400. Physical Science for Teachers

Fall, Winter, Spring, Summer. 3 or 4 credits. May re-enroll for a maximum of 12 credits. Teacher certification with science major or minor.

For in-service teachers stressing process, inquiry, meaning and field experience. Topics will be generated from the classroom experiences of participants.

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.

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.

890. Problems in Physical Science

Fall, Winter, Spring, Summer. 1 to 12 credits. May re-enroll for a maximum of 15 credits. Bachelors degree in a physical science.

PHYSICS PHY

College of Natural Science

Introductory physics courses are divided into four groups:

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

2) 281, 282, 283 (theory) for students of the natural sciences who have taken Calculus I (MTH 112).
Self-paced, under combined management with 291A, 291B, 292A, 292B, and the self-paced sections of 281A, 282A, 283A, 287, 288, 289.
Students in 281, 282, 283 may take either 257, 258, 259 or 297, 298, 299 laboratory course sequences.

3) 281A, 282A, 283A, 287, 288, 289 (theory) for students of the physical sciences, mathematics, engineering and others taking Calculus III (MTH 214). May be taken as 287 or as 281 plus 281A, 288, or as 282 plus 282A, as 289 or 283 plus 283A.
The self-paced sections are under combined management with 281, 282, 283, and 291A, 291B, 292A, 292B, 293A, 293B.
Students in 287A, 287B, 288A, 288B, 289A, 289B may take either 297, 298, 299 or 392, 393, 394 laboratory course sequences.

4) 291A, 291B, 292A, 292B, 293A, 293B (theory) for physics majors and others with a special interest in physics. Students should be taking Calculus III (MTH 214).
Self-paced, under combined management with 281, 282, 283, and self-paced sections of 281A, 282A, 283A, 287, 288, 289.
291, 292, 293, 294 (theory) for physics majors and others with a special interest in physics. Students should be taking Calculus III (MTH 214). Lecture-recitation format only.
Students in 292, 293, 294, 291A, 291B, 292A, 292B, 293A, 293B may take either 392, 393, 394, or 297, 298, 299 laboratory course sequences.

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 PHY 294, 357 or 364.

PHY 201, 256, 301, 357 and 430 cannot be used to meet the requirements for a major in physics.

All 400 level physics courses (except 430) require PHY 289 or 293B or equivalent and MTH 215 as prerequisites.

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

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

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) 201. Interdepartmental with and administered by the Mechanical Engineering Department.

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

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.

256. Energy Consumption and Environmental Quality

Spring. 3(3-0) Sophomores. Interdepartmental with and administered by Lyman Briggs College.

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) 237 or 281, or concurrently.

Mechanics and heat.

258. Introductory Physics Laboratory

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

Heat, electricity and magnetism.

259. Introductory Physics Laboratory

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

Wave motion, sound, light and modern developments.

281. Basic Physics I

Fall. 3 credits—Self-paced only. MTH 112.

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

281A. Physics IA

Fall. 1 credit—Self-paced only. MTH 113; PHY 281 or concurrently.

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

282. Basic Physics II

Winter. 3 credits—Self-paced only. 281, or 281A, or 287, or 291A, or 291B, or 291.

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

282A. Physics IIA

Winter. 1 credit—Self-paced only. 281 or 281A, or 287, or 291, or 291B; MTH 214 or approval of department.

Extensions of 282, plus: entopy, transport phenomena, general relativity, electrons, atoms, molecules, solids, Maxwell's equations, electromagnetic fields, energy, alternating currents, and other electricity and magnetism applications, numerical (computer) solutions.

283. Basic Physics III

Spring. 3 credits—Self-paced only. 282, or 282A, or 288, or 292, or 292A or 292B.

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

283A. Physics IIIA

Spring. 1 credit—Self-paced only. 282, or 282A, or 288, or 292A, or 292B; MTH 214 or approval of department.

Extensions of the 283 material, plus topics in: spectral origins and analysis, optics, standing wave phenomena, diffraction, quantum mechanics, numerical (computer) solutions, nuclei.

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 214 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.

291A. Honors Physics IA

Fall. 1 credit—Self-paced only. MTH 113; PHY 281A or 287.

Subjects and topics as in 287, generally on a more advanced level and less generally prescribed.

291B. Honors Physics IB

Fall. 5 credits—Self-paced only. MTH 113.

Combined course, equivalent to 287 plus 291A.

292. Physics II

Fall. 4(5-0) 291; MTH 215 or concurrently.

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

292A. Honors Physics IIA

Winter. 1 credit—Self-paced only. MTH 214; PHY 281A, or 287, or 291A, or 291B, or 291.

Subjects and topics as in 288, generally on a more advanced level and less closely prescribed.

292B. Honors Physics IIB

Winter. 5 credits—Self-paced only. MTH 214; PHY 281, 281A, or 287, or 291A, or 291B, or 291.

Combined course, equivalent to 288 plus 292A.

293. Physics III

Winter. 4(5-0) 292.

Continuation of 292. Wave physics including optics.

293A. Honors Physics IIIA

Spring. 1 credit—Self-paced only. MTH 215; PHY 282A, or 288, or 292A, or 292B.

Subjects and topics as in 289, generally on a more advanced level and less closely prescribed.

293B. Honors Physics IIIB

Spring. 5 credits—Self-paced only. MTH 215; PHY 282 and 282A, or 288, or 292A, or 292B.

Combined course, equivalent to 289 plus 293A.

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) 281, or 287, or 291B or 292 or concurrently.

Mechanics.

298. Principles of Physics Laboratory

Winter, Spring. 1(0-2) 282, or 288 or 292B, or 293 or concurrently.

Heat and thermodynamics, electricity and magnetism.

299. Principles of Physics Laboratory

Fall, Spring, Summer. 1(0-2) 283, or 289, or 293B, or 294 or concurrently.

Wave motion, sound, light and modern developments.

301. Bohr and Einstein: The Concept of Nature in Our Day

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).

310. Calculus Concepts in Physics

Fall, Summer. 5(5-0) 237, 238, 239; MTH 214.

A transition course to prepare students who had non-calculus introductory physics for upperdivision 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

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.

364. Introduction to Modern Physics I

Fall, Winter, Spring. 3(3-0) 289 or 293B or approval of department.

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

365. Introduction to Modern Physics II

Winter, Spring. 3(3-0) 364 or 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.

368. Elementary Solid State Physics I

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

Crystal structure and binding; lattice dynamics, specific heat, thermal conductivity; free electron theory of metals, conductivity, optical properties; elementary band theory; Hall effect, effective masses in metals and semi-conductors.

369. Elementary Solid State Physics II

Spring. 3(3-0) 368.

Ferroelectricity, paramagnetism, ferromagnetism, antiferromagnetism, domain walls; point defects, and dislocations in metals, formation and motion energies, internal friction, radiation damage.

392. Physics II Laboratory

Fall. 1(0-3) 287 or 291B or 292 or concurrently.

Experiments in classical mechanics and electricity and magnetism.

393. Physics III Laboratory

Winter. 1(0-3) 288, or 292B, or 293 or concurrently.

Experiments in wave motion and optics.

394. Physics IV Laboratory

Spring. 1(0-3) 289 or 293B, or 294 or concurrently.

Experiments in general and modern physics.

395. Physics V

Fall. 3(3-0) 293B, or 294, or 364.

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. Physical Phenomena and Electronic Instrumentation I

Winter. 4(3-3) 289 or 293B; MTH 215. Interdepartmental with the Electrical Engineering Department.

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) 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) 289 or 293B; 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.

430. Introduction to Radioactivity and Radioisotope Techniques

Fall, Summer. 3(2-3) One year each of general college chemistry and physics and CEM 161. CEM 162 recommended. Physics majors cannot apply course towards graduation requirements. Interdepartmental with the Chemistry Department.

Elementary nuclear properties and processes with emphasis on radioactivity, its measurement, and its interaction with matter. Special attention is given to experimental techniques and applications of radioisotopes to problems in chemistry, the life sciences and industry.

438. Optics

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

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

439. Optics

Winter. 4(3-3) 438.

Physical optics including Huygens-Fresnel Principles, diffraction; Fourier transforms of wave forms, convolution, diffraction and image formation; holography; polarization.

447. *Electricity and Magnetism I*

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

457G. *Advanced Physics Laboratory (General)*

(457.) Fall. 3(1-6) 15 credits in physics including 289 or 293B.

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)*

(457.) Winter of even-numbered years, Spring of odd-numbered years. 3(1-6) 15 credits in physics including 289 or 293B.

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)*

(457.) Spring of even-numbered years, Winter of odd-numbered years. 3(1-6) 15 credits in physics including 289 or 293B.

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*

(467.) Fall. 3(3-0) 294 or 364; 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*

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.

840. *Symmetry in Solid State Physics*

Spring. 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) 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.

850. *Ionized Gases*

Spring. 3(3-0) E E 835 or PHY 448. Interdepartmental with the Astronomy Department and Electrical Engineering and administered by Electrical Engineering.

Elastic collision processes; Boltzmann equation; moment equations; basic plasma phenomena; motion of a charged particle in electrical and magnetic field; individual and collective charged particle behavior.

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.

860. *General Relativity and Cosmology I*

Fall of even-numbered years. 3(3-0) 859 or approval of department. Interdepartmental with the Astronomy Department.

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) AST 860. Interdepartmental with the Astronomy Department.

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) 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.

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) 839 and 840.

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.

989. *Waves and Radiations in Plasmas*

Fall of even-numbered years. 3(3-0) 850. Interdepartmental with the Astronomy Department and Electrical Engineering and administered by Electrical Engineering.

Plasma oscillation; interaction, electromagnetic fields with plasmas, wave propagation in magnetionic media; plasma sheath; radiation of electric source in incompressive and compressive plasmas; electoacoustic waves; magnetohdrodynamics; research topics in plasmas.

999. *Research*

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

PHYSIOLOGY PSL

College of Human Medicine
College of Natural Science
College of Osteopathic Medicine
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.

401. *Comparative Physiology I*

(412.) Fall. 4(3-4) 240 or B S 212 and CEM 132. Interdepartmental with 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) 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) CEM 242 or 353.

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.

417. *Physiology of the Cell*

Summer. 4(3-3) 4(6-6) 5 weeks. This is equivalent to 3 hours of lecture and 3 hours of laboratory on a ten-week basis. Approval of department.

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.

440. *Avian Physiology*

Spring of odd-numbered years. 4(3-3) Approval of department. Interdepartmental and administered jointly with the Poultry Science Department.

A survey of the systemic physiology of birds emphasizing digestion, metabolism, the endocrines, and reproduction.

444. *Milk Secretion*

Winter. 4(3-2) Interdepartmental and administered jointly with the Dairy Science Department.

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.

445. *Endocrinology and Reproduction of Farm Animals*

Fall. 4(3-2) 240. Interdepartmntal and administered jointly with the Dairy Science Department.

Endocrine and reproductive systems are presented with emphasis upon characteristics which can be altered for economic benefit and upon causes, prevention, and treatment of endocrine abnormalities.