

840 Seminar in Value Theory
Spring. 2 to 4 credits. A student may earn a maximum of 10 credits in all enrollments for this course. R: Open only to graduate students in Philosophy or approval of department.

Major figures, themes, or periods in ethics or aesthetics. Topics vary.

850 Seminar in Social and Political Philosophy
Spring of even years. 2 to 4 credits. A student may earn a maximum of 10 credits in all enrollments for this course. R: Open only to graduate students in Philosophy or approval of department.

Major figures, themes, or periods in social and political philosophy. Topics vary.

860 Seminar in Metaphysics and Epistemology
Fall. 2 to 4 credits. A student may earn a maximum of 15 credits in all enrollments for this course. R: Open only to graduate students in Philosophy or approval of department.

Selected topics in metaphysics, epistemology, and philosophy of mind.

867 Nature and Practice of Cognitive Science
Spring. 3(3-0) Interdepartmental with Zoology; Psychology; Linguistics; Computer Science and Engineering. Administered by Department of Zoology. RB: Undergraduate course work in behavioral biology, cognitive psychology, philosophy, linguistics, or artificial intelligence.

Survey of how different disciplines explore the cognitive processes underlying intelligent behavior.

870 Seminar in Philosophy of Health Care
Fall. 2 to 4 credits. A student may earn a maximum of 15 credits in all enrollments for this course. R: Open only to graduate students in Philosophy or approval of department.

Ethical, political, theoretical, and methodological issues in medicine and health care.

880 Seminar in Philosophy of Science
Spring. 2 to 4 credits. A student may earn a maximum of 10 credits in all enrollments for this course. R: Open only to graduate students in Philosophy or approval of department.

Selected topics in the philosophy of the special sciences, in the metatheory of science, and in the social studies of science.

890 Independent Study
Fall, Spring, Summer. 1 to 10 credits. A student may earn a maximum of 20 credits in all enrollments for this course. R: Approval of department.

Special projects, directed reading, and research arranged by an individual graduate student and a faculty member in areas supplementing regular course offerings.

894 Practicum in Philosophy of Health Care
Fall, Spring. 1 to 6 credits. A student may earn a maximum of 12 credits in all enrollments for this course. RB: (PHL 344) R: Open only to graduate students in Philosophy or approval of department.

Study of ethical and policy issues in hospital and governmental agency settings.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 12 credits in all enrollments for this course. R: Approval of department.

Directed research leading to a master's thesis in partial fulfillment of Plan A master's degree requirements.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 75 credits in all enrollments for this course. R: Approval of department.

Doctoral dissertation research.

PHYSICAL MEDICINE PMR AND REHABILITATION

Department of Physical Medicine and Rehabilitation College of Osteopathic Medicine

590 Special Problems
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 24 credits in all enrollments for this course.

Each student works under faculty direction on an experimental, theoretical or applied problem in physical medicine and rehabilitation.

601 Physical Medicine and Rehabilitation Clerkship
Fall, Spring, Summer. 2 to 12 credits. Fall: Michigan Capital Med. Spring: Michigan Capital Med. Summer: Michigan Capital Med. A student may earn a maximum of 12 credits in all enrollments for this course.

Physical medicine and rehabilitation inpatient and ambulatory setting clinical experience, didactic sessions, case documentation and presentation, hospital rounds. Strong emphasis on evaluation of neuromusculoskeletal disorders and treatment of function deficits.

620 Directed Studies
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 24 credits in all enrollments for this course. R: Open only to juniors or seniors in the College of Osteopathic Medicine. Completion of Semester 6 in the graduate-professional program.

Individual or group projects on special problems related to physical medicine and rehabilitation.

806 Advanced Neuroscience Techniques Laboratory
Spring. 3(0-9) Interdepartmental with Neuroscience; Psychology; Pharmacology and Toxicology; Radiology. Administered by Program in Neuroscience. RB: (PHM 827) R: Open only to doctoral students in the Neuroscience major.

Methods and underlying principles of neuroscience research.

PHYSICS

PHY

Department of Physics and Astronomy College of Natural Science

101 Concepts in Physics
Fall. 1(1-0)
Conceptual foundations of physics emphasizing key experiments.

102 Physics Computations I
Spring. 1(0-3) P:M: (PHY 183 or concurrently or PHY 183B or concurrently or PHY 193H or concurrently or PHY 181B or concurrently) RB: (CSE 101 or CSE 231)
Use of Mathematica to solve, analyze and graph equations and data from mechanics.

170 Investigations in Physics
Fall. 3(0-6) R: Approval of department.
Experiments in optics, electronics, sound and mechanics; analysis of data using computers, library research and oral presentations.

181B Basic Physics I
Fall, Spring, Summer. 3 credits. P:M; (MTH 132 or MTH 152H or LBS 118) Not open to students with credit in LBS 271 or PHY 183 or PHY 183B or PHY 193H or PHY 231 or PHY 231B or PHY 231C, PHY 233B.

Newton's laws of motion, conservation of momentum and angular momentum, energy conservation, thermal physics, waves, and sound. This course is given in the competency based instruction format.

182B Basic Physics II
Fall, Spring, Summer. 3 credits. P:M: (PHY 183 or PHY 183B or PHY 181B or LBS 271 or PHY 193H) or (PHY 231 or concurrently and PHY 233B) or (PHY 231B or concurrently and PHY 233B) and (MTH 133 or MTH 153H or LBS 119) Not open to students with credit in LBS 272 or PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H.

Electricity and magnetism, optical phenomena, interference and diffraction of light, atomic and subatomic topics. This course is given in the competency based instruction format.

183 Physics for Scientists and Engineers I
Fall, Spring. 4(5-0) P:M: (MTH 132 or MTH 152H or LBS 118) Not open to students with credit in LBS 164 or PHY 181B or PHY 183B or PHY 193H or PHY 231 or PHY 231B.

Mechanics, Newton's laws, momentum, energy conservation laws, rotational motion, oscillation, gravity, waves.

183A Physics I
Fall, Spring, Summer. 1 credit. P:M: (PHY 181B) Not open to students with credit in LBS 271 or PHY 183 or PHY 183B or PHY 193H or PHY 231 or PHY 231B or PHY 231C.

Topics from: frames of reference, special relativity, rocket equation, forced oscillations, resonances, fluid motion, numerical solutions, moments of inertia, gyroscopic motion. This course plus PHY 181B is equal to PHY 183B. This course is given in the competency based instruction format.

Physics—PHY

183B Physics for Scientists and Engineers I

Fall, Spring, Summer. 4 credits. P:M: (MTH 132 or MTH 152H or LBS 118) Not open to students with credit in LBS 271 or PHY 181B or PHY 183 or PHY 193H or PHY 231 or PHY 231B or PHY 231C.

Mechanics, Newton's laws, momentum, energy conservation laws, rotational motion, oscillation, gravity, waves.

184 Physics for Scientists and Engineers II

Fall, Spring. 4(5-0) P:M: (PHY 183 or PHY 183B or PHY 193H or PHY 233B or PHY 183A) or (LBS 164 and PHY 233B) and (MTH 133 or MTH 153H or LBS 119) Not open to students with credit in LBS 267 or PHY 182B or PHY 184B or PHY 232 or PHY 232B or PHY 294H.

Electricity and magnetism, electromagnetic waves, light and optics, interference and diffraction.

184A Physics II

Fall, Spring, Summer. 1 credit. P:M: (PHY 182B) Not open to students with credit in PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H, PHY 232C or LBS 272.

Topics from: standing wave phenomena, atoms, electromagnetic fields, alternating currents, optics, quantum mechanics, elementary particles. This course plus PHY 182B is equivalent to PHY 184B. 182B is exactly 3/4 of 184B and 184A is the other 1/4. This course is given in the competency based instruction format.

184B Physics for Scientists and Engineers II

Fall, Spring, Summer. 4 credits. P:M: (PHY 183 or PHY 183B or PHY 193H) or (PHY 181B and PHY 183A) or (PHY 231B and PHY 233B) or (LBS 271 and PHY 233B) RB: (MTH 133 or MTH 153H or LBS 119) Not open to students with credit in LBS 272 or PHY 182B or PHY 184 or PHY 232 or PHY 232B or PHY 294H.

Electricity and magnetism, electromagnetic waves, light and optics, interference and diffraction.

191 Physics Laboratory for Scientists, I

Fall. 1(0-3) P:M: (PHY 183 or concurrently or PHY 183B or concurrently or PHY 193H or concurrently or PHY 231 or concurrently or PHY 231B or concurrently or LBS 271 or concurrently or PHY 181B or concurrently) Not open to students with credit in PHY 251 or LBS 271L.

Error analysis, exercises in motion, forces, conservation laws and some electricity and magnetism studies.

192 Physics Laboratory for Scientists, II

Spring. 1(0-3) P:M: (PHY 191 or MSM 211 or MSM 250) and (PHY 184 or concurrently or PHY 182B or concurrently or PHY 184B or concurrently or PHY 294H or concurrently or PHY 232 or concurrently or PHY 232B or concurrently or LBS 272 or concurrently) Not open to students with credit in PHY 252 or LBS 272L.

Electric and magnetic fields, circuits, wave optics, modern physics.

193H Honors Physics I-Mechanics

Spring. 3(4-0) P:M: (MTH 133 or concurrently or MTH 153H or concurrently or LBS 119 or concurrently) Not open to students with credit in PHY 183 or PHY 183B or PHY 231 or PHY 231B or LBS 164 or PHY 181B.

Mechanics and waves.

201 Physics Computations II

Fall. 1(0-3) P:M: (PHY 184 or concurrently or PHY 184B or concurrently or PHY 294H or concurrently) RB: (MTH 133 and PHY 102)

Computer methods to analyze and visualize physics problems. Tools used will include programming languages (Fortran) and mathematical software (Mathematica, etc).

205 Directed Studies

Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Approval of department.

Guided individualized study in an area of physics.

213H Navigating the Universe

Spring. 3(3-0) Interdepartmental with Integrative Studies in Physical Science. Administered by Center for Integrative Studies in General Science. P:M: (MTH 103 or MTH 110 or MTH 116 or LBS 117 or MTH 112 or concurrently or MTH 124 or concurrently or MTH 132 or concurrently or MTH 201 or concurrently or STT 200 or concurrently or STT 201 or concurrently) or designated score on Mathematics placement test. RB: High school physics, high school algebra, and high school trigonometry

Philosophical and biographical history of physics. Comparing physics of fields, relativity, quantum mechanics, elementary particle physics, and cosmology to art as an alternate way of understanding and representing the world.

215 Thermodynamics and Modern Physics

Fall, Spring. 3(4-0) P:M: (PHY 184 or concurrently or PHY 184B or concurrently or PHY 294H or concurrently or LBS 272 or concurrently or PHY 234B or concurrently) and (MTH 234 or concurrently or MTH 254H or concurrently or LBS 220 or concurrently) Not open to students with credit in PHY215B.

Thermodynamics, atomic physics, quantized systems, nuclear physics, solids, elementary particles.

215B Thermodynamics and Modern Physics

Fall, Spring, Summer. 3 credits. P:M: (PHY 184 or concurrently or PHY 184B or concurrently or LBS 272 or concurrently or PHY 294H or concurrently or PHY 234B or concurrently) and (MTH 234 or MTH 254H or LBS 220) Not open to students with credit in PHY 215.

Thermodynamics, atomic physics, quantized systems, nuclear physics, solids, elementary particles. This course is given in the competency based instruction format.

231 Introductory Physics I

Fall, Spring. 3(4-0) P:M: (MTH 103 or MTH 116 or LBS 117 or MTH 124 or MTH 132 or concurrently) Not open to students with credit in LBS 164 or PHY 181B or PHY 183 or PHY 183B or PHY 193H or PHY 231B or PHY 231C.

Mechanics, Newton's Laws, momentum, energy, conservation laws, thermodynamics, waves, sound.

231B Introductory Physics I

Fall, Spring, Summer. 3 credits. P:M: (MTH 103 or MTH 116 or LBS 117 or MTH 124 or MTH 132 or concurrently) Not open to students with credit in LBS 271 or PHY 181B or PHY 183 or PHY 183B or PHY 193H or PHY 231 or PHY 231C.

Mechanics, Newton's laws, momentum, energy, conservation laws, thermodynamics, waves, sound. This course is given in the competency based instruction format.

231C Introductory Physics I

Fall, Spring. 3 credits. RB: (MTH 116) Not open to students with credit in PHY 181B or PHY 183 or PHY 183B or PHY 193H or PHY 231 or PHY 231B or LBS 271.

Mechanics, Newton's Laws, momentum, energy, conservation laws, thermodynamics, waves, sound. This course is an internet based course.

232 Introductory Physics II

Fall, Spring. 3(4-0) P:M: (PHY 231 or PHY 231B or PHY 181B or PHY 183 or PHY 183B or LBS 271 or PHY 193H or PHY 231C) Not open to students with credit in PHY 184 or PHY 184B or PHY 232B or LBS 272 or PHY 182B.

Electricity and magnetism; optics; atomic, nuclear, and subnuclear physics.

232B Introductory Physics II

Fall, Spring, Summer. 3 credits. P:M: (PHY 231 or PHY 231B or PHY 231C or PHY 181B or PHY 183B or PHY 193H or LBS 271) Not open to students with credit in PHY 184 or PHY 184B or PHY 232 or PHY 232C or PHY 294H or PHY 182B or LBS 272.

Electricity and magnetism; optics; atomic, nuclear, and subnuclear physics. This course is given in the competency based instruction format.

232C Introductory Physics II

Fall, Spring. 3 credits. P:M: (PHY 182B or PHY 183 or PHY 183B or PHY 193H or PHY 231 or PHY 231B or PHY 231C or LBS 271) Not open to students with credit in PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H or LBS 272.

Electricity and magnetism; optics; atomic, nuclear, and subnuclear physics. This course is an internet based course.

233B Calculus Concepts in Physics I

Fall, Spring, Summer. 2 credits. P:M: (PHY 231) and (MTH 132 or MTH 152H or LBS 118) Not open to students with credit in PHY 183 or PHY 193H.

Kinematics, dynamics, applications of Newton's laws. PHY 231B plus PHY 233B is equivalent to PHY 183B. This course is given in the competency based instruction format.

234B Calculus Concepts in Physics II

Fall, Spring, Summer. 2 credits. P:M: (PHY 232 or PHY 232B) and (MTH 133 or concurrently or MTH 153H or concurrently or LBS 119 or concurrently)

Electricity and magnetism. PHY 232B plus PHY 234B equals PHY 184B. This course is given in the competency based instruction format.

- 251 Introductory Physics Laboratory I**
 Fall, Spring, Summer. 1(0-3) P:M: (PHY 231 or concurrently or PHY 231B or concurrently or LBS 271 or concurrently or PHY 181B or concurrently or PHY 183 or concurrently or PHY 183B or concurrently or PHY 231C or concurrently or PHY 193H or concurrently) RB: (MTH 103) Not open to students with credit in PHY 191 or LBS 271L.
 Laboratory exercises involving simple mechanical systems.
- 252 Introductory Physics Laboratory II**
 Fall, Spring, Summer. 1(0-3) P:M: (PHY 251 or PHY 191 or LBS 271L) and (PHY 232 or concurrently or PHY 232B or concurrently or PHY 232C or concurrently or PHY 184 or concurrently or PHY 184B or concurrently or PHY 294H or concurrently or LBS 272 or concurrently) Not open to students with credit in PHY 192 or LBS 272L.
 Laboratory exercises involving simple electromagnetic and optical systems.
- 294H Honors Physics II-Electromagnetism**
 Fall. 3(4-0) P:M: (PHY 193H) and (MTH 234 or concurrently or MTH 254H or concurrently or LBS 220 or concurrently) Not open to students with credit in PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 232C or PHY 182B or LBS 267.
 Electricity and magnetism, electromagnetic waves and optics.
- 301 Physics Computations III**
 Spring. 1(0-3) P:M: (PHY 471) RB: (CSE 232)
 Use of computer software to solve, analyze and graph equations and data from physics problems. Tools include Mathematica, Fortran 90 and C++.
- 305 Directed Studies**
 Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. P:M: (PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 232C or PHY 294H or LBS 272) R: approval of department.
 Guided individualized study in an area of physics.
- 321 Classical Mechanics I**
 Spring, Summer. 3(3-0) P:M: (PHY 184 or PHY 184B or PHY 294H or LBS 272) and (PHY 215 or concurrently or PHY 215B or concurrently) and (MTH 234 or concurrently or MTH 254H or concurrently or LBS 220 or concurrently)
 Newtonian point particles. Oscillations. One-particle chaos. Central-force motion. Systems of particles.
- 351B Computational Physics**
 Fall, Spring, Summer. 3 credits. P:M: (PHY 215 or PHY 215B) RB: (CSE 131 or CSE 231)
 Computer applications in physics research: printer graphics, Schrodinger equation solution, physics-symbol processing, physics information retrieval. Analysis of typical research data. This course is given in the competency based instruction format.
- 357B Topics in Contemporary Physics**
 Fall, Spring, Summer. 3 credits. P:M: (PHY 215 or PHY 215B) RB: (PHY 184 or PHY 184B or PHY 294H or PHY 234B or LBS 272) R: Not open to students in the Department of Physics and Astronomy.
 Atoms and nuclei, weak decay interaction, weak bosons, strong interaction, conservation laws, quarks and gluons. This course is given in the competency based instruction format.
- 390 Physics Journal Seminar**
 Spring. 1(3-0) P:M: Completion of Tier I writing requirement. R: Open only to juniors or seniors in the Department of Physics and Astronomy or Lyman Briggs School.
 Written and oral reports on selected articles in the current literature. Critique of presentations by peers.
- 405 Directed Studies**
 Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 5 credits in all enrollments for this course. P:M: (PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 232C or PHY 294H or LBS 272) R: Approval of department.
 Guided independent study of special topics.
- 410 Thermal and Statistical Physics**
 Spring. 3(3-0) P:M: (PHY 471)
 Equilibrium statistical mechanics and thermodynamics, kinetic theory, phase transformations.
- 415 Methods of Theoretical Physics**
 Spring of odd years. 4(4-0) Interdepartmental with Lyman Briggs School. Administered by Lyman Briggs School. P:M: (MTH 234 or concurrently or LBS 220 or concurrently or MTH 254H or concurrently) and (LBS 271 or PHY 183 or PHY 193H) and (LBS 272 or PHY 184 or PHY 294H) RB: (MTH 235 or concurrently or MTH 255H or concurrently)
 Mathematical methods as applied to physical problems in mechanics, electromagnetism, and thermodynamics. Topics include multiple integration, vector calculus, Fourier series, ordinary and partial differential equations, eigenvector problems, coordinate transformations, and complex analysis. Applications include Newtonian mechanics, rigid body dynamics, heat flow, electrostatics, harmonic motion, and wave propagation.
- 422 Classical Mechanics II**
 Fall. 3(3-0) P:M: (PHY 321)
 Hamiltonian and Lagrangian mechanics. Non-inertial frames. Coupled oscillations. Continuous systems.
- 423B Special Relativity**
 Summer. 3 credits. P:M: (PHY 321) RB: Some understanding about electric and magnetic fields.
 Concepts of special relativity applied to coordinate transformations, mechanics, and electrodynamics. This course is given in the competency based instruction format.
- 425B Mathematical Physics**
 Summer. 3 credits. RB: Calculus through differential equations. Some experience with complex variables.
 Fourier series and complex variables as applied to problems in quantum mechanics, electrodynamics, and mechanics. This course is given in the competency based instruction format.
- 431 Optics I**
 Fall. 3(2-3) P:M: (PHY 192) and (PHY 184 or PHY 184B or PHY 234B or PHY 183A or PHY 294H) and (PHY 215 or PHY 215B) and completion of Tier I writing requirement. SA: PHY 331
 Lenses, aberrations, apertures, and stops. Diffraction, interferometry, spectroscopy, fiber optics.
- 440 Electronics**
 Spring. 4(3-3) P:M: (PHY 192) and (MTH 235 or concurrently or MTH 255H or concurrently or LBS 220 or concurrently) and (PHY 184 or concurrently or PHY 184B or PHY 294H or LBS 272)
 Concepts of electronics used in investigating physical phenomena. Circuits, amplifiers, diodes, LEDs, transistors.
- 451 Advanced Laboratory**
 Fall. 3(1-6) P:M: (PHY 440) and completion of Tier I writing requirement. R: Completion of Tier I writing requirement.
 General research techniques, design of experiments, and the analysis of results based on some historical experiments in modern physics.
- 471 Quantum Physics I**
 Fall. 3(3-0) P:M: (PHY 215 or PHY 215B) and (PHY 321 or concurrently) and (MTH 235 or MTH 255H or LBS 220)
 Schrodinger equation, hydrogen atom, harmonic oscillator, and other one-dimensional systems.
- 472 Quantum Physics II**
 Spring. 3(3-0) P:M: (PHY 471) RB: A Mathematics course on Boundary-Value Problems
 Matrix formulation of quantum mechanics, perturbation theory, scattering.
- 480 Computational Physics**
 Spring of even years. 3(3-0) RB: (CSE 131 or CSE 230)
 Applications of scientific computational techniques to solutions of differential equations, matrix methods, and Monte Carlo methods used in physics.
- 481 Electricity and Magnetism I**
 Fall. 3(3-0) P:M: (MTH 234 or MTH 254H or LBS 220) R: Open only to juniors or seniors or graduate students.
 Electrostatics, dielectrics, magnetic fields of steady state currents, Faraday law of induction.
- 482 Electricity and Magnetism II**
 Spring. 3(3-0) P:M: (PHY 481) RB: A Mathematics course on Boundary-Value Problems.
 Maxwell's equations, scalar and vector potentials, electromagnetic plane waves.
- 490 Senior Thesis**
 Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 5 credits in all enrollments for this course. P:M: (PHY 390) and completion of Tier I writing requirement.
 Design, carry out, and analyze an original experiment or computation. A written and oral report is required.
- 491 Atomic, Molecular, and Condensed Matter Physics**
 Fall. 3(3-0) P:M: (PHY 471 and PHY 410) and completion of Tier I writing requirement.
 Many-electron atoms. Molecules, crystal structure, lattice dynamics. Band models of metals and semiconductors. Transport properties.

Physics—PHY

- 492 Nuclear and Elementary Particle Physics**
Spring. 3(3-0) P:M: (PHY 471) and completion of Tier I writing requirement. RB: (PHY 472)
Properties of nuclei, nuclear models, nuclear reactions. High-energy accelerators. Weak, electromagnetic and strong interactions. Symmetries and conservation laws. Elementary particle spectrum, quarks, gluons.
- 800 Research Methods**
Fall, Spring, Summer. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course.
Design and setup of experiments in various faculty research areas. Data collection and analysis. Study and practice of theoretical methods.
- 810 Methods of Theoretical Physics**
Fall. 3(3-0)
Theoretical methods used in classical mechanics, quantum mechanics, electrodynamics, and statistical mechanics.
- 820 Classical Mechanics**
Fall. 3(3-0)
Two-body central force problem, Hamilton's principle, Lagrangian and Hamiltonian equations of motion, variational methods, small oscillations, classical fields.
- 831 Statistical Mechanics**
Spring. 3(3-0)
Equilibrium statistical mechanics and thermodynamics. Boltzmann transport equations and hydrodynamics. Brownian and Langevin motion.
- 832 Special Topics in Statistical Mechanics**
Fall, Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. RB: (PHY 831 and PHY 841 and PHY 852)
Topics vary and may include superfluidity and superconductivity, magnetism, non-linear dynamics and chaos, phase transitions and critical phenomena, transport theory, disordered systems, and computational physics.
- 841 Classical Electrodynamics I**
Spring. 3(3-0) RB: (PHY 810)
Electrostatics, magnetostatics, time-varying fields and Maxwell's equations. Gauge transformations. Poynting's theorem and conservation laws.
- 842 Classical Electrodynamics II**
Fall. 3(3-0) RB: (PHY 841 and PHY 810 or concurrently)
Plane electromagnetic waves, polarization states, reflection, refraction. Wave guides and resonant cavities. Radiating systems, dipole fields, radiated power. Special theory of relativity.
- 850 Electrodynamics of Plasmas**
Spring of odd years. 3(3-0) Interdepartmental with Electrical and Computer Engineering; Astronomy and Astrophysics. Administered by Department of Electrical and Computer Engineering. RB: (ECE 835 or PHY 488) SA: EE 850
Plasma kinetic and macroscopic plasma transport theory. Electromagnetic wave propagation and charged particle diffusion processes in plasma. Electromagnetic energy absorption via elastic and inelastic collisions. Dc, rf, and microwave discharges.
- 851 Quantum Mechanics I**
Fall. 3(3-0) R: Open only to graduate students in the College of Engineering or College of Natural Science.
Axioms of quantum and wave mechanics, applications to spherically symmetric potentials. Hydrogen atom, harmonic oscillator, matrix mechanics, angular momentum theory, rotations.
- 852 Quantum Mechanics II**
Spring. 3(3-0) RB: (PHY 851)
Approximation methods, perturbation theory, atomic physics applications, scattering theory, identical particles, Pauli principle, Bose and Einstein statistics, Hartree-Fock approximation, collisions of identical particles, radiation.
- 853 Advanced Quantum Mechanics**
Fall. 3(3-0) RB: (PHY 852)
Quantum description of relativistic particles and fields. Dirac equation, interpretation of negative energy states, Lagrangian field theory, quantization of free fields, interactions, perturbation theory, S-matrix, and Feynman rules.
- 854 Quantum Electrodynamics**
Spring of odd years. 3(3-0) RB: (PHY 853)
Application of quantum field theory to the interaction of electrons and photons: pair annihilation, Compton scattering. Bound states, renormalization theory.
- 861 Beam Physics**
Spring of odd years. 3(3-0) RB: (PHY 820 and PHY 841)
Particle accelerator theory and design.
- 881 Subatomic Physics**
Fall. 3(3-0) RB: (PHY 851)
Application of conservation laws and physical principles to basic quantum mechanical problems in MeV energy range and femtometer size range. Application to nuclear data.
- 891 Elementary Particle Physics**
Spring. 3(3-0) RB: (PHY 853)
Nonabelian gauge theory, spontaneously broken gauge theory, electroweak interaction, QCD, W and Z boson coupling to quarks and leptons, charm, top and bottom quarks, particle generations.
- 899 Master's Thesis Research**
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 36 credits in all enrollments for this course. R: Open only to graduate students in Physics.
Master's thesis research.
- 901 Frontiers in Physics and Astronomy**
Spring. 1(1-0)
Seminar and discussions in physics. Attendance at weekly colloquium.
- 902 Case Studies in Physics Applications**
Fall, Spring, Summer. 1 to 3 credits. RB: (PHY 471 and PHY 481)
Assessment of an application of physics; written report and oral presentation required. Projects from industry and government agencies; optional internship.
- 905 Special Problems**
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open only to graduate students in the Department of Physics and Astronomy.
In-depth study of a topic in physics or in astrophysics and astronomy.
- 961 Non-Linear Beam Dynamics**
Fall, Spring. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. RB: (PHY 861)
Dynamics of particle beams.
- 962 Particle Accelerators**
Fall, Spring, Summer. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. RB: (PHY 861)
Theory of particle accelerator design.
- 963 U.S. Particle Accelerator School**
Fall, Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. RB: (PHY 861) SA: PHY 962C
Participation in suitable courses offered by the U.S. Particle Accelerator School.
- 964 Seminar in Beam Physics Research**
Fall, Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. RB: (PHY 861) SA: PHY 962D
Presentation of current research topics in beam physics or accelerator design.
- 971 Atomic and Electronic Structure of Matter**
Spring. 3(3-0) RB: (PHY 491 and PHY 852 and PHY 841 and PHY 831) SA: PHY 871
Atomic structure, bravais lattices, x-ray scattering. Vibrations, phonons, neutron scattering. Electron in solids, electron gas. Bloch's theorem. Metals, semiconductors and insulators. Introduction to cooperative phenomena.
- 972 Transport and Dynamics in Bulk and Mesoscopic Systems**
Fall. 3(3-0) RB: (PHY 971 and PHY 831 and PHY 841 and PHY 852)
Transport theory. Weak and strong localization. Quantum effects in small structures. Quantum hall effects and Wigner crystal. Superconductivity and other cooperative phenomena.
- 973 Special Topics in Condensed Matter Physics**
Fall, Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. RB: (PHY 971 and PHY 972)
Topics vary and may include quantum optics, scattering methods and Green's functions.
- 980 Advanced Reading in Physics**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 4 credits in all enrollments for this course. R: Approval of department.
- 981 Nuclear Structure**
Fall, Spring. 3(3-0) RB: (PHY 492 and PHY 831 and PHY 841 and PHY 852)
Nuclear forces, nuclear matter, nuclear-structure models, few-nucleon systems, electromagnetic and weak transitions.
- 982 Nuclear Dynamics**
Spring. 3(3-0) RB: (PHY 492 and PHY 831 and PHY 841 and PHY 852)
Scattering theory, resonance reactions, compound nuclear decay and fission, direct and breakup reactions, time-dependent Hartree-Fock, Vlasov equation, nuclear transport equations, particle production, nuclear liquid-gas phase transition, quark-gluon plasma.

- 983 Nuclear Astrophysics**
Fall, Spring. 3(3-0) RB: (PHY 410 and PHY 472 and PHY 482)

Low energy reaction theory, survey of astrophysics, physics of nuclei and reaction relevant to astrophysics, nuclear reaction rates in stellar environments, stellar evolution, solar neutrinos, big bang nucleosynthesis, dark matter, supernova explosions, r-process, hot CNO and rp-process, cosmochronology

- 992 Quantum Chromodynamics**
Fall. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. RB: (PHY 854)

Hadron-hadron interactions, interaction of hadrons with leptons.

- 999 Doctoral Dissertation Research**
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 120 credits in all enrollments for this course. R: Open only to graduate students in Physics.
Doctoral dissertation research.

PHYSIOLOGY

PSL

Department of Physiology College of Natural Science

- 101 Current Issues in Physiology**
Fall. 2(2-0) Not open to students with credit in PSL 250 or PSL 431 or PSL 432.

Physiological bases of health issues of broad social significance, and new approaches for the treatment of specific disorders.

- 250 Introductory Physiology**
Fall, Spring. 4(4-0) R: Not open to students in Physiology.

Function, regulation and integration of organs and organ systems of higher animals emphasizing human physiology.

- 323 Physiology and Hygiene of the Eye**
Fall of odd years. Summer of even years. 3(3-0) R: Not open to Physiology majors.

Basic anatomy, physiology, and hygiene of the visual system: normal and abnormal visual function, methods of correction, and educational implications.

- 331 Cell Physiology: Function of Specialized Cells**
Fall. 3(3-0) P:M: (BS 111 or LBS 145)

Functions of differentiated cells, including mechanisms of cell communication, excitable membranes, contraction, motility, transport, secretion, and extra cellular matrix.

- 410 Computational Problem Solving in Physiology**
Fall, Spring. 3(3-0) RB: (PSL 432) R: Approval of department.

Quantitative analysis of physiological data: mathematical models, curve fitting, data analysis and interpretation. Problem solving involving exponential and logistic growth. Cerebral blood flow, convective cooling, oxygen consumption, thermoregulation, other applications.

- 420 Membrane Biophysics: An Introduction**
Fall, Spring. 2(2-0) RB: One year of college physics or chemistry, and one year of college mathematics.

Biophysical and chemical aspects of biomembranes. Experimental model membrane systems including planar lipid bilayers and liposomes. Biotechnological applications of lipid bilayer sensors.

- 431 Human Physiology I**
Fall. 3(3-0) RB: (BS 111 and CEM 142)

Neural function including autonomic nervous system, physiological control systems, endocrinology, reproduction and digestive function.

- 432 Human Physiology II**
Spring. 3(3-0) RB: (PSL 431)

Continuation of PSL 431. Function and regulation of the cardiovascular, respiratory, and renal systems. Control of tissue blood flow, blood pressure, blood gases, body fluid volume and electrolytes.

- 440 Topics in Cell Physiology**
Fall, Spring. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.

Critical discussion and evaluation of a selected problem of mammalian cell physiology including cell biophysics, molecular biology of the cell.

- 441 Topics in Endocrinology**
Fall, Spring. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.

Selected topic on the role of hormones in the regulation of growth, metabolism, differentiation.

- 442 Topics in Cardiovascular Physiology**
Fall. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.

Selected topic in blood flow physiology.

- 443 Topics in Respiratory Physiology**
Fall of odd years. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.

Selected topic in the physiology of gas exchange and lung mechanics.

- 445 Topics in Environmental Physiology**
Spring of odd years. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.

Selected topic in environmental physiology with an emphasis on thermoregulation.

- 446 Topics in Visual Physiology**
Fall of even years. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.

Selected topic in the functioning of the visual system in health and disease.

- 447 Topics of Brain Function**
Fall. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.

Selected topic on the functioning of the mammalian brain.

- 448 Topics in Gastrointestinal Physiology**
Fall. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.

Selected topic in the physiology of the digestive system.

- 449 Developmental Neurophysiology**
Fall. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.

Development of the nervous system in invertebrate and vertebrate animals.

- 473 Environmental Fish Physiology**
Spring of odd years. 3(3-0) Interdepartmental with Fisheries and Wildlife. Administered by Department of Fisheries and Wildlife. P:M: (BS 111 or LBS 145 or LBS 149H) R: Not open to freshmen or sophomores.

Physiological adaptations of fish to environmental factors; bioenergetics, homeostasis, senses adaptations to diverse and extreme aquatic environments.

- 475 Capstone Laboratory in Physiology**
Spring. 2(1-3) RB: (PSL 432) R: Open only to Physiology majors.

Laboratory exercises in animal physiology including osmoregulation, receptor mediated regulation, nervous and hormonal control of function.

- 480 Special Problems**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 5 credits in all enrollments for this course. RB: (PSL 432) R: Open only to Physiology majors.

Independent study under the auspices of a faculty member.

- 483 Environmental Physiology**
Spring. 4(4-0) Interdepartmental with Zoology. Administered by Department of Zoology. P:M: (BS 110 or LBS 144 or LBS 148H) and (BS 111 or LBS 145 or LBS 149H) and (CEM 141 or CEM 151 or CEM 181H or LBS 171) and completion of Tier I writing requirement.

Aspects of physiology important to the environmental relations of vertebrates and invertebrates: energetics, thermal relations, osmotic-ionic relations, and exercise physiology.

- 501 Introductory Medical Physiology**
Fall. 3(3-0) R: Graduate-professional students in colleges of Human and Osteopathic Medicine.

Physiological basis of medical practice.

- 511 Veterinary Physiology**
Spring. 5(5-0) R: Completion of Semester 1 of the graduate professional program in the College of Veterinary Medicine.

Physiology of the nervous, cardiovascular, renal, respiratory, digestive, endocrine, and reproductive systems. Homeostasis.

- 534 Cell Biology and Physiology I**
Fall. 3 credits. Interdepartmental with Human Anatomy; Biochemistry and Molecular Biology. R: Open only to graduate-professional students in the College of Human Medicine or College of Osteopathic Medicine.

Modern concepts of cell biology as a basis for understanding the physiology of human tissues and organ systems in health and disease.