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

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

PHYSICAL SCIENCE  

PHYSICS AND ASTRONOMY

College of Natural Science  
The content of 405, as well as the problems course, 890, may vary from term to term. Brochures giving detailed information about individual courses are available in the College of Natural Science and the Office of the Assistant Dean for Lifelong Education. These courses are primarily designed for in-service teachers and interested adults and are offered in off-campus locations.

203. Foundations of Physical Sciences  
Fall, Winter, Spring. 4(3-3) 12 credits of Natural Science.  
An introduction to physical science for non-science majors. Emphasizes on basic concepts relating to human interaction with the physical environment. Topics selected from physics, chemistry, and the earth and space sciences.

405. Topics in Physical Science  
Fall, Winter, Spring. 1 to 3 credits. May reenroll for a maximum of 6 credits if different topic is taken. Approval of department.

Presentation of single topics from the physical sciences by senior faculty and guest lecturers. Topics are selected to facilitate development of strong physical science programs in schools.

431. Problems in Planetarium Education  
Fall, Winter, Spring. 1 to 3 credits. May reenroll for a maximum of 6 credits. Approval of department.

Individual study, training, or project under the direction of a faculty member. Often the training will be in the area of actual delivery of planetarium presentations.

590. 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.

PHYSICS AND ASTRONOMY  

(Please refer to the descriptions of courses for the College of Natural Science for more detailed information.)
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.

261. **Basic Physics I, CBI**
   Fall, Winter, Spring, Summer. 3 credits. MTH 112.
   Static equilibrium. Newton's laws. power, harmonic motion, rotational motion.

262. **Basic Physics II, CBI**
   Fall, Winter, Spring, Summer. 3 credits. PHY 281.
   Microscopic origin of heat flow and first law of thermodynamics, electric and magnetic forces and sources, direct currents.

263. **Basic Physics III, CBI**
   Fall, Winter, Spring, Summer. 3 credits. PHY 282.
   Physics of sound, light, and optical instruments, wave-particle duality, radioactivity, fusion and fission, elementary particles, fundamental forces of nature.

264. **Calculus Concepts in Physics I, CBI**
   Fall, Winter, Spring. 2 credits. PHY 237, MTH 113. Credit may not be earned in both PHY 284 and PHY 310.

265. **Calculus Concepts in Physics II, CBI**
   Fall, Winter, Summer. 2 credits. PHY 238, PHY 284, MTH 214. Credit may not be earned in both PHY 285 and PHY 310.
   Extension of PHY 238 involving calculus concepts. PHY 238 plus PHY 285 equals PHY 288. Electromagnetic interactions, magnetic fields, forces and sources, magnetostatics, and electrical circuits.

266. **Calculus Concepts in Physics III, CBI**
   Fall, Winter, Spring. 2 credits. PHY 239, MTH 314. Credit may not be earned in both PHY 289 and PHY 310.
   Extension of PHY 239 involving calculus concepts. PHY 239 plus PHY 286 equals PHY 290. Wave phenomena, photons, atomic states and transitions, quantum mechanics, subatomic phenomena.

267. **Principles of Physics**
   Fall, Winter, Spring. 4(5-0) MTH 113. Mechanics.

268. **Physics IA, CBI**
   Fall, Winter, Spring. 1 credit. MTH 113; PHY 281. May not be taken concurrently with PHY 281.
   Extensions of PHY 281, plus topics from: frames of reference, special relativity, rocket equation, forced oscillations, resonances, fluid motion, numerical (computer) solutions, moments of inertia, gyroscopic motion.
287B. Principles of Physics I, CBI
Fall, Winter, Spring, Summer. 4 credits. MTH 117.
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. (4-0) PHY 287; MTH 214 or approval of department. Heat and thermodynamics, electricity and magnetism.

288A. Physics IIIA, CBI
Fall, Winter, Spring, Summer. 1 credit. PHY 282, MTH 214 or approval of department. May not be taken concurrently with PHY 282.

288B. Principles of Physics II, CBI
Fall, Winter, Spring, Summer. 4 credits. PHY 287A, PHY 287B 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. (4-0) PHY 289; MTH 214 or approval of department. Wave motion, sound, light, and modern developments.

289A. Physics IIIB, CBI
Fall, Winter, Spring. Summer. 1 credit. PHY 283, MTH 214 or approval of department. May not be taken concurrently with PHY 283.

289B. Principles of Physics III, CBI
Fall, Winter, Spring. Summer. 4 credits. PHY 289, PHY 289A, or PHY 289B, MTH 214 or approval of department. The CBI version of PHY 289. Course content is identical to content of PHY 283 plus PHY 289A.

291. Honors Physics I, CBI
Fall, Winter, Spring, Summer. 1 credit. PHY 287A, MTH 115.
Subjects and topics as in PHY 281 and PHY 287A, generally on a more advanced level.

292A. Honors Physics IIA, CBI
Fall, Winter, Spring, Summer. 1 credit. PHY 288A, MTH 214.
Subjects and topics as in PHY 282 and PHY 289A, generally on a more advanced level.

292B. Honors Physics IIB, CBI
Fall, Winter, Spring, Summer. 5 credits. PHY 291B, MTH 214.
Combined material of PHY 282 plus PHY 288A plus PHY 292A is covered in one term.

292H. Physics II
Fall, Winter, Spring. (4-0) PHY 291H, MTH 215 or concurrently. Continuation of PHY 291H. Electricity and magnetism with some special relativity.

293A. Honors Physics IIIA, CBI
Fall, Winter, Spring, Summer. 1 credit. PHY 289A, MTH 215.
Subjects and topics as in PHY 283 and PHY 289A, generally on a more advanced level.

293B. Honors Physics IIIB, CBI
Fall, Winter, Spring, Summer. 5 credits. PHY 292B, MTH 215.
Combined material of PHY 283 plus PHY 289A plus PHY 293A is covered in one term.

293H. Physics III
Winter. (4-0) PHY 292H.
Continuation of PHY 292H. Wave physics including optics.

294. Physics IV
Spring. (4-0) PHY 293H or PHY 289.
Continuation of PHY 293H. Introduction to quantum physics.

296. Physics Computations Laboratory
Spring. (1-0) PHY 291H concurrently or approval of department.
Micro computers are utilized in developing computational skills in solving physics problems encountered in introductory classical mechanics.

297. Principles of Physics Laboratory
Fall, Winter, Spring. (1-0) PHY 291 or concurrently. Mechanics.

298. Principles of Physics Laboratory
Winter. (1-0) PHY 292 or concurrently. PHY 291 or approval of department.
Heat and thermodynamics, electricity and magnetism.

299. Principles of Physics Laboratory
Spring. (1-0) PHY 293 or concurrently. PHY 291 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(0-0) Junior.
Basic contemporary ideas about the natural world and their significance presented through the study 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 297, PHY 298, PHY 299, MTH 214. Students may not earn credit in both PHY 310 and PHY 294 or PHY 285 or PHY 296.
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.

356. Physics of Nuclear Arms and Nuclear War
Fall. (3-0) One full year of general college physics.
The physics of nuclear weaponry and strategic delivery systems, including physical detonation effects and the mathematical analysis of counterforce vulnerability and deterrence. Approved through Fall 1986.

357. Topics in Contemporary Physics, CBI
Fall, Winter, Spring. Summer. 4 credits. One year of general college physics.
Atomic and nuclear physics, cosmic rays and elementary particles, nuclear energy, new theoretical concepts. Recommended for prospective high school teachers.

364. Introduction to Modern Physics I
Winter. (3-0) PHY 289, MTH 215.
Atomic structure; wave and particle aspects of radiant energy; optical and X-ray spectra.

364B. Introduction to Modern Physics I, CBI
Fall, Winter, Spring, Summer. 3 credits. PHY 289, MTH 215.
The CBI version of PHY 364.

365. Introduction to Modern Physics II
Spring. (3-0) PHY 364 or PHY 294.
Nuclear, molecular, solid state and elementary particle physics. Special emphasis is given to applications such as reactors, super conductors, semiconductor, fusion reactions, particle accelerators, etc.

365B. Introduction to Modern Physics II, CBI
Fall, Winter, Spring, Summer. 3 credits. PHY 364 or PHY 294.
The CBI version of PHY 365.

395. Physics V
Fall. (3-0) PHY 293B, or PHY 294, or PHY 364.
Continuation of PHY 294. Thermodynamics and statistical physics.

400II. Honors Work
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 10 credits.

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

419. Physical Phenomena and Electronic Instrumentation I
Winter. (4-3) 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 Electronic Instrumentation II
Spring. (3-2-3) PHY 419.
Noise and its characterization. Typical electronic instruments are analyzed in detail. A reliable instrument that uses a physical effect is developed by the student.
Descriptions — Physics and Astronomy of Courses

427. Intermediate Mechanics
Fall, Summer. 3(3-0) PHY 286; MTH 310 or concurrently.
Static and dynamics of a particle and of rigid bodies; linear and non-linear oscillations; gravitation from a field point of view; transformation properties of physical quantities; introduction to mathematical techniques of theoretical physics.

428. Intermediate Mechanics
Winter, Summer. 3(3-0) PHY 427.
Continuation of PHY 427.

429. Advanced Mechanics
Spring. 3(3-0) PHY 428.
Advanced methods of theoretical mechanics; generalized coordinates; Lagrange's and Hamilton's equations; the wave equation, theory of vibrations.

430. Introduction to Radioactivity and Radioisotope Techniques
Spring, Summer. 1(0-3) CEM 161, CEM 430 concurrently. CEM 162 recommended. Interdepartmentally with the Department of Chemistry.
Introduction to nuclear instrumentation, experimental techniques for application of radioisotopes to problems in chemistry, the life sciences, and industry.

431. 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 aperture and stop.

432. Physical Optics
Winter. 4(3-3) PHY 289, PHY 299 or approval of department, MTH 215.
Physical optics including Huygens-Fresnel Principles, interference, diffraction, and coherence. Additional topics will be selected from Fourier transforms of wave forms, convolution, diffraction and image formation, spatial filtering, holography and polarization.

447. Electricity and Magnetism I
Fall, Summer. 3(3-0) 18 credits in Physics. 281 and above.
Foundations of electrostatics, electrostatic problems in two and three dimensions, dielectrics, electrostatic energy. Magnetic fields of steady currents.

448. Electricity and Magnetism II
Winter, Summer. 3(3-0) PHY 447.

449. Electricity and Magnetism III
Spring. 3(3-0) PHY 448.
Radiation emission, antennas, electrodynamic, special theory of relativity.

457G. Advanced Physics Laboratory
(General)
Fall. 3(1-6) 15 credits in PHY 281 and above including PHY 286 and PHY 296.
Experiments in modern physics of historical interest and in general physics research techniques. Emphasizes experimental methodology 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.

457J. Advanced Physics Laboratory
(Solid State)
Spring, Summer. 3(1-6) 15 credits in PHY 281 and above including PHY 298 and PHY 299.
Experiments in low temperature and solid state physics. Emphasis on research methods and proper treatment and interpretation of data. Independent work encouraged.

491. Introduction to Quantum Mechanics I
Fall, Summer. 3(3-0) PHY 294 or PHY 384; MTH 310 or concurrently.
Schrödinger equation and its applications; angular momentum; one electron atom; moments and spin; perturbation methods; absorption and emission of radiation; atomic and molecular structure.

492. Introduction to Quantum Mechanics II
Winter, Summer. 3(3-0) PHY 491.
Continuation of PHY 491.

493. Introduction to Quantum Mechanics III
Spring, Summer. 3(3-0) PHY 492.
Continuation of PHY 492.

496. Introduction to Solid State Physics
Winter, Summer. 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, 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, Summer. 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.

499. Electromagnetic Theory I
Fall. 3(3-0) PHY 425, PHY 448.
Electrostatics; Laplace's equation, Poisson's equation; Green's theorem; solution of problems by method of images; boundary-value problems in Cartesian, spherical and cylindrical coordinates; spherical harmonics; Bessel functions.
Descriptions — Physics and Astronomy

Courses

119. General Astronomy (N)
Fall, Winter, Spring, Summer. 4(4-6)
Intended primarily for non-science majors. Not open to engineering or physical science majors. Students may not receive credit in more than one of the following: AST 119, AST 217, AST 229, N S 135, N S 155.
A qualitative presentation of the current view of the universe including birth and death of stars, cosmology, comparisons of planets, and life in the universe.

120. Topics in Astronomy
Winter, Spring. 4(4-0) AST 119.
Detailed qualitative discussion of currently interesting topics in astronomy. May include such topics as quasars, pulsars, black holes, planetary exploration, cosmology, concepts of relativity.

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

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

237. Introductory Observatory Laboratory
Fall. 1(0-3) AST 217 or AST 229 or concurrently.
Photographic and spectroscopic telescopic observations. Darkroom processing.

327. Practical Astronomy
Winter. 3(3-0) AST 217 or AST 229. MTH 113.

378. Contemporary Astronomy
Winter. 3(3-0) AST 217 or AST 229.
A continuation of General Astronomy with particular emphasis on modern developments. May include such topics as planetary exploration, interstellar matter, star formation, evolution through final stages, supernovae, pulsars, neutron stars, black holes, galaxies, and cosmology.

437. Observatory Practice
Spring. 3(4-1) AST 327 and approval of department.

451. Solar System Astrophysics
Fall. 3(3-0) PHY 427 or concurrently or approval of department.
Application of physical principles to the study of the planets, satellites, asteroids, comets, and interplanetary dust and gas. Mechanics of solar system objects.

452. Stellar and Interstellar Astrophysics
Winter. 3(3-0) PHY 364 or PHY 294 and PHY 395 or approval of department.
Emission, absorption and transfer of radiation in stars and the interstellar medium. Application of physical principles to the study of the interstellar medium and stellar interiors. Evolution of stars.

453. Galactic and Extragalactic Astrophysics
Spring. 3(3-0) PHY 364 or PHY 294 and PHY 395 or approval of department.
The large scale structure of stellar systems, clusters and galaxies. Stellar kinematics, spiral structures, interstellar and intergalactic medium, evolution of galaxies. Theoretical models will be compared with observation.

490. Special Problems
Fall, Winter, Spring, Summer. 1 to 5 credits. May reenroll for a maximum of 6 credits. Approval of department.
Individual study or project under the direction of a faculty member. An oral report on the work may be required in department seminar.

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

501. Seminar
Winter. 1(1-0) May reenroll for a maximum of 2 credits. Graduate students or approval of department.
Seminars to be presented by both faculty and students to review papers in the current astronomical research literature.

520. Advanced Topics in Astrophysics
Winter. 3(3-0) May reenroll for a maximum of 15 credits. AST 452 or PHY 385 or PHY 429 or approval of department.
Possible topics include dynamics of stars in galaxies, astrophysical fluid dynamics, quasar theory, stellar atmosphere, stellar interiors, stellar spectroscopy, and stellar photometry.

580. Electrodynamics of Plasmas I
Fall. 3(3-0) E& E 855 or PHY 448; E & E 874. Interdepartmental with Electrical Engineering and Physics, Administered by Electrical Engineering.
Boltzmann equation; moment equations; two-fluid theory of plasma, warm and anisotropic infinite plasma; waves in bounded plasma structures, energy flow in anisotropic plasmas.

600. General Relativity and Cosmology I
Fall of even-numbered years. 3(3-0) PHY 588 or approval of department. Interdepartmental with and administered by Physics.
Conceptual foundations of general relativity theory; elements of tensor calculus, Riemann-Christoffel curvature tensor; the field equations; experimental tests; special solutions; the extension to cosmology.

651. General Relativity and Cosmology II
Winter of odd-numbered years. 3(3-0) PHY 980. Interdepartmental with and administered by Physics.
Relativistic cosmology: the model universes; steady-state theory; observational evidence and possibilities for decision among models; current problems.

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

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

PHYSIOLOGY

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

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

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

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