

**890. Problems in Physical Science**  
Fall, Winter, Spring, Summer. 1 to 12 credits. May reenroll for a maximum of 15 credits. Bachelor's degree in a physical science.

## PHYSICAL SYSTEMS IN AGRICULTURE AND NATURAL RESOURCES

See Agricultural Engineering

## PHYSICS PHY

### College of Natural Science

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.

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.

Credit may not be earned for more than one of the courses 294, 357, or 364.

100, 201, 202, 203, 301, 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.

### 100. The Universe as Home for Man Spring, 4(4-0)

The place of man in the physical universe. Cosmology, complexities on the human scale, paradoxes of sub-atomic physics, universal conditions for life, future for man, space colonization. Approved through Winter 1981.

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

Winter. 3(3-0) or 4(4-0) Interdepartmental with the Department of Mechanical Engineering.

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

### 202. The Science of Sound II

Spring. 3(3-0) or 4(4-0) PHY 201. Interdepartmental with and administered by the Department of Mechanical Engineering.

Nature, generation, and propagation of sound. Acoustical phenomenon and measurements. Storage and manipulation of sound in numerical form. Music programming.

### 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.

### 227. Physics for Audiology and Speech Sciences

Fall, Spring. 3(3-0) 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 237.

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

### 237B. Introductory Physics I, CBI

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

Wave motion, sound, light and modern developments.

### IDC. Energy Consumption and Environmental Quality

For course description, see Interdisciplinary Courses.

### 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. 3 credits. MTH 112.

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

### 282. Basic Physics II, CBI

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

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

## Descriptions – Physics

### of Courses

- 283. Basic Physics III, CBI**  
Fall, Winter, Spring. 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 and MTH 113.  
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, and MTH 214.  
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 and MTH 214.  
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**  
(281A.) Fall, Winter, Spring. 1 credit. MTH 113; 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**  
(282A.) Fall, Winter, Spring. 1 credit. PHY 282, MTH 214 or approval of department.  
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**  
(283A.) Fall, Winter, Spring. 1 credit. PHY 283, MTH 214 or approval of department.  
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. 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. 5 credits. MTH 113.  
Combined material of PHY 281 plus PHY 287A plus PHY 291A are taken in one term.
- 291H. Physics I**  
(291.) Spring. 4(5-0) MTH 214 (honors section recommended) or concurrently.  
First of a five-term course sequence in elementary physics consisting of PHY 291, PHY 292, PHY 293, PHY 294 and PHY 395. 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. 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. 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**  
(292.) 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. 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. 5 credits. PHY 292B, MTH 215.  
Combined material of PHY 283 plus PHY 289A plus PHY 293A is covered in one term.
- 293H. Physics III**  
(293.) Winter. 4(5-0) PHY 292H.  
Continuation of PHY 292H. Wave physics including optics.
- 294. Physics IV**  
Spring. 4(5-0) PHY 293H or PHY 289.  
Continuation of PHY 293H. Introduction to quantum physics.
- 297. Principles of Physics Laboratory**  
Fall, Winter. 1(0-2) PHY 281 or concurrently.  
Mechanics.
- 298. Principles of Physics Laboratory**  
Winter, Spring. 1(0-2) PHY 282 or concurrently, PHY 297 or approval of department.  
Heat and thermodynamics, electricity and magnetism.
- 299. Principles of Physics Laboratory**  
Fall, Spring. 1(0-2) PHY 283 or concurrently, PHY 297 or approval of department.  
Wave motion, sound, light and modern developments.
- 301. Bohr and Einstein: The Concept of Nature in Our Day (N)**  
Fall. 3(3-0) Juniors.  
Basic contemporary ideas about the natural world and their significance for man presented through study of the lives of Niels Bohr (quantum theory) and Albert Einstein (relativity theory).
- 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.  
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.
- 357. Topics in Contemporary Physics, CBI**  
Fall, Winter, Spring. 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**  
Fall, Winter, Spring. 3(3-0) PHY 289, MTH 215.  
Atomic structure; wave and particle aspects of radiant energy; optical and X-ray spectra.
- 365. Introduction to Modern Physics II**  
Fall, Winter, Spring. 3(3-0) PHY 364 or PHY 294.  
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.
- 395. Physics V**  
Fall. 3(3-0) PHY 293B, or PHY 294, or PHY 364.  
Continuation of PHY 294. Thermodynamics and statistical physics.

- 400H. Honors Work**  
Fall, Winter, Spring. Variable credit.
- 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. 3(3-0) PHY 289; MTH 310 or concurrently.  
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. 3(3-0) PHY 427.  
Continuation of PHY 427.
- 429. Advanced Mechanics**  
Spring. 3(3-0) PHY 428.  
Advanced methods of the 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**  
Winter. 4(4-0) 18 credits in PHY 281 and above.  
Advanced study of electromagnetic phenomena; electrostatic potentials from Laplace's and Poisson's equations; effects of dielectric and magnetic materials; magnetic fields and potentials; induced e.m.f.; Maxwell's equations; electromagnetic radiation and waves.
- 448. Electricity and Magnetism II**  
Spring. 4(4-0) PHY 447.  
Continuation of PHY 447.
- 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.
- 491. Introduction to Quantum Mechanics I**  
Fall. 3(3-0) PHY 294 or PHY 364; MTH 310 or concurrently.  
Schrödinger wave equation and its applications; angular momentum; one electron atoms; moments and spin; perturbation methods; absorption and emission of radiation; atomic and molecular structure.
- 492. Introduction to Quantum Mechanics II**  
Winter. 3(3-0) PHY 491.  
Continuation of PHY 491.
- 493. Introduction to Quantum Mechanics III**  
Spring. 3(3-0) PHY 492.  
Continuation of PHY 492.
- 496. Introduction to Solid State Physics**  
Winter. 3(3-0) PHY 364 or PHY 294.  
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 294 or PHY 364 or PHY 491.  
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. 3(3-0) PHY 294 or PHY 364 or PHY 491.  
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 the Department of 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.
- 828. Theoretical Physics II**  
Summer of even-numbered years. 3(3-0) PHY 448 or approval of department.  
Special relativity, Maxwell's equations, electrodynamics and electromagnetic waves.
- 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) PHY 428, PHY 491.  
The formulation of quantum mechanics, superposition principle, state vector and representations; uncertainty principle; Schrödinger 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.

**Descriptions – Physics  
of  
Courses**

**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; spherical 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. Ionized Gases**

*Fall. 3(3-0) E E 835 or PHY 448; E E*

*874. Interdepartmental with Electrical Engineering and the Department of Astronomy and Astrophysics, and administered by Electrical Engineering.*

Elastic collision processes; Boltzmann equation; moment equations; motion of a charged particle in electrical and magnetic field; individual and collective charged particle behavior; macroscopic properties of plasmas, waves in the fluid plasma; transport phenomena in plasma.

**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 the Department of Astronomy and Astrophysics.*

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 the Department of 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. Nonequilibrium distributions 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**

*Fall of even-numbered years. 3(3-0) PHY 869.*

Properties of elementary particles; invariance principles and conservation laws; strong, electromagnetic, and weak interactions; pion physics.

**928. Elementary Particle Physics**

*Winter of odd-numbered years. 3(3-0) PHY 927.*

Baryon and meson resonances, unitary symmetry, dispersion relations.

**929. Elementary Particle Physics**

*Spring of odd-numbered years. 3(3-0) PHY 928.*

Selected current topics, partial wave amplitudes and Regge poles, current algebra and weak interactions.

**937. Molecular Structure and Spectra I**

*Fall of even-numbered years. 3(3-0) PHY 837 or concurrently.*

Structure and spectra of diatomic molecules.

**938. Molecular Structure and Spectra II**

*Winter of odd-numbered years. 3(3-0) PHY 937.*

Structure and spectra of polyatomic molecules.

**939. Molecular Structure and Spectra III**

*Spring of odd-numbered years. 3(3-0) PHY 938.*

Advanced topics in vibration-rotation theory of polyatomic molecules.

**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-electron theory; Hartree-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, nuclear sizes and shapes, multipole moments; shell model; collective states.

**958. Nuclear Physics II**

*Winter of even-numbered years. 3(3-0) PHY 957.*

Experimental methods and instrumentation; nuclear reactions; inelastic scattering and particle transfer.

**959. Nuclear Physics III**

*Spring of even-numbered years. 3(3-0) PHY 958.*

Many-body methods in nuclear physics; Bethe-Goldstone equation; effective interaction; nuclear models.

**984. Advanced Readings in Physics or Astronomy**

*Fall, Winter, Spring, Summer. Variable credit. Interdepartmental with the Department of Astronomy 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. **Waves and Radiations in Plasmas**  
 Winter of even-numbered years. 3(3-0)  
 E E 850. Interdepartmental with the Department of Astronomy and Astrophysics and Electrical Engineering. Administered by Electrical Engineering.  
 Plasma oscillation; interaction, electromagnetic fields with plasmas, wave propagation in magnetonic media; plasma sheath; radiation of electric source in incompressive and compressive plasmas; electroacoustic waves; magnetohydrodynamics; research topics in plasmas.
999. **Doctoral Dissertation Research**  
 Fall, Winter, Spring, Summer. Variable credit. Approval of department.

431. **Human Physiology**  
 (331.) Winter. 4(4-0) ANT 316 or one year of biological science, CEM 132 or approval of department.
432. **Human Physiology**  
 (332.) Spring. 4(4-0) PSL 431.
440. **Avian Physiology**  
 Spring. 4(3-3) Approval of department. Interdepartmental and administered jointly with the Department of Poultry Science. A survey of the systemic physiology of birds emphasizing digestion, metabolism, the endocrines, and reproduction.
444. **Mammary Physiology**  
 Winter. 4(3-2) PSL 240, BCH 200. Interdepartmental and administered jointly with the Department of Dairy Science. Anatomy of mammary gland. Hormonal and nervous control of mammary growth, initiation and maintenance of lactation. Biochemistry of milk secretion. Physiology of milking; physiological, pathological and management factors affecting lactation.

801. **Advanced Physiology**  
 Winter. 4(3-2) PSL 432 or PSL 402 or approval of department; courses in anatomy, histology, biochemistry and calculus recommended.  
 Principles of physiological control systems. Physiology of the nervous system including, neuromuscular, reflex, sensory and autonomic nervous function. Physiology of respiration; acid-base, regulation of body fluids.
802. **Advanced Physiology**  
 Spring. 4(3-2) PSL 432 or PSL 402 or approval of department; courses in anatomy, histology, biochemistry and calculus recommended.  
 Physiology of kidney and micturition, blood and cardiovascular system.
803. **Advanced Physiology**  
 Fall. 4(3-2) PSL 432 or PSL 402 or approval of department; courses in anatomy, histology, biochemistry and calculus recommended.  
 Physiology of the digestive system, regulation of metabolism; endocrinology and reproduction.

**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. 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 BS 212 and CEM 132. 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. 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 vertebrate organs and systems

445. **Endocrinology and Reproductive Physiology**  
 Fall. 4(5-0) PSL 240. Interdepartmental and administered jointly with the Department of Dairy Science.  
 Processes of reproduction and endocrinology with special emphasis on anatomy of reproductive systems, folliculogenesis, gametogenesis, reproductive cycle, fertilization, sex determination, gestation and artificial regulation of these reproductive events for economic benefit.
- IDC. **Biological Membranes**  
 For course description, see Interdisciplinary Courses.
480. **Special Problems**  
 Fall, Winter, Spring, Summer. 1 to 5 credits. Approval of department.
497. **Principles of Endocrinology**  
 Winter. 4(4-0) One year organic chemistry; ZOL 317. Interdepartmental with and administered by the Department of Zoology.  
 Hormonal principles, illustrated by experimental observations, in vertebrates and invertebrates. Emphasis on cellular endocrinology. Group discussion, background in organic chemistry and cell biology strongly recommended. Term paper required.

- 500A. **Introductory Physiology for Medicine**  
 (500.) Fall, Winter. 5(5-0) Admission to the professional program in a college of medicine.  
 Concepts and problems in physiology to be followed by supplemental physiology instruction during subsequent phases of medical training.
- 500B. **Introductory Physiology for Medicine**  
 Fall. 4(4-0) Admission to the professional program in a college of medicine.  
 Principles of systemic physiology germane to the practice of medicine with introduction to clinical physiopathology.
- 500C. **Introductory Physiology for Medicine**  
 Winter. 5(5-0) Admission to the professional program in a college of medicine.  
 Continuation of PSL 500B.

- 804A. **Neuroscience Laboratory I**  
 Winter. 4(2-4) Approval of instructor. Interdepartmental with the departments of Biophysics, Psychology and Zoology and administered by the Department of Psychology.  
 Development of skills in the methods, techniques and instrumentation necessary for research in a variety of areas concerned with neuroscience.
- 804B. **Neuroscience Laboratory II**  
 Spring. 4(2-4) PSY 804A. Interdepartmental with the departments of Biophysics, Psychology and Zoology and administered by the Department of Psychology.  
 Continuation of PLS 804A.
808. **Neuroendocrinology**  
 Winter. 3(3-0) Approval of department.  
 Anatomical, biochemical and physiological aspects of neuroendocrinology. Control systems and interaction among endocrine glands will be emphasized.
819. **Kidney Physiology and Electrolyte Metabolism**  
 Summer. 4(4-0) PSL 802, approval of department.  
 Critical study of the literature on classical and contemporary principles of renal physiology and related aspects of body fluid and electrolyte metabolism.
835. **Neurophysiology**  
 Winter of odd-numbered years. 4(2-4) Approval of department.  
 Functions and properties of the peripheral and central nervous systems.
836. **Physical Principles of Biological Systems**  
 Winter. 3(3-0)  
 Application of laws and methods of physics to measurement and description of physiological phenomena.
837. **Radiobiology**  
 Fall. 3(3-0) Approval of department.  
 Application of radioactive tracer techniques to study of biological functions. Determination of turnover rates and tissue constituents by isotope dilution. Control of radiation hazards.