PHYSICS AND ASTRONOMY

(Name change effective September 1, 1981. Formerly the Department of Physics and the Department of Astronomy and Astrophysics.)

College of Natural Science

Physics PHY

Introductory physics courses are offered in both the lecture-recitation and the Competency-Based-Instructional (CBI) format. In the latter format the students are carefully guided through each course via written materials with ample consulting time available. Both content and pace of course are flexible to suit student's needs and interests, final grades being based on total amount of material for which student's mastery is certified. The introductory courses may be grouped by the application of two criteria: The interests of the students the courses are designed to serve and the method of instruction employed.

Lecture-Recitation Format

237, 238, 239, three credits each, designed primarily for students with interests in the life and earth sciences. The mathematics prerequisite is credit for or concurrent enrollment in college algebra and trigonometry (MTH 109 or 111).

287, 288, 289, four credits each, designed primarily for students with interest in the physical sciences, mathematics and engineering. The mathematics prerequisite is credit for or concurrent enrollment in calculus III with vectors (MTH 214).

291H, 292H, 293H, four credits each, designed primarily for Physics majors and others with a special interest in Physics. The mathematics prerequisite is credit for or concurrent enrollment in calculus III with vectors (MTH 214), the Honors section recommended.

Competency Based Instructional Format

237B, an alternate way to earn credit in 237. 281, 282, 283, three credits each, designed for students with interest in the natural sciences, including the life and earth sciences. The mathematics prerequisite is calculus I with analytic geometry (MTH 112).

287A, 288A, 289A, one credit each, to follow 281, 282, 283 to give a four credit per term introductory series. However, 287A may not be taken concurrently with 281, 288A may not be taken concurrently with 282, and 289A may not be taken concurrently with 283.

287B, 288B, 289B, in which the four credit introductory series is covered in one term for each course.

291A, 292A, 293A, one credit each to follow 281, 287A; 282, 288A; 283, 289A or 287, 288, 289 or 287B, 288B, 289B to give a five credit introductory series.

291B, 292B, 293B in which the five credit introductory series is covered in one term for each course.

The courses taught via the two formats may be grouped to give a wide variety of introductory physics courses. The following equivalencies exist:
237, 238, 239 may be taken as 237B, 238, 239.

287, 288, 289 may be taken as 281, 287A; 282, 288A; 283, 289A; or 287B, 288B, 289B.

291B, 292B, 293B may be taken as 281, 287A, 291A; 282, 288A, 292A; 283, 289A, 293A; or as 287, 291A; 288, 292A; 289, 293A; or as 287B, 291A; 288B, 292A; 289B, 293A.

A student may change from one group of introductory courses to another, but may not earn credit for more than one complete sequence. This statement also applies to the Lyman Briggs School Physics courses LBS 162, 261, and 263 except that credit for LBS 162 may be earned in addition to calculus-based introductory physics courses.

Credit may not be earned for both 364 and 391.

201, 202, 203, 205, 357, 430, and 431 cannot be used to meet the requirements for a major in Physics.

Prerequisites to nearly all the first courses in the 300-400 level course sequences are stated in terms of the Introductory Physics courses. The course selected for prerequisite is that which requires the least number of credits and the least mathematical background the department considers adequate. The corresponding term of any introductory sequence that requires a mathematical background equal to or greater than that of the stated prerequisite may be substituted for the stated prerequisite.

All 400 level physics courses (except 430 and 431) require 289 or 293H.

201. The Science of Sound I: Rock, Bach and Oscillators (N)

Winter. 4(4-0) Interdepartmental with the Department of Mechanical Engineering.

Production, propagation, detection of sounds. Voice, hearing, scales, timbre, musical instruments. Room acoustics. Electronic reproduction and synthesis of music. Demonstrations emphasized.

203. Science of Light and Color for Nonscientists

Spring. 4(4-0)

Properties of light with applications to mirrors, lenses, eyes, cameras, lasers, holography. Light spectra, color TV, color vision, filters, pigments. Black and white and color photography.

205. Bohr and Einstein: The Concept of Nature in Our Day (N)

(PHY 301.) Fall. 4(4-0)

Basic contemporary ideas about the natural world and their significance presented through study of the lives of Niels Bohr (quantum theory) and Albert Einstein (relativity theory).

227. Physics for Audiology and Speech Sciences

Fall, Spring. 4(4-0) MTH 108. Not open to students with credit in PHY 237. Interdepartmental with the Department of Audiology and Speech Sciences.

Introductory physics for Audiology and Speech Sciences majors: kinematics, Newton's Law, conservation of energy and momentum, waves and vibrations, sound propagation, resonance, speech production.

237. Introductory Physics

Fall, Winter, Spring. 3(4-0) MTH 109 or MTH 111 or concurrently. Not open to students with credit in PHY 227.

Mechanics, including Newton's Law, momentum, energy, and conservation laws.

237B. Introductory Physics I, CBI

Fall, Winter, Spring, Summer. 3 credits. MTH 109 or MTH 111 or concurrently.

Mechanics including Newton's Law, momentum, energy, and conservation laws.

238. Introductory Physics

Fall, Winter, Spring. 3(4-0) PHY 237.

Heat, electricity and magnetism.

238B. Introductory Physics II, CBI

Fall, Winter, Spring, Summer. 3 credits. PHY 237B or PHY 237.

Heat, electricity and magnetism.

239. Introductory Physics

Fall, Winter, Spring. 3(4-0) PHY 238.

Wave motion, sound, light, and modern developments.

239B. Introductory Physics III, CBI

Fall, Winter, Spring, Summer. 3 credits. PHY 238B or PHY 238.

Wave motion, sound, light and modern developments.

256. Energy Consumption and Environmental Quality (N)

Spring. 4(4-0) Interdepartmental with Lyman Briggs School.

The role of energy as a fundamental pollutant will be discussed along with the availability of fossil energy sources. Limitations on the safe utilization of both fossil and nuclear energy will also be considered.

257. Introductory Physics Laboratory

Fall, Winter, Summer. 1(0-2) PHY 237 or PHY 281 or concurrently.

Mechanics and heat.

258. Introductory Physics Laboratory

Winter, Spring, Summer. 1(0-2) PHY 238 or PHY 282 or concurrently.

Heat, electricity and magnetism.

259. Introductory Physics Laboratory

Fall, Spring, Summer. 1(0-2) PHY 239 or PHY 283 or concurrently.

Wave motion, sound, light and modern developments.

281. Basic Physics I, CBI

Fall, Winter, Spring, Summer. 3 credits. MTH 112.

Static equilibrium, Newton's laws, power, harmonic motion, rotational motion.

282. Basic Physics II, CBI

Fall, Winter, Spring, Summer. 3 credits. PHY 281.

Microscopic origin of heat flow and first law of thermodynamics, electric and magnetic forces and sources, direct currents.

283. Basic Physics III, CBI

Fall, Winter, Spring, Summer. 3 credits. PHY 282.

Physics of sound, light, and optical instruments, wave-particle duality, radioactivity, fission and fusion, elementary particles, fundamental forces of nature.

284. Calculus Concepts in Physics I, CBI

Fall, Winter, Spring, Summer. 2 credits. PHY 237, MTH 113. Credit may not be earned in both PHY 284 and PHY 310.

Extension of PHY 237 involving calculus concepts. PHY 237 plus PHY 284 equals PHY 287. Kinematics, dynamics, rigid body motions, energy, and oscillatory motion.

285. Calculus Concepts in Physics II, CBI

Fall, Winter, Spring, Summer. 2 credits. PHY 238, PHY 284, MTH 214. Credit may not be earned in both PHY 285 and PHY 310.

Extension of PHY 238 involving calculus concepts. PHY 238 plus PHY 285 equals PHY 288. Electrostatic interactions, magnetic fields: forces and sources, magnetostatics, and electrical circuits.

286. Calculus Concepts in Physics III, CBI

Fall, Winter, Spring, Summer. 2 credits. PHY 239, PHY 285, MTH 214. Credit may not be earned in both PHY 286 and PHY 310.

Extension of PHY 239 involving calculus concepts. PHY 239 plus PHY 286 equals PHY 289. Wave Phenomena, photons, atomic states and transitions, quantum mechanics, subatomic phenomena.

287. Principles of Physics

Fall, Winter, Spring. 4(5-0) MTH 113.

Mechanics.

287A. Physics IA, CBI

Fall, Winter, Spring, Summer. 1 credit. MTH 113; PHY 281. May not be taken concurrently with PHY 281.

Extensions of PHY 281, plus topics from: frames of reference, special relativity, rocket equation, forced oscillations, resonances, fluid motion, numerical (computer) solutions, moments of inertia, gyroscopic motion.

287B. Principles of Physics I, CBI

Fall, Winter, Spring, Summer. 4 credits. MTH 113

The CBI version of PHY 287. Course content is identical to content of PHY 281 plus PHY 287A.

288. Principles of Physics

Fall, Winter, Spring. 4(5-0) PHY 287; MTH 214 or approval of department.

Heat and thermodynamics, electricity and magnetism.

288A. Physics IIA, CBI

Fall, Winter, Spring, Summer. 1 credit. PHY 282, MTH 214 or approval of department. May not be taken concurrently with PHY 282.

Extensions of topics from PHY 282, plus topics from: entropy, transport phenomena, general relativity, electrons, atoms, molecules, solids, electromagnetic fields, energy, alternating currents, numerical (computer) solutions.

288B. Principles of Physics II, CBI

Fall, Winter, Spring, Summer. 4 credits. PHY 287, PHY 287A or PHY 287B, MTH 214 or approval of department.

The CBI version of PHY 288. Course content is identical to content of PHY 282 plus PHY 288A.

289. Principles of Physics

Fall, Winter, Spring. 4(5-0) PHY 288; MTH 214 or approval of department.

Wave motion, sound, light, and modern developments.

289A. Physics IIIA, CBI

Fall, Winter, Spring, Summer. 1 credit. PHY 283, MTH 214 or approval of department. May not be taken concurrently with PHY 283.

Extensions of the PHY 283 material plus topics from: spectral origins and analysis, optics, standing wave phenomena, diffraction, quantum mechanics, numerical (computer) solutions, radioactivity, elementary particles.

289B. Principles of Physics III, CBI

Fall, Winter, Spring, Summer. 4 credits. PHY 288, PHY 288A, or PHY 288B, MTH 214 or approval of department.

The CBI version of PHY 289. Course content is identical to content of PHY 283 plus PHY 289A.

291A. Honors Physics IA, CBI

Fall, Winter, Spring, Summer. 1 credit. PHY 287A, MTH 113.

Subjects and topics as in PHY 281 and PHY 287A, generally on a more advanced level.

291B. Honors Physics IB, CBI

Fall, Winter, Spring, Summer. 5 credits. MTH 113.

Combined material of PHY 281 plus PHY 287A plus PHY 291A is taken in one term.

291H. Physics I

Spring. 4(5-0) MTH 214 (honors section recommended) or concurrently.

Three term course sequence in elementary physics consisting of PHY 291H, 292H, 293H. In this sequence the principles of physics are presented in a unified manner that emphasizes modern concepts. Mechanics, including special relativity.

292A. Honors Physics IIA, CBI

Fall, Winter, Spring, Summer. 1 credit. PHY 288A, MTH 214.

Subjects and topics as in PHY 282 and PHY 288A, generally on a more advanced level.

292B. Honors Physics IIB, CBI

Fall, Winter, Spring, Summer. 5 credits. PHY 291B, MTH 214.

Combined material of PHY 282 plus PHY 288A plus PHY 292A is covered in one term.

292H. Physics II

Fall. 4(5-0) PHY 291H, MTH 215 or concurrently.

Continuation of PHY 291H. Electricity and magnetism with some special relativity.

293A. Honors Physics IIIA, CBI

Fall, Winter, Spring, Summer. 1 credit. PHY 289A, MTH 215.

Subjects and topics as in PHY 283 and PHY 289A, generally on a more advanced level.

293B. Honors Physics IIIB, CBI

Fall, Winter, Spring, Summer. 5 credits. PHY 292B, MTH 215.

Combined material of PHY 283 plus PHY 298A plus PHY 293A is covered in one term.

293H. Physics III

Winter. 4(5-0) PHY 292H.

Continuation of PHY 292H. Wave physics including optics.

296. Physics Computations Laboratory

Spring. 1(0-2) PHY 291H concurrently or approval of department.

Micro computers are utilized in developing computational skills in solving physics problems encountered in introductory classical mechanics.

297. Principles of Physics Laboratory

Fall, Winter, Spring. 1(0-2) PHY 281 or concurrently.

Mechanics.

298. Principles of Physics Laboratory

Winter. 1(0-2) PHY 282 or concurrently, PHY 297 or approval of department.

Heat and thermodynamics, electricity and magnetism.

299. Principles of Physics Laboratory

Spring. 1(0-2) PHY 283 or concurrently, PHY 297 or approval of department.

Wave motion, sound, light and modern developments.

304. Special Problems

Fall, Winter, Spring, Summer. 1 to 5 credits. May reenroll for a maximum of 5 credits. Approval of department.

310. Calculus Concepts in Physics, CBI

Fall, Winter, Spring, Summer. 5 credits. PHY 237, PHY 238, PHY 239; MTH 214. Students may not earn credit in both PHY 310 and PHY 284 or PHY 285 or PHY 286.

A transition course to prepare students who had non-calculus introductory physics for upper division courses. Discussions and problems in mechanics, electricity and magnetism, wave motion and modern physics. Familiarity with non-calculus introductory physics is assumed.

351. Computational Physics, CBI

Fall, Winter, Spring, Summer. 3 credits. PHY 289 or PHY 289B.

Computer applications used in physics research: printer graphics, Schrodinger equation solution, physics-symbol processing, physics information retrieval, analysis of typical research data.

356. Physics of Nuclear Arms and Nuclear War

Fall. 3(3-0) One full year of general college physics.

The physics of nuclear weaponry and strategic delivery systems, including physical detonation effects and the mathematical analysis of counterforce vulnerability and deterrence.

Approved through Fall 1986.

357. Topics in Contemporary Physics, CBI

Fall, Winter, Spring, Summer. 4 credits. One year of general college physics.

Atomic and nuclear physics, cosmic rays and elementary particles, nuclear energy, new theoretical concepts. Recommended for prospective high school teachers.

364. Introduction to Modern Physics I

Winter. 3(3-0) PHY 289, MTH 215.

Atomic structure; wave and particle aspects of radiant energy; optical and X-ray spectra.

364B. Introduction to Modern Physics I, CBI

Fall, Winter, Spring, Summer. 3 credits. PHY 289, MTH 215.

The CBI version of PHY 364.

365. Introduction to Modern Physics II

Spring. 3(3-0) PHY 364 or PHY 364B.

Nuclear, molecular, solid state and elementary particle physics. Special emphasis is given to applications such as reactors, super conductors, semi-conductors, fusion reactions, particle accelerations, etc.

365B. Introduction to Modern Physics II, CBI

Fall, Winter, Spring, Summer. 3 credits. PHY 364 or PHY 364B.

The CBI version of PHY 365.

391. Introduction to Quantum Physics

Spring, Summer. 4(4-0) PHY 293H or PHY 289 or PHY 289B; MTH 310.

Special relativity, black body radiation, photoelectric effect, line spectra, waves and particles, Schroedinger equation, one and three dimensional systems.

395. Statistical Physics and Thermodynamics I

Spring. 3(3-0) PHY 391.

Basic principles of statistical mechanics and thermal physics, including the origin and selected applications of the laws of thermodynamics.

396. Statistical Physics and Thermodynamics II

Fall. 3(3-0) PHY 395.

Selected applications of statistical mechanics and thermodynamics: condensed phase and molecular physics, quantum and classical gases, phase transformations and equilibrium, electromagnetic radiation and astrophysical phenomena.

400H. Honors Work

Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 10 credits.

404. Special Problems

Fall, Winter, Spring, Summer. 1 to 5 credits. PHY 289 or PHY 293H; approval of department.

419. Physical Phenomena and Electronic Instrumentation I

Winter. 4(3-3) PHY 289, PHY 298 or approval of department, MTH 215. Interdepartmental with Electrical Engineering.

Concepts of electronics relative to uses in investigations of physical phenomena and their subsequent applications to provide reliable instrumentation. Nuclear radiation detectors, photometers and magnetometers are examples of specific topics covered.

420. Physical Phenomena and Electronics Instrumentation II

Spring. 3(2-3) PHY 419.

Noise and its characterization. Typical electronics instruments are analyzed in detail. A reliable instrument that uses a physical effect is developed by the student.

427. Intermediate Mechanics

Fall, Summer. 3(3-0) PHY 289; MTH 310 or concurently.

Statics and dynamics of a particle and of rigid bodies; linear and non-linear oscillations; gravitation from a field point of view; transformation properties of physical quantities; introduction to mathematical techniques of theoretical physics.

428. Intermediate Mechanics

Winter, Summer. 3(3-0) PHY 427.

Continuation of PHY 427.

429. Advanced Mechanics

Spring. 3(3-0) PHY 428.

Advanced methods of theoretical mechanics; generalized coordinates; Lagrange's and Hamilton's equations; the wave equation, theory of vibrations.

430. Introduction to Radioactivity and Radioisotope Techniques

Spring, Summer. 2(3-0) or 3(3-0) One year each of general college chemistry and physics. Interdepartmental with the Department of Chemistry.

First 7 weeks. Elementary nuclear processes and properties with emphasis on radioactivity, its measurement, and its interaction with matter. Effects of radiation on chemical and biological systems. Applications of nuclear technology, safety and environmental factors.

Last 3 weeks. Fundamentals of nuclear models, reactions and decay mechanisms. Basic principles of nuclear reactors and accelerators.

431. Laboratory for Radioactivity and Radioisotope Techniques

Spring, Summer. 1(0-3) CEM 161, CEM 430 concurrently. CEM 162 recommended. Interdepartmental with the Department of Chemistry.

Introduction to nuclear instrumentation. Experimental techniques for application of radioisotopes to problems in chemistry, the life sciences, and industry.

438. Geometrical Optics

Fall. 4(3-3) PHY 289, PHY 299 or approval of department, MTH 215.

Geometrical optics including Fermat's Principle, reflection, refraction, mirrors, thin lenses, thick lenses, aberrations, and the effects of apertures and stops.

439. Physical Optics

Winter. 4(3-3) PHY 289, PHY 299 or approval of department, MTH 215.

Physical optics including Huygens-Fresnel Principles, interference, diffraction, and coherence. Additional topics will be selected from Fourier transforms of wave forms, convolution, diffraction and image formation, spatial filtering, holography and polarization.

447. Electricity and Magnetism I

Fall, Summer. 3(3-0) 18 credits in Physics, 281 and above.

Foundations of electrostatics, electrostatic problems in two and three dimensions, dielectrics, electrostatic energy, magnetic fields of steady currents.

448. Electricity and Magnetism II

Winter, Summer. 3(3-0) PHY 447.

Magnetic properties of matter, Faraday Law of Induction, magnetic energy, Maxwell's equations, scalar and vector potentials, plane wave propagation, reflection and refraction.

449. Electricity and Magnetism III

Spring. 3(3-0) PHY 448.

Radiation emission, antennas, electrodynamics, special theory of relativity.

457G. Advanced Physics Laboratory (General)

Fall. 3(1-6) 15 credits in PHY 281 and above including PHY 298 and PHY 299.

Experiments in modern physics of historical interest and in general physics research techniques. Emphasizes experimental methods and proper treatment of data. Independent work encouraged.

457N. Advanced Physics Laboratory (Nuclear)

Winter. 3(1-6) 15 credits in PHY 281 and above including PHY 298 and PHY 299.

Experiments in nuclear physics. Detection of nuclear radiation and determination of nuclear properties. Emphasizes research methods and proper treatment and interpretation of data. Independent work encouraged.

457S. Advanced Physics Laboratory (Solid State)

Spring. 3(1-6) 15 credits in PHY 281 and above including PHY 298 and PHY 299.

Experiments in low temperature and solid state physics. Emphasizes research methods and proper treatment and interpretation of data. Independent work encouraged.

492. Quantum Physics I

Fall, Summer. 3(3-0) PHY 391.

Applications of Schroedinger equation, hydrogen atom, harmonic oscillator. Angular momentum and spin.

493. Quantum Physics II

Winter, Summer. 3(3-0) PHY 492.

Atomic structure and periodic table. Perturbation methods.

496. Introduction to Solid State Physics

Winter, Summer. 3(3-0) PHY 391.

Crystal structure and binding, lattice dynamics, thermal properties, free-electron and band models of metals and semiconductors, magnetism, optical properties, superconductivity, lattice defects.

497. Introduction to Elementary Particle Physics

Fall. 3(3-0) PHY 391.

Relativistic kinematics, invariance principles. Phenomenological analysis of elementary particle interactions with matter. Weak, electromagnetic and strong interactions. High energy accelerators and techniques in experimental high energy physics.

498. Introduction to Nuclear Physics

Spring, Summer. 3(3-0) PHY 391.

Interactions of nuclear radiations with matter; properties of nuclei; alpha, beta, gamma decay; nuclear models; nuclear reactions and elementary applications of scattering theory; reactors accelerators; introduction to high-energy physics.

800. Research Methods

Fall, Winter, Spring, Summer. 2(0-6) May reenroll for a maximum of 6 credits. Beginning graduate students. Interdepartmental with Astronomy and Astrophysics.

Problems and techniques of current research by taking part in the design and setup of experiments, data taking and reduction; study and practice of theoretical methods. Areas of study: solid state and molecular structure, nuclear, elementary particles, astronomy, astrophysics.

817. Techniques of Theoretical Physics

Fall. 3(3-0) Graduate students; or approval of department.

Application of contour integration to physical problems; basic concepts in theoretical formulation of quantum mechanical systems; solution of physical problem using Green's Functions, the delta function, series, integral transforms.

827. ***Theoretical Physics I***
Summer of odd-numbered years. 3(3-0) PHY 428 or approval of department.
Vector analysis, mechanics of a particle and of systems of particles. Lagrange's equations, Hamiltonian methods, rotational motion.

829. ***Thermal and Statistical Physics***
Winter. 3(3-0) Approval of department.
Principles of thermodynamics; topics in kinetic theory; introduction to statistical mechanics.

837. ***Quantum Mechanics I***
Fall. 3(3-0) Approval of department.
The formulation of quantum mechanics, superposition principle, state vector and representations; uncertainty principle; Schroedinger equation and its solution for physical systems.

838. ***Quantum Mechanics II***
Winter. 3(3-0) PHY 837.
Approximation methods, perturbation theory, applications to atomic transitions, angular momentum.

839. ***Quantum Mechanics III***
Spring. 3(3-0) PHY 838.
Collision processes and scattering theory, applications; many-particle systems.

840. ***Symmetry in Solid State Physics***
Spring of odd-numbered years. 3(3-0) Graduates or approval of department.
Translational symmetry and Bloch's Theorem, reciprocal lattice, Brillouin zones; point groups, representations, character tables, molecular vibrations, group of the wave vectors and band theory of solids, crystal fields.

847. ***Electromagnetic Theory I***
Fall. 3(3-0) PHY 428, PHY 448.
Electrostatics; Laplace's equation, Poisson's equation; Green's theorem; solution of problems by method of images; inversion; boundary-value problems in Cartesian, spherical and cylindrical coordinates; spherial harmonics; Bessel functions.

848. ***Electromagnetic Theory II***
Winter. 3(3-0) PHY 847.
Multipoles and multipole expansions; electrostatics of macroscopic materials, dielectrics, magnetostatics, vector potential, magnetic moments, Maxwell's equations for time-varying fields, energy and momentum conservation. Plane electromagnetic waves and polarization.

849. ***Electromagnetic Theory III***
Spring. 3(3-0) PHY 848.
Wave guides and resonant cavities, boundary-value problems. Simple radiating systems, antennas. Special relativity, covariance of electrodynamics, transformation of electromagnetic fields. Radiation by moving charges, Lienard-Wiechert potentials.

850. ***Electrodynamics of Plasmas I***
Fall. 3(3-0) E E 835 or PHY 448; E E 874. Interdepartmental with Astronomy and Astrophysics, and Electrical Engineering. Administered by Electrical Engineering.
Boltzmann equation; moment equations; two-fluid theory of plasma, waves in cold, warm and anisotropic infinite plasma; waves in bounded plasma structures, energy flow in anisotropic plasmas.

857. ***Theoretical Mechanics I***
Winter. 3(3-0)
Two-body central force problems, rigid body motion, small oscillations, Hamilton's principle, Lagrangian and Hamiltonian formalism for particles and fields, canonical transformations, relativity.

858. ***Theoretical Mechanics II***
Spring. 3(3-0) Approval of department.
Hamiltonian formalism for particles and fields, variational methods, canonical transformations, small oscillators, classical fields, relativity.

860. ***General Relativity and Cosmology I***
Fall of even-numbered years. 3(3-0) PHY 858 or approval of department. Interdepartmental with Astronomy and Astrophysics.
Conceptual foundations of general relativity theory; elements of tensor calculus; Riemann-Chistoffel curvature tensor; the field equations; experimental tests; special solutions; the extension to cosmology.

861. ***General Relativity and Cosmology II***
Winter of odd-numbered years. 3(3-0) PHY 860. Interdepartmental with Astronomy and Astrophysics.
Relativistic cosmology: the model universes; steady-state theory; observational evidence and possibilities for decision among models; current problems.

867. ***Quantum Mechanics IV***
Fall. 3(3-0) PHY 839.
Transformation theory and invariance principles; the rotation group and theory of angular momentum; Wigner-Eckart theorem and applications.

868. ***Relativistic Quantum Mechanics***
Winter. 3(3-0) PHY 867.
Relativistic equations of motion; Dirac Equation, free particle solutions and Lorentz transformation properties; interaction with electromagnetic fields; quantization of scalar, electromagnetic and Dirac fields.

869. ***Quantized Fields***
Spring. 3(3-0) PHY 868.
Heisenberg representation, S-matrix reduction formulae, Feynman rules, quantum electrodynamics; topics from many-body theory.

877. ***Statistical Mechanics I***
Fall. 3(3-0) Approval of department.
Necessity of statistical considerations, ensembles, probability distributions and density matrices, Liouville's equation, equilibrium distributions, microscopic basis of thermodynamics; applications to thermodynamics of spin systems.

878. ***Statistical Mechanics II***
Winter. 3(3-0) PHY 877.
Applications to thermodynamic properties of ideal classical and quantum gases, and to imperfect gases and interacting spin systems. Non-equilibrium dstributions and transport theory, the Boltzmann equation, Kubo's linear response theory, Onsager's relations.

879. ***Statistical Mechanics III***
Spring. 3(3-0) PHY 878.
Special topics chosen at discretion of instructor. Topics may include phase transitions, critical phenomena and renormalization group techniques; Green's function and diagrammatic techniques for interacting systems.

899. ***Master's Thesis Research***
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

927. ***Elementary Particle Physics I***
Fall of even-numbered years. 3(3-0) PHY 869.
Review of field theory for spins 0, 1/2, 1; Abelian gauge theory - QED; weak interaction phenomenology; gauge theories of weak interactions - leptons; non-Abelian gauge theories; spontaneous symmetry breaking; Higgs' mechanism; the Weinberg-Salam Model.

928. ***Elementary Particle Physics II***
Winter of odd-numbered years. 3(3-0) PHY 927.
Quarks and hadronic weak interactions; quarks in Weinberg-Salam model; strong interactions of quarks; SU(3) color model; quark spectroscopy in electron-positron annihilation; leptonic decays of heavy vector mesons; gluonic decays of heavy mesons.

929. ***Elementary Particle Physics III***
Spring of odd-numbered years. 3(3-0) PHY 928.
The quark-parton model; deep inelastic lepton scattering; hadron-hadron high transverse momentum scattering.

947. ***Solid State Physics I***
Fall of odd-numbered years. 3(3-0) PHY 839 and PHY 840.
Crystal symmetry, crystal binding, lattice vibrations and specific heat, one-electon theory; Hartee-Fock equation, Brillouin zones.

948. ***Solid State Physics II***
Winter of even-numbered years. 3(3-0) PHY 947.
Effective mass approximation. Exchange and correlation corrections. Theory of conductivity and related effect, metals and semiconductors.

949. ***Solid State Physics III***
Spring of even-numbered years. 3(3-0) PHY 948.
Ionic crystals. Imperfections in crystals, plastic deformations, color centers. Optical properties. Rectification, transistors, selected topics.

957. ***Nuclear Physics I***
Fall of odd-numbered years. 3(3-0) PHY 867.
Nucleon-nucleon scattering; the nucleon-nucleon interaction; the deuteron; meson theory of the NN interaction; Racah algebra.

958. ***Nuclear Physics II***
Winter of even-numbered years. 3(3-0) PHY 957.
Bulk properties of nuclei; sizes and magnetic moments; the shell model; effective interactions; second quantization; Hartree-Fock theory.

959. ***Nuclear Physics III***
Spring of even-numbered years. 3(3-0) PHY 958.
Bethe-Goldstone Theory; Random-phase approximation; BCS theory; quasi-particles; deformations; nuclear reactions.

984. ***Advanced Readings in Physics or Astronomy***
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 6 credits. Interdepartmental with Astromony and Astrophysics.

987. Advanced Topics in Physics
Fall, Winter, Spring. 3(3-0) or 4(4-0)
In any one term this course will be devoted to a single topic, such as advanced quantum theory, quantum electrodynamics, specialized topics in solid state physics, statistical mechanics, relativity theory and cosmology.

989. Electrodynamics of Plasmas II
Winter of odd-numbered years. 3(3-0) E E 850. Interdepartmental with Astronomy and Astrophysics, and Electrical Engineering. Administered by Electrical Engineering.
One fluid plasma model, magnetohydrodynamics, Maxwell's stress tensor, low frequency waves, transport phenomena, Landau damping, collision and rate coefficients. Diffusions in a magnetic field; investigation of dc, rf and microwave discharges.

999. Doctoral Dissertation Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

Astronomy and Astrophysics AST

119. General Astronomy (N)
Fall, Winter, Spring, Summer. 4(4-0) Intended primarily for nonscience majors. Not open to engineering or physical science majors. Students may not receive credit in more than one of the following: AST 119, AST 217, AST 229, N S 135, N S 155.
A qualitative presentation of the current view of the universe including birth and death of stars, cosmology, comparisons of planets, and life in the universe.

217. General Astronomy (N)
Fall, Winter, Spring. 4(4-0) MTH 109 or MTH 111. High school physics recommended. Students without the necessary science or math background are directed to AST 119. Intended primarily for physical science majors. Students may not receive credit in more than one of the following: AST 119, AST 217, AST 229, N S 135, N S 155.
A semiquantitative presentation of current views of the universe including birth and death of stars, cosmology, comparisons of planets, and life in the universe, and their interpretation through physical laws.

229. General Astronomy
Fall. 4(4-0) PHY 287 or PHY 291H or concurrently; MTH 113. Intended for physical science majors and recommended for astrophysics majors. Students may not receive credit in more than one of the following: AST 119, AST 217, AST 229, N S 135, N S 155.
Fundamental observations in astronomy and their interpretation through physical laws. Quantitative discussions of orbital motion, time, telescopes, solar system, stars, galaxies, and cosmology.

230. General Astronomy
Winter. 3(3-0) AST 229.
Fundamental observations in astronomy and their interpretation through physical laws. Continuation of AST 229.

327. Practical Astronomy
Spring. 3(3-0) AST 230.
Celestial coordinate systems. Time conversion and sidereal time. Atmospheric refraction, parallax, proper motion, aberration, and precession. Star catalogs and ephemerides. Finding charts and setting of equatorial telescopes.

437. Observatory Practice
Spring. 3(1-4) AST 327 and approval of department.
Stellar photography. Photographic photometry. Photoelectric photometry and corrections for atmospheric extinction. Multicolor photometric systems. Astronomical spectroscopy and radial velocity determinations.

442. Radiation Astrophysics
Winter. 3(3-0) PHY 395.
Emission, absorption and transfer of radiation in an astrophysical context. Stellar atmospheres, line formation, plasma diagnostics. Synchrotron radiation.

443. Astrophysical Fluid Dynamics
Spring. 3(3-0) PHY 396.
Dynamics of fluids in an astrophysical context. Fundamental equations. Applications to stellar structure, interstellar medium, and compact objects.

490. Special Problems
Fall, Winter, Spring, Summer. 1 to 5 credits. May reenroll for a maximum of 10 credits. Approval of department.
Individual study or project under the direction of a faculty member. An oral report on the work may be required in department seminar.

800. Research Methods
Fall, Winter, Spring, Summer. 2(0-6) May reenroll for a maximum of 6 credits. Beginning graduate students. Interdepartmental with and administered by Physics.
Problems and techniques of current research by taking part in the design and setup of experiments, data taking and reduction; study and practice of theoretical methods. Areas of study: solid state and molecular structure, nuclear, elementary particles, astronomy, astrophysics.

820. Advanced Topics in Astrophysics
Winter. 3(3-0) May reenroll for a maximum of 15 credits. AST 452 or PHY 395 or PHY 429 or approval of department.
Possible topics include dynamics of stars in galaxies, astrophysical fluid dynamics, quasar theory, stellar atmospheres, stellar interiors, stellar spectroscopy, and stellar photometry.

850. Electrodynamics of Plasmas I
Fall. 3(3-0) E E 835 or PHY 448; E E 874. Interdepartmental with Electrical Engineering and Physics. Administered by Electrical Engineering.
Boltzmann equation; moment equations; two-fluid theory of plasma, waves in cold, warm and anisotropic infinite plasma; waves in bounded plasma structures, energy flow in anisotropic plasmas.

860. General Relativity and Cosmology I
Fall of even-numbered years. 3(3-0) PHY 858 or approval of department. Interdepartmental with and administered by Physics.
Conceptual foundations of general relativity theory; elements of tensor calculus; Riemann-Christoffel curvature tensor; the field equations; experimental tests; special solutions; the extension to cosmology.

861. General Relativity and Cosmology II
Winter of odd-numbered years. 3(3-0) PHY 860. Interdepartmental with and administered by Physics.
Relativistic cosmology: the model universes; stead-state theory; observational evidence and possibilities for decision among models; current problems.

984. Advanced Readings in Physics or Astronomy
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 6 credits. Interdepartmental with and administered by Physics.

989. Electrodynamics of Plasmas II
Winter of odd-numbered years.3(3-0) E E 850. Interdepartmental with Electrical Engineering, and Physics. Administered by Electrical Engineering.
One fluid plasma model, magnetohydrodynamics, Maxwell's stress tensor, low frequency waves, transport phenomena, Landau damping, collision and rate coefficients. Diffusions in a magnetic field; investigation of dc, rf and microwave discharges.

PHYSIOLOGY PSL

College of Human Medicine
College of Natural Science
College of Osteopathic Medicine
College of Veterinary Medicine

240. Introductory Physiology
Fall, Spring. 4(4-0) Sophomores or approval of department.
Physiology of the cell, nerve and reflex activity, skeletal muscle, brain, and cardiovascular system emphasizing environmental influences such as disease and exercise.

241. Introductory Physiology
Winter. Summer of even-numbered years. 4(4-0) PSL 240 or approval of department.
Continuation of PLS 240. Physiology of respiration, digestion, metabolism, kidney, endocrinology, and reproduction.

323. Physiology, Anatomy, and Hygiene of the Eye
Fall. Summer of even-numbered years. 3(2-2) PSL 240; Elementary Education or Special Education major, or approval of department.
Basic course in anatomy, physiology, and hygiene of the visual system; includes discussion of normal visual functioning and abnormal visual functioning, with methods of correction and education implications.

401. Comparative Physiology I
Fall. 4(3-4) PSL 240 or B S 212; CEM 131 or CEM 141. Interdepartmental with the Department of Zoology.
A comparison of osmoregulation, digestion, respiration, and other physiological processes in a wide range of organisms.

402. Comparative Physiology II
Winter. 4(4-0) PSL 401 or approval of department. Interdepartmental with and administered by the Department of Zoology.
A comparison of sensory, motor, endocrine and other integrative mechanisms in animals.

416. Physiology of the Cell
Fall. Summer of odd-numbered years. 3(3-0) BCH 401 or BCH 451.
Physiologic mechanisms common to all living cells with emphasis on those of the vertebrates. The functions of the cell membrane and cytoplasm are studied as the basis for the physiologic behavior of vetebrate organs and systems.