapy and finally nanosurgery.

**Lecture:** 3 **Lab:** 0 **Credits:** 3

### PHY 525
**Applied Physics Methods for Scientists and Engineers**

This is the first of a two-part course designed to provide science and engineering students with the opportunity to investigate the underlying physics and engineering principles governing challenging real-world problems or needs. Each student selects a topic based on her or his background and interest such as the development of novel or new scientific instruments, medical devices, consumer products, energy (conservation, transport, and storage) system, thermal management devices and systems, sustainability, etc.). Experimental, theoretical, numerical techniques or a combination thereof are used, as needed, in the development of new or improved designs, methodologies, systems, and solutions. No specific background is required other than curiosity, interest, and dedication.

**Lecture:** 3 **Lab:** 0 **Credits:** 3

### PHY 526
**Applied Physics Case Studies for Scientists and Engineers**

This is the second of a two-part course designed to provide science and engineering students with the opportunity to investigate the underlying physics and engineering principles governing challenging real-world problems or needs. Each student selects a topic based on her or his background and interest such as the development of novel or new scientific instruments, medical devices, consumer products, energy (conservation, transport, and storage) system, thermal management devices and systems, sustainability, etc.). Experimental, theoretical, numerical techniques or a combination thereof are used, as needed, in the development of new or improved designs, methodologies, systems, and solutions. No specific background is required other than curiosity, interest, and dedication.

**Prerequisite(s):** PHY 525 with min. grade of B

**Lecture:** 3 **Lab:** 0 **Credits:** 3

### PHY 537
**Solid State Physics I**


**Prerequisite(s):** (PHYS 405 with min. grade of C and PHYS 406 with min. grade of C) or PHYS 509 with min. grade of C

**Lecture:** 3 **Lab:** 0 **Credits:** 3

### PHY 538
**Solid State Physics II**


**Prerequisite(s):** PHY 510* with min. grade of C. An asterisk (*) designates a course which may be taken concurrently.

**Lecture:** 3 **Lab:** 0 **Credits:** 3

### PHY 539
**Physical Methods of Characterization**

A survey of physical methods of characterization including x-ray diffraction and fluorescence surface techniques including SEM, TEM, AES and ESCA, thermal methods and synchrotron radiation methods. Same as CHEM 509.

**Lecture:** 3 **Lab:** 0 **Credits:** 3

### PHY 540
**Computational Accelerator Physics**

Single-particle dynamics and numerical integration; transverse and longitudinal motion; phase space distributions and ellipses; transfer map methods; periodic systems; advanced beam optics modules; magnetic fields and FEM; RF cavities; errors and resonances; symplectic integration; other topics (final presentations).

**Corequisite(s):** PHYS 505

**Lecture:** 3 **Lab:** 0 **Credits:** 3

### PHY 545
**Particle Physics I**

The course is an introduction to and overview of the field of elementary particle physics. No previous exposure is assumed. The first third of the course is devoted to the symmetries of the strong interaction. The second third is a modern introduction to the gauge theories of the electromagnetic, strong, and weak interactions, and their leading evaluation via Feynman diagrams. The final third introduces topics of current and speculative research.

**Prerequisite(s):** PHY 510 with min. grade of C and PHYS 509 with min. grade of C

**Lecture:** 3 **Lab:** 0 **Credits:** 3

### PHY 546
**Particle Physics II**

The course is a continuation of PHYS 545, but it is self-contained. The goal is to provide a fundamental understanding of particle physics phenomenology of QED, QCD, and electroweak physics. Topics include QED: Spin-dependent cross sections, crossing symmetries, C/P/CP; QCD: Gluons, parton model, jets; Electroweak interactions: W, Z, and Higgs. Weak decays and production of weak bosons; Loop calculations: Running couplings, renormalization.

**Prerequisite(s):** PHY 510 with min. grade of C and PHYS 509 with min. grade of C

**Lecture:** 3 **Lab:** 0 **Credits:** 3
PHYS 550
Radiation Instrumentation Laboratory
Detecting and measuring radioactive material and radiation levels depends upon many types of detectors and instrumentation. Theory of detectors ranging from chambers operating in pulse and current producing modes to solid state detectors is applied to measuring and monitoring systems. Electronics ranging from simple rate meters and scalers to high speed multi-channel analyzers are used. Computer-linked instrumentation and computer-based applications are applied to practical problems.
Prerequisite(s): PHYS 571 with min. grade of C
Lecture: 1 Lab: 4 Credits: 3

PHYS 553
Quantum Field Theory
Quantum field theory is a language to understand large numbers of degrees of freedom in most areas of physics such as high energy, statistical, and condensed matter physics. Topics covered include: canonical quantization of fields; path integral quantizations of scalar, Dirac, and gauge theories; symmetries and conservation laws; perturbation theory and generating functionals; regularization and renormalization.
Prerequisite(s): PHYS 510 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

PHYS 561
Radiation Biophysics
Lecture: 3 Lab: 0 Credits: 3

PHYS 563
Project Management: Business Principles
The course will cover a wide range of business principles highlighting project management and the components of business that employees may encounter. The goal of the course is to help the student understand basic business principles and project management skills, help the student understand the application of organizational behavior in today’s workplace and equip the student to function more effectively both independently and as a team in today’s organizations.
Lecture: 2 Lab: 0 Credits: 2

PHYS 566
Environmental Health Physics
Impact of ionizing radiation and radionuclides on the environment. Identifying environmental effects of specific natural and artificial nuclides. Models for deposition and transport of nuclides, including air and water disbursement. Environmental dosimetry and remediation. Facility decommissioning and decontamination.
Lecture: 2 Lab: 0 Credits: 2

PHYS 567
Radiological Emergency Preparedness and Response
This course is designed to provide students an introduction of the nature of the nuclear and radiological emergencies arising from either accidents or malicious acts, and the management actions in the preparedness and response. The lecture content is to familiarize students with emergency management guidance documents. It will focus on several aspects of emergency preparedness and response. In the process it will also include the recovery from the incident.
Lecture: 3 Lab: 0 Credits: 3

PHYS 568
Radiation Source Security and Management
This course is designed to introduce radioactive sources that are currently used in all applications including defense, industry and medical areas. It will address the necessity to control and manage the licensed sources, particularly those designated by the International Atomic Energy Agency (IAEA) as Category I or II sources. The discussion will cover the potential consequences and impact of the lost sources either by lack of management or by theft. The course will also address the potential use of radioactive sources for malicious intents, such as for the radiological dispersal device (RDD, or “dirty bomb”) or for the improvised nuclear device (IND).
Lecture: 3 Lab: 0 Credits: 3

PHYS 569
Seminars on Radiological Emergency Field Experience
This course will provide a series of discussions on the practical aspects in radiological emergency management by acquiring experiences from speakers representing various organizations in the emergency management community across the federal, state and local level. It is intended to provide students with valuable experiences in radiological emergency preparedness and response.
Lecture: 3 Lab: 0 Credits: 3

PHYS 570
Introduction to Synchrotron Radiation
Production and characterization of synchrotron radiation, dynamical and kinematical diffraction, absorption and scattering processes, x-ray optics for synchrotron radiation and x-ray detectors. Overview of experimental techniques including XAFS, XPS, SAXS, WAXS, diffraction, inelastic x-ray scattering, fluorescence spectroscopy, microprobe, tomography and optical spectroscopy.
Lecture: 3 Lab: 0 Credits: 3

PHYS 571
Radiation Physics
Fundamentals of Radiation Physics will be presented with an emphasis on problem-solving. Topics covered are review of atomic and nuclear physics, radioactivity and radioactive decay law; and interaction of radiation with matter, including interactions of heavy and light charged particles with matter, interactions of photons with matter, and interactions of neutrons with matter.
Lecture: 3 Lab: 0 Credits: 3
PHY 572
Introduction to Health Physics
Health Physics profession; Units in radiation protection; Radiation sources; Interaction of ionizing radiation with matter; Detectors for radiation protection; Biological effects of ionizing radiation; Introduction to microdosimetry; Medical health physics; Fuel cycle health physics; Power reactor health physics; University health physics; Accelerator health physics; Environmental health physics; Radiation accidents.
Lecture: 3 Lab: 0 Credits: 3

PHY 573
Standards, Statutes and Regulations
This course studies the requirements of agencies that regulate radiation hazards, their basis in law and the underlying US and international standards. An array of overlapping requirements will be examined. The effect regulatory agencies have upon the future of organizations and the consequences of noncompliance are explored.
Lecture: 3 Lab: 0 Credits: 3

PHY 574
Introduction to the Nuclear Fuel Cycle
This course introduces the concept and components of the nuclear fuel cycle that originated from the mining of uranium through the production and utilization of nuclear fuel to the nuclear/radioactive waste generation and disposal. The mechanisms of normal operations through the fuel cycle process will be discussed, as well as the accidental situations, with expanded coverage on nuclear reactor issues. Emphasis will be placed on the radiological health and safety aspects of the operations. The study will also include key regulatory compliance issues.
Lecture: 2 Lab: 0 Credits: 2

PHY 575
Case Studies in Health Physics
This is a non-instructional course designed to promote the understanding of radiation safety through lessons learned from the past incidents. The focus will be on the means for improving the future operations of the facilities/devices. The course is recommended to be among the last courses taken by students who have gained at least one year of academic exposure in health physics and with some level of capability to address the underlying technical aspects. This course should be taken in a student's final semester.
Prerequisite(s): PHYS 571 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

PHY 576
Radiation Dosimetry
This course is designed to study the science and technique of determining radiation dose and is fundamental to evaluating radiation hazards and risks to humans. This course covers both external dosimetry for radiation sources that are outside the human body and internal dosimetry for intake of radioactive materials into the human body. Topics will include: dosimetry recommendations of ICRP for occupational exposure; US NRC and DOE requirements for particular work environments; and MIRD methodology for medical use of radionuclides.
Prerequisite(s): PHYS 572 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

PHY 577
Operational Health Physics
Covers the basic principles for establishing and maintaining an effective institutional radiation safety program including the following: facility design criteria; organizational management issues; training; internal and external radiation control; radioactive waste disposal; environmental monitoring; radiation safety instrumentation; ALARA program; and emergency response planning. The course will also cover facility licensing/registration with state and federal agencies and legal issues such as institutional and individual liability, fines, violations, and worker rights and responsibilities.
Lecture: 2 Lab: 0 Credits: 2

PHY 578
Medical Health Physics
Medical Health Physics (MHP) profession; sources of radiation in the medical environment; radioisotopes in nuclear medicine; diagnostic use of X-rays (radiography, mammography, CT, fluoroscopy); therapeutic use of X-ray and gamma radiation (Co-60 and LINAC based radiation therapy); radiotherapy using sealed radioisotopes (brachytherapy); radiation protection in diagnostic and interventional radiology; radiation protection in nuclear medicine; radiation protection in external beam radiotherapy; radiation protection in brachytherapy; radiation accidents in medicine.
Lecture: 2 Lab: 0 Credits: 2

PHY 580
Intro to Radiochemistry
This course is designed to introduce the fundamental principle of radiation science for students majoring in radiochemistry.
Lecture: 3 Lab: 0 Credits: 3

PHY 581
Radiochemistry Laboratory
This laboratory-related course will offer opportunities for students to have hands-on experience in sample preparation, source preparation, and counting measurements.
Prerequisite(s): PHYS 550 with min. grade of C
Lecture: 1 Lab: 2 Credits: 3

PHY 582
Applications of Radiochemistry
This course will provide discussion and overview of practical applications of radiochemistry. Various special topics in the following five general series of practical radiochemistry will be offered. Each series covers different topics related to that particular discipline. 1. Actinide Chemistry Series 2. Environmental Radiochemistry/Bioassay 3. Nuclear Fuel Cycle Series 4. Nuclear Forensics 5. Radioelement Compounds.
Lecture: 3 Lab: 0 Credits: 3

PHY 585
Physics Colloquium
Lectures by invited scientists in areas of physics generally not covered in the department. May be taken twice by M. S. students to fulfill course credit requirements.
Lecture: 1 Lab: 0 Credits: 1
PHYS 591
Research and Thesis M.S.
(Credit: variable) Prerequisite: Instructor permission required.
Credit: Variable

PHYS 594
Research Project
Research project.
Credit: Variable

PHYS 597
Reading and Special Problems
Independent study to meet the special needs of graduate students in department-approved graduate degree programs. Requires the written consent of the instructor. May be taken more than once. Receives a letter grade. (Credit: variable) Prerequisite: Instructor permission required.
Credit: Variable

PHYS 600
Continuation of Residence
Continuation of Residence.
Lecture: 0 Lab: 0 Credits: 0

PHYS 685
Physics Colloquium
Lectures by invited scientists in areas of physics generally not covered in the department. Must be taken twice by M. S. students and four times by Ph. D. students. May be substituted by PHYS 585 for M. S. students.
Lecture: 1 Lab: 0 Credits: 0

PHYS 691
Research and Thesis Ph.D.
(Credit: Variable)
Credit: Variable