841. *Seminar in Epistemology*

Fall, Winter, Spring. 4 credits. May re-enroll for credit. Approval of department.

845. *Seminar in Metaphysics*

Fall, Winter, Spring. 4 credits. May re-enroll for credit. Approval of department.

850. *Seminar in Aesthetics*

Fall. 4(3-0) Approval of department.

The nature of aesthetic values, grounds of criticism, function of the arts, etc.

860. *Seminar in Social Philosophy*

Spring. 4(3-0) Approval of department.

Philosophy of law and of the state.

870. *Seminar in the Philosophy of Language*

Fall. 4(3-0) Approval of department.

Concrete bases of language and nature of meaning.

880. *Seminar in the Philosophy of Science*

Fall, Winter. 4 credits. Approval of department.

890. *Graduate Reading Course*

Fall, Winter, Spring, Summer. 1 to 10 credits. May re-enroll for credit. Approval of department.

Supervised reading course for advanced graduate students for more thorough investigation of special fields.

899. *Research*

Fall, Winter, Spring, Summer. Variable credit. Approval of department.

999. *Research*

Fall, Winter, Spring, Summer. Variable credit. Approval of department.

PHYSICAL SCIENCE PHS

College of Natural Science

203. *Foundations of Physical Sciences*

Fall, Winter, Spring, Summer. 4(3-3) Primarily for elementary school teachers.

Integrated descriptive course in the elements of physical science including the interrelations among chemistry, geology, meteorology, astronomy, and physics.

401. *Mathematics for Teachers*

Fall. 4(4-0) Teaching experience and approval of department.

Provides mathematical background for science teachers. It will emphasize the basic concepts of mathematics, including number systems. Topics will be selected from algebra, analytic geometry and trigonometry to illustrate the principles of number, operation, relation, proof and other basic mathematical ideas.

402. *Mathematics for Teachers*

Fall, Winter. 4(4-0) 401 or approval of department.

Continuation of 401.

403. *Mathematics for Teachers*

Winter, Spring. 4(4-0) 402 or approval of department.

Continuation of 402.

404. *Physical Science for Teachers*

Fall, Winter, Spring. 4(3-3) Bachelor's degree.

An integrated course in the physical sciences on the nature of the matter and energy gained by interrelating the facts, principles and laws about light, electricity, magnetism and sound as well as the structure and properties of substances, rates of reaction, equilibria. The concepts of measurement will be stressed. The course is for general science teachers and is not applicable for chemistry or physics majors.

405. *Physical Science for Teachers*

Fall, Winter, Spring. 4(3-3) 404.

Continuation of 404.

406. *Physical Science for Teachers*

Fall, Winter, Spring. 4(3-3) 405.

Continuation of 405.

407. *Earth Science for Teachers*

Fall. 3(3-0) or 4(3-3)

Fundamentals of climatology and its relationship to weathering in rocks; agents of erosion, transportation, and deposition; study of the common minerals; the three classes of rocks, and igneous, sedimentary and metamorphic processes; geomorphic features including glaciers, volcanoes, oceans, lakes, deserts, caves and others. Laboratory includes identification of minerals, rocks; study of topographic maps; and field trips to points of geologic interest.

408. *Earth Science for Teachers*

Winter. 3(3-0) or 4(3-3) 407.

Continuation of physical geology and introduction to historical geology, containing discussions of earth structures, mountain building, economic geology; geologic time, basic astronomy, theories of earth origin; the earliest geologic eras, first evidences of life.

409. *Earth Science for Teachers*

Spring. 3(3-0) or 4(3-3)

Historical development of the various geologic periods through time with reference to the evolutionary development of the physical landscape, ancient geography, past climate, diastrophic events, and marine and land animals and plants. Laboratory includes the identification of important animal and plant fossils, fossil environments, geologic maps; field trips to collecting localities.

410. *Seminar on Recent Advances in Physical Science*

Fall, Winter, Spring, Summer. 3(3-0) May re-enroll for a maximum of 6 credits if different topic is taken. Approval of department.

A series of lectures by senior faculty of topics on the history, development, the most recent advances and the possible future and limits of the Physical Sciences.

411. *Seminar on Man, His Universe*

Fall, Winter, Spring, Summer. 3(3-0) Approval of department.

A creative review by senior faculty from Astronomy, Biochemistry, Biophysics, Geology, Physics and Philosophy on the impact of recent space probes in developing modern concepts of the universe.

412. *Seminar on Man, His Earth*

Fall, Winter, Spring, Summer. 3(3-0) Approval of department.

A summary by senior faculty from Astronomy, Anthropology, Botany, Geology, Meteorology, and Zoology of new ideas, methods, and theories employed by current researchers to unravel the mysteries of the origin of the earth, its interior, the forces developing the scenic surface features, and the evolution of life in its historical setting.

PHYSICS PHY

College of Natural Science

Introductory courses are divided into three groups:

(1) 237, 238, 239 (theory) and 257, 258, 259 (laboratory) open to students who are taking at the same time, or who have taken, first year mathematics through college algebra and trigonometry.

(2) 287, 288, 289 (theory) and 297, 298, 299 (laboratory) for students of engineering, physical sciences, mathematics, and others. Those electing this sequence should have completed courses in mathematics through two terms of analytic geometry and calculus.

(3) 291, 292, 293, 294, 392, 393, 394, 395 for physics majors and others who have a special interest in physics. Students electing this sequence should have completed or should be taking the second term of analytic geometry and calculus.

A student may change from one group of introductory courses to another but may not receive credit for the equivalent of more than one complete three-term introductory sequence.

Credit may not be earned for more than one of the courses PHY 294, 357, 364 or 491.

PHY 357 and 360 cannot be used to meet the requirements for a major in physics.

All 400 level physics courses require PHY 289 or 293 as prerequisites.

237. *Introductory Physics*

Fall, Winter. 3(4-0) MTH 102 or 109 or 111 or concurrently.

Mechanics and heat.

238. *Introductory Physics*

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

Heat, electricity and magnetism.

239. *Introductory Physics*

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

Wave motion, sound, light, and modern developments.

257. *Introductory Physics Laboratory*

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

Mechanics and heat.

258. *Introductory Physics Laboratory*

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

Heat, electricity and magnetism.

259. *Introductory Physics Laboratory*

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

Wave motion, sound, light and modern developments.

287. *Principles of Physics*

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

Mechanics.

288. *Principles of Physics*

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

Heat and thermodynamics, electricity and magnetism.

289. *Principles of Physics*

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

Wave motion, sound, light, and modern developments.

291. Physics I

Spring. 4(5-0) MTH 113 or concurrently.

First of a five-term course sequence in elementary physics consisting of 291, 292, 293, 294 and 395. In this sequence the principles of physics are presented in a unified manner that emphasizes modern concepts. Mechanics, including special relativity.

292. Physics II

Fall. 4(5-0) 291; MTH 214 or concurrently.

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

293. Physics III

Winter. 4(5-0) 292; MTH 215 or concurrently.

Continuation of 292. Wave physics including optics.

294. Physics IV

Spring. 4(5-0) 293 or 289.

Continuation of 293. Introduction to quantum physics.

297. Principles of Physics Laboratory

Fall, Winter. 1(0-2) 287 or concurrently.

Mechanics.

298. Principles of Physics Laboratory

Winter, Spring. 1(0-2) 288 or concurrently.

Heat and thermodynamics, electricity and magnetism.

299. Principles of Physics Laboratory

Fall, Spring, Summer. 1(0-2) 289 or concurrently.

Wave motion, sound, light and modern developments.

357. Topics in Contemporary Physics

Spring. 4(4-0) 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.

360. Introduction to Radioactivity

Summer. 3(2-3) One year of college physics or approval of department.

Elementary nuclear properties and processes emphasizing nature of radioactivity and its measurement. Special attention given to experimental techniques used with radioisotopes, and their associated radiations provide physical background for biological and industrial applications.

364. Atomic Physics for Engineers

Fall, Winter, Spring. 3(3-0) Engineering Juniors or approval of department.

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

392. Physics II Laboratory

Fall. 1(0-3) 292 or concurrently.

Experiments in classical mechanics and electricity and magnetism.

393. Physics III Laboratory

Winter. 1(0-3) 293 or concurrently.

Experiments in wave motion and optics.

394. Physics IV Laboratory

Spring. 1(0-3) 294 or concurrently.

Experiments in general and modern physics.

395. Physics V

Fall. 3(3-0) 294 or approval of department.

Continuation of 294. Thermodynamics and statistical physics.

400H. Honors Work

Fall, Winter, Spring. Variable credit.

404. Special Problems

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

419. Electronics

Spring. 3(2-3) 418.

Electron tube and electric circuits designed for control and physical measurement. Laboratory work provides direct study of characteristics of tubes and circuits.

427. Intermediate Mechanics

Fall. 3(3-0) 289 or 293; MTH 215.

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) 427.

Continuation of 427.

429. Advanced Mechanics

Spring. 3(3-0) 428.

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

438. Optics

Winter. 4(3-3) 289 or 293; MTH 215.

Geometrical and physical optics. Treatment of thick lens theory, interference, diffraction and polarization phenomena, and propagation of light in material media.

439. Optics

Spring. 4(3-3) 438.

Continuation of 438.

447. Electricity and Magnetism I

Winter. 4(4-0) Eighteen credits in physics, including 289 or 293; MTH 215.

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) 447.

Continuation of 447.

457. Advanced Physics Laboratory

Fall, Winter, Spring. 2(0-6) May re-enroll for a maximum of 6 credits. 15 credits in physics including 289 or 293.

Laboratory courses consisting of experiments in modern physics of historical interest and in research techniques in solid-state and nuclear physics. Emphasizes experimental methods and proper treatment and interpretation of data. Independent work encouraged.

459. Intermediate Solid State Physics

Winter. 3(3-0) 294 or 364.

Classification of solids (crystal structure and X-ray methods); imperfections; electrical, magnetic, and thermal properties of solids; electron theory of metals; super-conductors; semi-conductors.

491. Introduction to Quantum Mechanics

(467.) Fall. 3(3-0) 294; MTH 215.

Schroedinger 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

(468.) Winter. 3(3-0) 491.

Continuation of 491.

493. Introduction to Quantum Mechanics III

(469.) Spring. 3(3-0) 492.

Continuation of 492.

498. Introduction to Nuclear Physics

(368.) Spring. 3(3-0) 294 or 364 or 491.

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

817. Techniques of Theoretical Physics I

Fall. 2(2-0) Graduate students; or approval of department.

Formulation of physical problems and practical methods of solving frequently encountered differential and integral equations including numerical methods; approximations appropriate to physical situations are stressed.

818. Techniques of Theoretical Physics II

Winter. 2(2-0) 817.

Special functions of importance to theoretical physics are described. Solution of physical problems using Green's Functions, the delta function, expansions in series, integral transforms.

819. Techniques of Theoretical Physics III

Spring. 2(2-0) 818, MTH 423.

Application of methods of contour integration to solution of physical problems; introduction to basic concepts involved in theoretical formulation of quantum mechanical states, observables, and development of dynamical systems.

827. Theoretical Physics I

Summer of odd-numbered years. 3(3-0) 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) 448 or approval of department.

Special relativity, Maxwell's equations, electrodynamics and electromagnetic waves.

829. Theoretical Physics III

Spring. Summer of odd-numbered years. 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) 428, 491.

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) 837.

Approximation methods, perturbation theory, applications to atomic transitions, angular momentum.

839. *Quantum Mechanics III*
Spring. 3(3-0) 838.

Collision processes and scattering theory, applications; many-particle systems.

847. *Electromagnetic Theory I*
Fall. 3(3-0) 428, 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) 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) 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.

857. *Theoretical Mechanics I*
Fall. 2(2-0)

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*
Winter. 2(2-0) Approval of department.

Hamiltonian formalism for particles and fields, variational methods, canonical transformations.

859 *Theoretical Mechanics III*
Spring. 2(2-0) Approval of department.

Small oscillations, classical fields, relativity.

867. *Quantum Mechanics IV*
Fall. 3(3-0) 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) 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) 868.

Heisenberg representation, S-matrix reduction formulae, Feynman rules, quantum electrodynamics; topics from many-body theory.

877. *Equilibrium Statistical Mechanics*
Fall. 3(3-0) Approval of department.

Ensembles, partition functions, thermodynamic potentials with applications to simple thermodynamics; topics from many-body theory.

878. *Nonequilibrium Statistical Mechanics*
Winter. 3(3-0) 877.

Time-dependent Liouville equation, Bloch equation, and master equation, with application to relaxation processes and atomic, molecular, and nuclear systems.

879. *Quantum Statistical Mechanics*
Spring. 3(3-0) 878.

Green's function techniques with application to transport theory, superconductivity, magnetism.

899. *Research*
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

907. *Sound and Ultrasonics*
Fall, Winter, Spring. 4(4-0) May re-enroll for a maximum of 12 credits. MTH 215.

Physical effects and properties of sonic and ultrasonic waves. Special attention to experimental methods for studying sound fields and measuring acoustical quantities. Applications of sonic and ultrasonic energy in colloidal chemistry, biology, medicine, metallurgy, nondestructive testing communications, and other fields.

927. *Elementary Particle Physics*
Fall. 3(3-0) 869.

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

928. *Elementary Particle Physics*
Winter. 3(3-0) 927.

Baryon and meson resonances, unitary symmetry, dispersion relations.

929. *Elementary Particle Physics*
Spring. 3(3-0) 928.

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

937. *Molecular Structure and Spectra I*
Fall of odd-numbered years. 3(3-0) 837 or concurrently.

Structure and spectra of diatomic molecules.

938. *Molecular Structure and Spectra II*
Winter of even-numbered years. 3(3-0) 937.

Structure and spectra of polyatomic molecules.

939. *Molecular Structure and Spectra III*
Spring of even-numbered years. 3(3-0) 938.

Advanced topics in vibration-rotation theory of polyatomic molecules.

947. *Solid State Physics I*
Fall. 3(3-0) 459 and 839.

Crystal symmetry, crystal binding, lattice vibrations and specific heat, one-electron theory; Hartee-Fock equation, Brillouin zones.

948. *Solid State Physics II*
Winter. 3(3-0) 947.

Effective mass approximation. Exchange and correlation corrections. Theory of conductivity and related effect, metals and semiconductors.

949. *Solid State Physics III*
Spring. 3(3-0) 948.

Ionic crystals. Imperfections in crystals, plastic deformations, color centers. Optical properties. Rectification, transistors, selected topics.

957. *Nuclear Physics I*
Fall. 3(3-0) 867.

Nucleon-nucleon scattering, nuclear sizes and shapes, multipole moments; shell model; collective states.

958. *Nuclear Physics II*
Winter. 3(3-0) 957.

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

959. *Nuclear Physics III*
Spring. 3(3-0) 958.

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

960. *Techniques in Nuclear and Particle Physics*
Fall. 3(3-0) Approval of department.

Properties of accelerators and particle beams, passage of radiation through matter, particle detection, pulse electronics, statistics, on-line computation.

961. *Accelerator Physics*
Winter. 3(3-0) 849, 859.

Cyclotrons, betatrons, synchrotrons, and linear accelerators. Theory of magnetic focussing: constant gradient, alternating gradient, edge focussing. Acceleration processes, longitudinal motion. Non-linear resonances, stability limits. Beam injection, extraction, and transport.

984. *Advanced Readings in Physics*
Fall, Winter, Spring, Summer. Variable credit.

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.

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

PHYSIOLOGY PSL

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

240. *Introductory Physiology*
Fall, Spring, Summer. 4(3-2) Sophomores or approval of department.

Survey of the physiology of circulatory system, excretion, nervous system and special senses, digestion, metabolism and endocrinology.

241. *Introductory Physiology*
Winter, Summer. 4(3-2) 240.

Continuation of 240. Physiology of muscle function and neuro-muscular relationships; exercise; respiration; changes in organ systems in relation to muscular exercise.

323. *Physiology, Anatomy, and Hygiene of the Eye*
Fall. Summer of even-numbered years. 3(2-2) 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.

331. *Human Physiology*
Winter. 4(3-2) ANT 316; CEM 132, or approval of department.

332. *Human Physiology*
Spring. 4(3-2) 331.