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

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).


Students in 281, 282, 283 may take either 287 or 288, or 287 or 289, or 287 or 288. 287 may be taken at 287 or as 287 plus 291A, 291B, or as 287 plus 292A, as 287 or 289 plus 283A.

The self-paced sections are under combined management with 281, 282, 283, and 291A, 291B, 292B, 293A, 293B.

Students in 287A, 287B, 288A, 288B, 289A, 289B. Students may take either 297, 298, 299 or 292, 293, 294 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 at 287 or as 287 plus 291A, 291B, or as 287 plus 283A or 289 or 283 plus 283A.

The self-paced sections are under combined management with 281, 282, 283, and 291A, 291B, 292B, 293A, 293B.

Students in 287A, 287B, 288A, 288B, 289A, 289B may take either 297, 298, 299 or 292, 293, 294 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 254, 257 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 293 or 293B or equivalent and MTH 215 as prerequisites.

201. The Science of Sound I: Rock, Bach and Oscillators
Winter. 3(3-2) or 4(4-0) Interdepartmental with the Mechanical Engineering Department.

202. The Science of Sound II
Spring. 3(3-0) or 4(4-0) 201. Interdepartmental with and administered by the Mechanical Engineering Department.

237. Introductory Physics
Fall, Winter. 3(4-0) MTH 102 or 105 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. 3(3-0) 238 or concurrently.
Heat, electricity and magnetism.

259. Introductory Physics Laboratory
Fall, Spring, Summer. 1(0-2) 239 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, analog (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 IIB
Winter. 1 credit—Self-paced only. 282, or 281A, or 287, or 291A, or 291B, or 292B.
Physics of sound, light, and optical instruments, wave-particle duality, radioactivity, fusion and fission, elementary particles, fundamental forces of nature.

283. Basic Physics III
Spring. 3 credits—Self-paced only. 282, or 282A, or 289, or 292, or 292A or 292B.
Physics of light, sound, heat, and electrical currents, wave-particle duality, radioactivity, fusion and fission, elementary particles, fundamental forces of nature.

283A. Physics IIIA
Spring. 1 credit—Self-paced only. 283, or 292A, 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 waves, electronic devices, modern developments.

287. Principles of Physics
Fall, Winter. 4(4-0) 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 295. 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 or 287A, 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 285, or 292A, or 292B.  
Subjects and topics as in 293, 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 286, or 293A, or 293B.  
Combined course, equivalent to 293 plus 293A.

294. Physics IV  
Spring, 4(5-0) 293 or 290.  
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) Junior.  
Basic contemporary ideas about the nature world and their significance for man presented through studies 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 207, 208, 209.  
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  
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 concurrently.  
Atomic structure; wave and particle aspects of radiant energy; optical and X-ray spectra.

385. 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, superconductors, semi-conductors, fusion reactions, particle accelerators, etc.

386. Elementary Solid State Physics I  
Winter, 3(3-0) 294 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.

389. Elementary Solid State Physics II  
Spring, 3(3-0) 388.  
Fermiology, paramagnetism, ferromagnetism, antiferromagnetism, domain walls, point defects, and dislocations in metals, formation and motion energies, internal friction, radiation damage.

393. Physics II Laboratory  
Fall, 1(0-2) 297 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 295.  
Continuation of 294. Thermodynamics and statistical physics.

400H. Honors Work  
Fall, Winter, Spring. Variable credit.

404. Special Problems  
Fall, Winter, Spring. 1 to 5 credits.  
Fall, Winter, Spring; approval of department.

419. Physical Phenomena and Electronic Instrumentation I  
Winter, 4(3-3) 289 or 293B; MTH 215.  
Introduction of the Electrical Engineering Department.  
Concepts of electronics relative to uses in investigations of physical phenomena and their subordinate applications as they provide reliable instrumentation. Nuclear radiation detectors, photometers and magnetometers are examples of specific topics covered.

420. Physical Phenomena and Electronic Instrumentation II  
Spring, 3(2-3) 419.  
Noise and its characterization. Typical electronic circuits are analyzed in detail. A reliable instrument that uses a physical effect is developed by the student.

427. Intermediate Mechanics  
Fall, 3(3-0) 299 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(2-3) 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, 2(2-3) 243.  
One year each of general college chemistry and physics and CEM 151. CEM 152 recommended. Physics majors cannot apply course towards graduation requirements. Interdepartmental with the Chemistry Department.

431. Nuclear Physics  
Fall, Winter, Spring. 4(3-2) 431.  
Elementary nuclear properties and processes with emphasis on radioactive, its measurement, and its interaction with matter. Special attention is given to technical applications of radioisotopes to problems in chemistry, the life sciences and industry.

432. Geometrical Optics  
Fall, 4(3-3) 289 or 293B; MTH 215.  
Applications of the laws of reflection and refraction to mirrors, lenses, and systems thereof.  
Applicable to those majoring in science, engineering, mathematics.

433. Optics  
Winter, 3(3-3) 433.  
Physical optics including Fermat's Principle, refraction, reflection, mirrors, thin lenses, thick lenses, aberrations, and the effects of apertures and stops, interference.

434. Optics  
Winter, 3(3-3) 434.  
Physical optics including Huygen's-Fresnel Principles, diffraction, Fourier transforms of wave forms, convolution, diffraction and image formation; holography; polarization.
447. Physics E 457G. Advanced Electromagnetic Phenomena; electrostatic potentials from Laplace's and Poisson's equations, effects of dielectric and magnetic materials, magnetic fields and potentials; introduction to quantum mechanics, applications to physics. 3(3-0) 15. Spring of even-numbered years. Continuation of 447.


450. Ionized Gases Spring. 3(3-0) E E 855 or PHY 449. Interdepartmental with the Astronomy Department and Electrical Engineering and administered BY Electrical Engineering.

452. Theoretical Physics II Spring. 3(3-0) 452 or approval of department. Vector analysis, mechanics of a particle and of systems of particles. Lagrange's equations, Hamiltonian methods, rotational motion.

452. Theoretical Physics II Spring. 3(3-0) 459 or approval of department. Special relativity, Maxwell's equations, electrodynamics and electromagnetic waves.

453. Quantum Mechanics I Fall. 3(3-0) 428, 491. The formulation of quantum mechanics, superposition principle, state vector and representations; uncertainty principle; Schrödinger equation and its solution for physical systems.

454. Electromagnetic Theory I Fall. 3(3-0) 428, 449. 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.

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


457C. Advanced Physics Laboratory (General)

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.
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, Boltzmann 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 applications to transport theory; superconductivity, magnetism.

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

927. *Elementary Particle Physics*  
*Fall, 3(3-0) 889.*  
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.*  
Rayon models; 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) 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; Hartree-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 effects, metals and semiconductors.

949. *Solid State Physics III*  
*Spring, 3(3-0) 948.*  
Ionic crystals. Impurities 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.

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.*  

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

967. *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, specialised 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) 859.*  
interdepartmental with the Astronomy Department and Electrical Engineering and administered by Electrical Engineering. Plasma oscillation; interaction, electromagnetic fields with plasmas, wave propagation in magnetized media; plasma sheets; radiation of electric source in incompressive and compressive plasmas; electromagnetic waves; magnetohydrodynamics; research topics in plasmas.

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

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**PHYSIOLOGY**

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

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**Introduction to Physiology**  
*Fall, Spring, Summer. 4(3-2) Sophomores or approval of department.*  
Survey of the physiology of the circulatory system, excretion, nervous system and sensory systems, digestion, metabolism and endocrinology.

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**Introduction to Physiology**  
*Winter. 4(3-2) 240.*  
Continuation of 240. Physiology of muscle function and neuro-muscular relationships; excretion; respiration; changes in organ systems in relation to muscular exercise.

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

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**Human Physiology**  
*Winter. 4(3-2) 331.*

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**Comparative Physiology I**  
*Fall, 4(3-2) 940 or B S 919 and CEM 133. Interdepartmental with Department of Zoology.*  
A comparison of oogenesis, digestion, respiration, and other physiological processes in a wide range of organisms.

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

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**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.

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**Physiology of the Cell**  
*Summer, 4(3-2) 4(4-6) 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.

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**Physiology of the Cell**  
*Summer, 4(3-2) 4(4-6) 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.

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**Interdepartmental and administered jointly with the Poultry Science Department:**

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

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**Endocrinology and Reproduction of Farm Animals**  
*Fall, 4(3-2) 240 Interdepartmental and administered jointly with the Dairy Science Department.*  
Endocrine and reproductive systems are presented with emphasis upon those characteristics which can be altered for economic benefit and upon causes, prevention, and treatment of endocrine abnormalities.