

Department of Physics and Astronomy

Tim Tait, Department Chair

4129 Frederick Reines Hall

949-824-7727

<http://www.physics.uci.edu> (<http://www.physics.uci.edu/>)

Physics is that branch of science concerned with the study of natural phenomena at the fundamental level. Physicists study the smallest particles of matter (quarks and leptons), nuclei, and atoms; the fundamental forces; the properties of solids, liquids, gases, and plasmas; the behavior of matter on the grand scale in stars and galaxies; and even the origin and fate of the universe. Other disciplines such as chemistry, biology, medicine, and engineering often build upon the foundations laid by physics.

The Department of Physics and Astronomy offers introductory and advanced courses for students of various interests, from those in the humanities and social sciences, to those in biological sciences, and to those in physics, engineering, and other sciences. The Department offers majors in Physics and Applied Physics, with interdisciplinary concentrations and tracks that include astrophysics, engineering physics, science education, and courses taught by faculty in Biological Sciences, Chemistry, Engineering, and Medicine.

Furthermore, the faculty is vigorous, innovative, and engaged in a wide variety of research, education, and public service activities. The Department encourages student-faculty interaction and student involvement in undergraduate research. Faculty conduct active research in forefront research areas, providing students access to research opportunities in specialized areas like cosmology, particle physics, plasmas and fusion, condensed matter physics, biophysics, and medical physics.

- Applied Physics, B.S.
- Physics, B.S.
- Physics, Ph.D.

Faculty

Kevorg N. Abazajian, Ph.D. University of California, San Diego, *Professor of Physics and Astronomy*

Jun F. Allard, Ph.D. University of British Columbia, *Associate Professor of Mathematics; Physics and Astronomy* (mathematical and computational biology)

Ioan Andricioaei, Ph.D. Boston University, *Professor of Chemistry; Physics and Astronomy* (chemical biology, physical chemistry and chemical physics, theoretical and computational)

Aaron J. Barth, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy*

Christopher P.J. Barty, Ph.D. Stanford University, *Distinguished Professor of Physics and Astronomy*

Steven W. Barwick, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy*

Gregory A. Benford, Ph.D. University of California, San Diego, *Professor Emeritus of Physics and Astronomy*

Jianming Bian, Ph.D. Chinese Academy of Sciences, *Assistant Professor of Physics and Astronomy*

Paulo Brando, Ph.D. University of Florida, *Assistant Professor of Physics and Astronomy*

James S. Bullock, Ph.D. University of California, Santa Cruz, *Dean of the School of Physical Sciences and Professor of Physics and Astronomy*

David A. Buote, Ph.D. Massachusetts Institute of Technology, *Professor of Physics and Astronomy*

Kieron Burke, Ph.D. University of California, Santa Barbara, *Professor of Chemistry; Physics and Astronomy* (physical chemistry and chemical physics, theoretical and computational)

David W. Casper, Ph.D. University of Michigan, *Associate Professor of Physics and Astronomy*

Gary A. Chanan, Ph.D. University of California, Berkeley, *Professor Emeritus of Physics and Astronomy*

Liu Chen, Ph.D. University of California, Berkeley, *Research Professor and Professor Emeritus of Physics and Astronomy*

Mu-Chun Chen, Ph.D. University of Colorado Boulder, *Professor of Physics and Astronomy*

Alexander L. Chernyshev, Ph.D. Russian Academy of Sciences, *Professor of Physics and Astronomy*

Philip Collins, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy*

Michael Cooper, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy*

Asantha R. Cooray, Ph.D. University of Chicago, *Professor of Physics and Astronomy*

Michael B. Dennin, Ph.D. University of California, Santa Barbara, *Professor of Physics and Astronomy*

Franklin Dollar, Ph.D. University of Michigan, *Associate Professor of Physics and Astronomy* (applied physics)

Igor E. Dzyaloshinskii, Ph.D. Moscow State University, *Professor Emeritus of Physics and Astronomy*

Jonathan L. Feng, Ph.D. Stanford University, *Professor of Physics and Astronomy*

Zachary Fisk, Ph.D. University of California, San Diego, *UCI Distinguished Professor Emeritus of Physics and Astronomy*

Enrico Gratton, Ph.D. University of Rome, *Distinguished Professor of Biomedical Engineering; Developmental and Cell Biology; Physics and Astronomy* (design of new fluorescence instruments, protein dynamics, single molecule, fluorescence microscopy, photon migration in tissues)

Steven P. Gross, Ph.D. University of Texas at Austin, *Professor of Developmental and Cell Biology; Physics and Astronomy* (force generation by molecular motors in living cells)

Arnold Guerra, Ph.D. University of California, Irvine, *Lecturer of Physics and Astronomy*

Gultekin Gulsen, Ph.D. Bogazici University, *Associate Professor of Radiological Sciences; Biomedical Engineering; Physics and Astronomy*

Herbert W. Hamber, Ph.D. University of California, Santa Barbara, *Professor Emeritus of Physics and Astronomy*

William W. Heidbrink, Ph.D. Princeton University, *Professor of Physics and Astronomy*

Wilson Ho, Ph.D. University of Pennsylvania, *Donald Bren Professor and Professor of Physics and Astronomy; Chemistry*

Herbert J. Hopster, Ph.D. Aachen University, *Professor Emeritus of Physics and Astronomy*

Luis A. Jauregui, Ph.D. Purdue University, *Assistant Professor of Physics and Astronomy*

Manoj Kaplinghat, Ph.D. Ohio State University, *Professor of Physics and Astronomy*

Anne A. Kirkby, Ph.D. California Institute of Technology, *Lecturer of Physics and Astronomy*

David P. Kirkby, Ph.D. California Institute of Technology, *Professor of Physics and Astronomy*

Ilya N. Krivorotov, Ph.D. University of Minnesota, *Professor of Physics and Astronomy*

Andrew J. Lankford, Ph.D. Yale University, *Professor of Physics and Astronomy*

Jon M. Lawrence, Ph.D. University of Rochester, *Professor Emeritus of Physics and Astronomy*

Zhihong Lin, Ph.D. Princeton University, *Professor of Physics and Astronomy*

Mark A. Mandelkern, Ph.D. University of California, Berkeley, *Research Professor and Professor Emeritus of Physics and Astronomy*

Alexei A. Maradudin, Ph.D. University of Bristol, *Professor Emeritus of Physics and Astronomy*

Roger D. McWilliams, Ph.D. Princeton University, *Associate Dean of the School of Physical Sciences and Professor of Physics and Astronomy*

William R. Molzon, Ph.D. University of Chicago, *Professor of Physics and Astronomy*

Shaul Mukamel, Ph.D. Tel Aviv University, *UCI Distinguished Professor of Chemistry; Physics and Astronomy* (physical chemistry and chemical physics, polymer, materials, nanoscience, theoretical and computational)

Simona Murgia, Ph.D. Michigan State University, *Associate Professor of Physics and Astronomy*

Riley D. Newman, Ph.D. University of California, Berkeley, *Professor Emeritus of Physics and Astronomy; Logic and Philosophy of Science; Physics and Astronomy*

Juan Pedro Ochoa-Ricoux, Ph.D. California Institute of Technology, *Assistant Professor of Physics and Astronomy*

Xiaoqing Pan, Ph.D. Saarlandes University, *Henry Samueli Endowed Chair and Director of Irvine Materials Research Institute (IMRI) and Professor of Materials Science and Engineering; Physics and Astronomy* (atomic-scale structure, properties and dynamic behaviors of advanced materials including thin films and nanostructures for memories, catalysts, and energy conversion and storage devices)

William H. Parker, Ph.D. University of Pennsylvania, *Professor Emeritus of Physics and Astronomy*

Arvind Rajaraman, Ph.D. Stanford University, *Professor of Physics and Astronomy*

Michael Ratz, Ph.D. Technical University of Munich, *Professor of Physics and Astronomy*

Thorsten Ritz, Ph.D. University of Ulm, *Professor of Physics and Astronomy*

Paul M. Robertson, Ph.D. University of Texas at Austin, *Assistant Professor of Physics and Astronomy*

Judit Romhányi, Ph.D. Budapest University of Technology and Economy, *Assistant Professor of Physics and Astronomy*

James E. Rutledge, Ph.D. University of Illinois at Chicago Circle, *Professor Emeritus of Physics and Astronomy*

Nathan Rynn, Ph.D. Stanford University, *Professor Emeritus of Physics and Astronomy*

Javier D. Sanchez-Yamagishi, Ph.D. Massachusetts Institute of Technology, *Assistant Professor of Physics and Astronomy*

Jonas Schultz, Ph.D. Columbia University, *Professor Emeritus of Physics and Astronomy; Logic and Philosophy of Science*

Aomawa Shields, Ph.D. University of Washington, *Assistant Professor of Physics and Astronomy*

Yuri Shirman, Ph.D. University of California, Santa Cruz, *Professor of Physics and Astronomy*

Dennis J. Silverman, Ph.D. Stanford University, *Professor Emeritus of Physics and Astronomy*

Albert Siryaporn, Ph.D. University of Pennsylvania, *Assistant Professor of Physics and Astronomy; Molecular Biology and Biochemistry*

Zuzanna S. Siwy, Ph.D. Silesian University of Technology, *Professor of Physics and Astronomy; Biomedical Engineering; Chemistry*

Tammy Ann Smecker-Hane, Ph.D. Johns Hopkins University, *Associate Professor of Physics and Astronomy*

Henry W. Sobel, Ph.D. Case Western Reserve University, *Professor Emeritus of Physics and Astronomy*

Min-Ying Su, Ph.D. University of California, Irvine, *Professor of Radiological Sciences; Physics and Astronomy*

Peter Taborek, Ph.D. California Institute of Technology, *Professor of Physics and Astronomy*

Agnes Taffard, Ph.D. University of Liverpool, *Professor of Physics and Astronomy*

Timothy Tait, Ph.D. Michigan State University, *Department Chair and Professor of Physics and Astronomy*

Fumiko Tajima, Ph.D. University of Tokyo, *Lecturer of Physics and Astronomy*

Toshiki Tajima, Ph.D. University of California, Irvine, *UCI Endowed Chair and Adjunct Professor of Physics and Astronomy*

Virginia L. Trimble, Ph.D. California Institute of Technology, *Professor of Physics and Astronomy*

Laura Tucker, Ph.D. University of California, San Diego, *Assistant Professor of Teaching of Physics and Astronomy*

Mark Vagins, Ph.D. Yale University, *Adjunct Professor of Physics and Astronomy*

Gerard Vanhoven, Ph.D. Stanford University, *Professor Emeritus of Physics and Astronomy*

Richard F. Wallis, Ph.D. Catholic University of America, *Professor Emeritus of Physics and Astronomy*

Frank J. Wessel, Ph.D. University of California, Irvine, *Project Scientist of Physics and Astronomy*

Steven R. White, Ph.D. Cornell University, *Professor of Physics and Astronomy*

Daniel Whiteson, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy; Logic and Philosophy of Science*

Ruqian Wu, Ph.D. Institute of Physics, Chinese Academy of Science, *Professor of Physics and Astronomy*

Jing Xia, Ph.D. Stanford University, *Professor of Physics and Astronomy*

Huolin Xin, Ph.D. Cornell University, *Assistant Professor of Physics and Astronomy; Materials Science and Engineering*

Clare C. Yu, Ph.D. Princeton University, *Professor of Physics and Astronomy*

Jin Yu, Ph.D. University of Illinois at Urbana-Champaign, *Assistant Professor of Physics and Astronomy*

Courses

PHYSICS 2. Introduction to Mathematical Methods for Physics. 4 Units.

Provides the applied mathematics and problem solving/presentation skills necessary for success in an introductory physics sequence. Focuses on practical exercises in problem solving. Covers kinematics in one and two dimensions in detail. Additional topics include vectors, differentiation, and integration.

Prerequisite or corequisite: MATH 2A or MATH 5A or AP Calculus AB or AP Calculus BC. AP Calculus AB with a minimum score of 4. AP Calculus BC with a minimum score of 3

Restriction: PHYSICS 2 may not be taken for credit if taken after PHYSICS 7C.

PHYSICS 3A. Basic Physics I. 4 Units.

Vectors; motion, force, and energy.

Corequisite: MATH 2A or MATH 5A, or a score of 4 or higher on the AP Calculus AB exam, or a score of 3 or higher on the AP Calculus BC exam.

Restriction: PHYSICS 3A may not be taken for credit if taken after PHYSICS 7C.

(II and VA).

PHYSICS 3B. Basic Physics II. 4 Units.

Fluids; heat; electricity and magnetism.

Prerequisite: PHYSICS 3A or AP Physics C: Mechanics. AP Physics C: Mechanics with a minimum score of 5

(II and VA).

PHYSICS 3C. Basic Physics III. 4 Units.

Waves and sound; optics; quantum ideas; atomic and nuclear physics; relativity.

Corequisite: MATH 2B or MATH 5B, or a score of 4 or higher on the AP Calculus BC exam.

Prerequisite: PHYSICS 3A or AP Physics C: Mechanics. AP Physics C: Mechanics with a minimum score of 5

(II and Va).

PHYSICS 3LB. Basic Physics Laboratory. 1.5 Unit.

Practical applications of electronics and classical physics to biology. Goals include skill to use oscilloscope and other basic instrumentation. Materials fee.

PHYSICS 3LC. Basic Physics Laboratory. 1.5 Unit.

Practical applications of physics to medical imaging. Topics include optics, radioactivity, and acoustics. Materials fee.

PHYSICS 7C. Classical Physics. 4 Units.

Topics include force, energy, momentum, rotation, and gravity.

Corequisite: MATH 2B or AP CALCULUS BC, min score = 4.

Prerequisite: PHYSICS 2 or (MATH 2D and (CHEM 1C or CHEM H2C or CHEM M3C) or CHEM M2C) or AP Physics C: Mechanics or AP Physics C: Electricity and Magnetism or SAT Mathematics or ACT Mathematics. PHYSICS 2 with a grade of C or better. AP Physics C: Mechanics with a minimum score of 4. AP Physics C: Electricity and Magnetism with a minimum score of 4. SAT Mathematics with a minimum score of 650. ACT Mathematics with a minimum score of 27. Recommended: One year of high school physics or equivalent physics background.

Restriction: Physics Majors have first consideration for enrollment.

(II and VA).

PHYSICS 7D. Classical Physics. 4 Units.

Electricity and magnetism.

Corequisite: PHYSICS 7LD and MATH 2D

Prerequisite: PHYSICS 7C and (MATH 2B or AP Calculus BC). AP Calculus BC with a minimum score of 4

Restriction: Physics Majors have first consideration for enrollment.

(II and Va).

PHYSICS 7E. Classical Physics. 4 Units.

Fluids; oscillations; waves; and optics.

Prerequisite: PHYSICS 7C and MATH 2B

Restriction: Physics Majors have first consideration for enrollment.

(II and VA).

PHYSICS 7LC. Classical Physics Laboratory. 1 Unit.

Experiments related to lecture topics in Physics 7C. Materials fee.

Corequisite: PHYSICS 7C

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 7LD. Classical Physics Laboratory. 1 Unit.

Electricity and magnetism.

Corequisite: PHYSICS 7D

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 12. Science Fiction and Science Fact. 4 Units.

An introduction to fundamental physics principles, the scientific process, and the mathematical language of science, used to analyze topics drawn from superheroes, science fiction works, and current science news to distinguish science fiction and science fact.

Overlaps with PHYSICS 21.

(II and VA).

PHYSICS 14. Energy and the Environment. 4 Units.

The physics of society's energy production and consumption, and of their influences on the environment. Topics include fossil and renewable energy resources; nuclear power; prospects for a hydrogen economy; efficient and environmentally benign transportation; efficient home and commercial energy usage.

(II, Va)

PHYSICS 15. Physics of Music. 4 Units.

Introduces basic physical principles underlying generation and properties of music, including basic properties of sound waves, musical scales and temperament, musical instruments, and acoustics of music halls. No mathematics background required, but high school algebra is recommended.

(II)

PHYSICS 17. Physics of Athletics. 4 Units.

Introduces basic physical principles behind motion. Examples are drawn from a range of athletic endeavors (such as ice skating, baseball, diving, and dance). No mathematics background required, but high school algebra is recommended.

(II)

PHYSICS 18. How Things Work. 4 Units.

Survey of the physical basis of modern technology, with an emphasis on electronics and materials. Topics include power generation and distribution, communication (radio, TV, telephone, computers, tape recorders, CD players), imaging (optics, x-rays, MRI), and modern materials (alloys, semiconductors, superconductors).

(II)

PHYSICS 19. Great Ideas of Physics. 4 Units.

Introduces non-science majors to physics, examining important breakthroughs and controversies. Potential topics: Einstein's Relativity; Heisenberg's Uncertainty Principle; black holes; extra-dimensions; antimatter. Case studies illustrate the essential nature of scientific review and independent confirmation of results. No mathematics background required.

(II)

PHYSICS 20A. Introduction to Astronomy. 4 Units.

History of astronomy. Underlying physics. Objects in the solar system and how they are studied. Properties of stars: their formation, structure, and evolution. Pulsars and black holes. Galaxies and quasars.

(II and VA).

PHYSICS 20B. Cosmology: Humanity's Place in the Universe. 4 Units.

An overview of the origin, evolution, and ultimate fate of the Universe. Galaxies and dark matter. The Big Bang and dark energy. Ancient world models.

(II and VA).

PHYSICS 20D. Space Science. 4 Units.

Space exploration. Human missions to the moon, Mars, and beyond. Space stations, observatories, and deep-space probes. Robots and drones on distant worlds. Propulsion mechanisms, rockets, space flight, and the dangers of solar radiation.

(II and VA).

PHYSICS 20E. Life in the Universe. 4 Units.

An overview of the scientific quest to discover life elsewhere in the universe. Topics include the origin of life on Earth, Mars, extra-solar planets, interstellar travel, and extra-terrestrial intelligence.

(II, Va)

PHYSICS 21. Special Topics in Physics. 4 Units.

Topics addressed vary each quarter. Past topics have included physics and music, Newton, planetary science. Lectures on areas of special interest in physics used to introduce students to scientific method, fundamental laws of science, qualitative and quantitative analysis of data.

Repeatability: Unlimited as topics vary.

Overlaps with PHYSICS 12, PHYSICS XI12.

(II)

PHYSICS 50. Introductory Mathematical Physics. 4 Units.

Introduction to math methods for upper-division physics. Taylor and Fourier series; complex algebra; ordinary differential equations; matrices, tensors and vector spaces; eigensystems; orthogonal coordinates; vector calculus and fields. Symbolic computation with Mathematica is incorporated throughout.

Corequisite: MATH 2E

Prerequisite: MATH 3A

Overlaps with PHYSICS 100.

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 51A. Modern Physics. 4 Units.

Wave-particle duality; quantum mechanics; special relativity; statistical mechanics.

Prerequisite: (PHYSICS 7E or PHYSICS 3C) and MATH 2D

Overlaps with PHYSICS 61A.

Restriction: No Physics Majors.

PHYSICS 52A. Fundamentals of Experimental Physics. 2 Units.

Optics: lenses, mirrors, polarization, lasers, optical fibers, interference, spectra. Materials fee.

Corequisite: PHYSICS 7E or PHYSICS 3C.

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 52B. Fundamentals of Experimental Physics. 2 Units.

Circuits: oscilloscope, meters, DC and AC circuits. Materials fee.

Prerequisite: PHYSICS 7D or PHYSICS 3B

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 52C. Fundamentals of Experimental Physics. 2 Units.

Data analysis: random and systematic errors, curve fitting; nuclear counting; quantum experiments. Error analysis: random and systematic errors, curve fitting, nuclear counting, and quantum experiments. Materials fee.

Prerequisite: PHYSICS 51A or PHYSICS 61A

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 53. Introduction to Programming and Numerical Analysis. 4 Units.

Introduction to structured programming; in-depth training in python. Elementary numerical methods applied to physics problems.

Prerequisite: MATH 3A and MATH 3D

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 60. Thermal Physics. 4 Units.

Introduction to thermodynamics and systems of many particles. Topics include first and second laws of thermodynamics, ideal gas laws, kinetic theory, heat engines and refrigerators, thermodynamic potentials, phase transitions, dilute solutions, chemical equilibrium, and basic statistical distributions.

Prerequisite: (PHYSICS 7E or PHYSICS 3C) and MATH 2D

Restriction: Physics Majors only.

PHYSICS 61A. Modern Physics for Majors. 4 Units.

Wave-particle duality; Schrödinger equation; angular momentum.

Prerequisite: (PHYSICS 7E or PHYSICS 3C) and MATH 2D

Overlaps with PHYSICS 51A.

Restriction: Physics Majors only.

PHYSICS 61B. Modern Physics for Majors. 4 Units.

Atomic transitions; molecules; solids; nuclei; elementary particles; cosmological models.

Prerequisite: PHYSICS 61A or PHYSICS 51A

Overlaps with PHYSICS 51B.

Restriction: Physics Majors only.

PHYSICS 61C. Introduction to Astrophysics. 4 Units.

Introduction to fundamental topics in astrophysics, including stellar structure and evolution; stellar remnants; detection and characterization of exoplanets; physics of interstellar gas and star-forming regions.

Prerequisite: PHYSICS 61A or PHYSICS 51A

PHYSICS H80. Impact of World War I on Science. 4 Units.

Introduction to science in 1914 and WWI. Participants in groups of two or three will pick a preferred science; find out what happened to it during and after the war; write reports and present what they learned.

Restriction: Campuswide Honors Collegium students only.

(II)

PHYSICS H90. The Idiom and Practice of Science. 4 Units.

A series of fundamental and applied scientific problems of social relevance. Possible topics include Newton's Law, calculus, earthquake physics, and radiation.

Restriction: Campuswide Honors Collegium students only.

(II, Va)

PHYSICS 99. Current Topics in Physics. 2 Units.

Designed to introduce undergraduate students to current topics in physics. Focus is discussion of selected readings on current research issues.

Repeatability: Unlimited as topics vary.

PHYSICS 100. Computational Methods. 4 Units.

Mathematical and numerical analysis using Mathematica and C programming, as applied to problems in physical science.

Overlaps with PHYSICS 50.

Concurrent with PHYSICS 229A.

PHYSICS 106W. Advanced Data Acquisition, Analysis, and Scientific Writing. 4 Units.

Introduces modern practical laboratory techniques for developing data interface devices, acquiring and analyzing data, and writing up results in manuscript format. Experiments include interfacing with instruments through software and hardware development, PID controller, Fourier analysis, and lock-in amplifier.

Prerequisite: PHYSICS 52B and PHYSICS 194

Concurrent with PHYSICS 206 and CHEM 206.

(Ib)

PHYSICS 111A. Classical Mechanics. 4 Units.

One-dimensional motion and oscillations; three-dimensional motion, non-inertial coordinates, conservation laws, and Lagrangian and Hamiltonian dynamics; rigid body motion and relativity.

Corequisite: PHYSICS 50

Prerequisite: (PHYSICS 7E or PHYSICS 3C)

PHYSICS 111B. Classical Mechanics. 4 Units.

One-dimensional motion and oscillations; three-dimensional motion, non-inertial coordinates, conservation laws, and Lagrangian and Hamiltonian dynamics; rigid body motion and relativity.

Prerequisite: PHYSICS 111A

PHYSICS 112A. Electromagnetic Theory. 4 Units.

Electric, magnetic, and gravitational fields and potentials; electrodynamics; mechanical and electromagnetic waves and radiation.

Prerequisite: (PHYSICS 7D or PHYSICS 3B) and PHYSICS 50

PHYSICS 112B. Electromagnetic Theory. 4 Units.

Electric, magnetic, and gravitational fields and potentials; electrodynamics; mechanical and electromagnetic waves and radiation.

Prerequisite: PHYSICS 7E and PHYSICS 112A

PHYSICS 113A. Quantum Physics. 4 Units.

Inadequacy of classical physics; time independent and time dependent Schrodinger equation; systems in one, two, and three dimensions; matrices; Hermitian operators; symmetries; angular momentum; perturbation theory; scattering theory; applications to atomic structure; emphasis on phenomenology.

Prerequisite: (PHYSICS 51A or PHYSICS 61A) and PHYSICS 50

PHYSICS 113B. Quantum Physics. 4 Units.

Inadequacy of classical physics; time independent and time dependent Schrodinger equation; systems in one, two, and three dimensions; matrices; Hermitian operators; symmetries; angular momentum; perturbation theory; scattering theory; applications to atomic structure; emphasis on phenomenology.

Prerequisite: PHYSICS 111B and PHYSICS 112B and PHYSICS 113A

PHYSICS 113C. Quantum Physics. 4 Units.

Inadequacy of classical physics; time independent and time dependent Schrodinger equation; systems in one, two, and three dimensions; matrices; Hermitian operators; symmetries; angular momentum; perturbation theory; scattering theory; applications to atomic structure; emphasis on phenomenology.

Prerequisite: PHYSICS 111B and PHYSICS 112B and PHYSICS 113B

PHYSICS 115A. Statistical Physics. 4 Units.

Microscopic theory of temperature, heat, and entropy; kinetic theory; multicomponent systems; quantum statistics.

Prerequisite: PHYSICS 50 and (PHYSICS 60 or CHEM 1C or ENGRMAE 91)

PHYSICS 116. Relativity and Black Holes. 4 Units.

Introduces students to both special and general relativity; includes the formalism of four-vectors, equivalence principle, curved space-time, and modern issues with black holes.

Prerequisite: PHYSICS 50 and PHYSICS 111A

PHYSICS 120. Electronics for Scientists. 4 Units.

Applications of modern semiconductor devices to physical instrumentation. Characteristics of semiconductor devices, integrated circuits, analog and digital circuits. Materials fee.

Prerequisite: PHYSICS 52B

Concurrent with PHYSICS 220.

PHYSICS 121W. Advanced Laboratory. 4 Units.

Experiments in atomic, condensed matter, nuclear, particle, and plasma physics. Introduction to instrumentation and a first experience in the research laboratory.

Prerequisite: (PHYSICS 51B or PHYSICS 61B or PHYSICS 61C) and (PHYSICS 52C or PHYSICS 193) and (PHYSICS 194 or EDUC 143BW)

Repeatability: May be taken for credit 3 times.

Restriction: Physics Majors only.

(Ib)**PHYSICS 125A. Mathematical Physics. 4 Units.**

Complex variables; Legendre and Bessel functions; complete sets of orthogonal functions; partial differential equations; integral equations; calculus of variations; coordinate transformations; special functions and series.

Prerequisite: PHYSICS 50 and MATH 3D

PHYSICS 125B. Mathematical Physics. 4 Units.

Complex variables; Legendre and Bessel functions; complete sets of orthogonal functions; partial differential equations; integral equations; calculus of variations; coordinate transformations; special functions and series.

Prerequisite: PHYSICS 125A and PHYSICS 113A

PHYSICS 133. Introduction to Condensed Matter Physics. 4 Units.

Phenomena of solids and their interpretation in terms of quantum theory.

Prerequisite: PHYSICS 113B and PHYSICS 115A

PHYSICS 134A. Physical and Geometrical Optics. 4 Units.

Focuses on the practical aspects of optics and optical engineering, starting at the fundamentals. Topics include geometrical optics, ray tracing, polarization optics, interferometers, and diffractive optics.

Corequisite: PHYSICS 112B

Prerequisite: PHYSICS 112A

Concurrent with CBEMS 242A and CHEM 242A.

PHYSICS 135. Plasma Physics. 4 Units.

Basic concepts, orbits, kinetic and fluid equations, Coulomb collisions, fluctuations, scattering, radiation.

Prerequisite: PHYSICS 112B

Concurrent with PHYSICS 239A.

PHYSICS 136. Introduction to Particle Physics. 4 Units.

Experimental techniques and theoretical concepts of high-energy phenomena: accelerators and detectors; classification of particles and interactions; particle properties; symmetries and mass multiplets; production and decay mechanisms.

Prerequisite: PHYSICS 113B

PHYSICS 137. Introduction to Cosmology. 4 Units.

Solution of the differential equations governing the expansion of the Universe. Observational determinations of the parameters governing the expansion. Big Bang inflation, primordial nucleosynthesis, and cosmic microwave background. Dark matter, dark energy, and large-scale structure of the Universe.

Prerequisite or corequisite: PHYSICS 111A

PHYSICS 138. Astrophysics of Galaxies. 4 Units.

Introduction to the solar neighborhood, Milky Way, and other galaxies. Interstellar medium. Star formation. Stellar populations. Evolution of spiral, elliptical, and irregular galaxies. Supermassive black holes, quasars, and active galaxies. Galaxies as probes of the expansion rate of the Universe.

Prerequisite: PHYSICS 111A and PHYSICS 61C

PHYSICS 139. Observational Astrophysics. 4 Units.

Telescopes and astronomical observations, imaging with CCD detectors and image processing techniques. Photometry and spectroscopy of stars, galaxies, and quasars. Advanced imaging techniques such as deconvolution, adaptive optics, and interferometry.

Corequisite: PHYSICS 194

Prerequisite: PHYSICS 52A and PHYSICS 52B and PHYSICS 52C and PHYSICS 53

PHYSICS 144. Stellar Astrophysics. 4 Units.

Stars: their structure and evolution; physical state of the interior; the Hertzsprung- Russell diagram, stellar classification, and physical principles responsible for the classification; star formation; nuclear burning; giant and dwarf stars; neutron stars and black holes.

Prerequisite: (PHYSICS 51A or PHYSICS 61A) and PHYSICS 111A and PHYSICS 112A

PHYSICS 145. High-Energy Astrophysics. 4 Units.

Production of radiation by high-energy particles, white dwarfs, neutron stars, and black holes. Evolution of galactic nuclei, radio galaxies, quasars, and pulsars. Cosmic rays and the cosmic background radiation.

Prerequisite: (PHYSICS 51A or PHYSICS 61A) and PHYSICS 111A and PHYSICS 112A

PHYSICS 146A. Biophysics of Molecules and Molecular Machines. 4 Units.

Physical concepts and experimental and computational techniques used to study the structure and function of biological molecules and molecular machines with examples from enzyme action, protein folding, molecular motors, photobiology, chemotaxis, and vision.

Prerequisite: PHYSICS 115A

Concurrent with PHYSICS 230A.

PHYSICS 146B. Biophysics of Molecules and Molecular Machines. 4 Units.

Physical concepts and experimental and computational techniques used to study the structure and function of biological molecules and molecular machines with examples from enzyme action, protein folding, molecular motors, photobiology, chemotaxis, and vision.

Prerequisite: PHYSICS 115A

Concurrent with PHYSICS 230B.

PHYSICS 147B. Techniques in Medical Imaging I: X-ray, Nuclear, and NMR Imaging. 4 Units.

Ionizing radiation, planar and tomographic radiographic and nuclear imaging, magnetism, NMR, MRI imaging.

Prerequisite: PHYSICS 147A

Concurrent with PHYSICS 233B and EECS 202B.

PHYSICS 147C. Techniques in Medical Imaging II: Ultrasound, Electrophysiological, Optical. 4 Units.

Sound and ultrasound, ultrasonic imaging, physiological electromagnetism, EEG, MEG, ECG, MCG, optical properties of tissues, fluorescence and bioluminescence, MR impedance imaging, MR spectroscopy, electron spin resonance and ESR imaging.

Prerequisite: PHYSICS 147B

Concurrent with PHYSICS 233C and EECS 202C.

PHYSICS 150. Special Topics in Physics and Astronomy. 4 Units.

Current topics in physics. Includes topics from nano-science, biological sciences, astrophysics, and the common use of estimation across subdisciplines within physics.

Repeatability: Unlimited as topics vary.

PHYSICS 191. Field Experience in Physics Education. 1-4 Units.

Students develop and perform physics assemblies at neighboring public schools.

Prerequisite: PHYSICS 7C and PHYSICS 7D and PHYSICS 7E

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit for 8 units.

PHYSICS 192. Tutoring in Physics. 1-2 Units.

Formalizes the already existing free tutoring for the lower-division physics courses that is provided by the Society of Physics Students (SPS). Includes instructions on tutoring techniques.

Prerequisite: PHYSICS 7E

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit for 12 units.

Restriction: Society of Physics Students (SPS) tutoring program students only.

PHYSICS 193. Research Methods. 4 Units.

Explores tools of inquiry for developing and implementing science research projects. Students undertake independent projects requiring data collection, analysis, and modeling, and the organization and presentation of results. Additional topics include ethical issues and role of scientific literature.

Prerequisite: BIO SCI 14 or PHY SCI 5

Same as BIO SCI 108, CHEM 193.

PHYSICS 194. Research Communication for Physics Majors. 2 Units.

Students learn the fundamentals of communicating about research. Topics include preparing abstracts, proposals, and literature reviews. Provides preparation for presentation of independent research projects in PHYSICS 121 and PHYSICS 196.

Prerequisite: PHYSICS 61A. Satisfactory completion of the Lower-Division Writing requirement.

Restriction: Physics Majors only.

PHYSICS 195. Undergraduate Research. 4 Units.

Independent research under the guidance of a Physics faculty member.

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Juniors only. Physics Majors only.

PHYSICS 196A. Thesis in Physics I. 2 Units.

Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Corequisite: PHYSICS 194

Overlaps with PHYSICS H196A.

Restriction: Physics Majors only.

PHYSICS 196B. Thesis in Physics II. 4 Units.

Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Prerequisite: PHYSICS 196A

Overlaps with PHYSICS H196B.

Restriction: Physics Majors only.

PHYSICS 196C. Thesis in Physics III. 4 Units.

Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Prerequisite: PHYSICS 196B

Overlaps with PHYSICS H196C.

Restriction: Physics Majors only.

PHYSICS H196A. Honors Thesis in Physics I. 2 Units.

Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Corequisite: PHYSICS 194

Overlaps with PHYSICS 196A.

Restriction: Physics Majors only. Campuswide Honors Collegium students only. Honors Program in Physics students only.

PHYSICS H196B. Honors Thesis in Physics II. 4 Units.

Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Prerequisite: PHYSICS H196A

Overlaps with PHYSICS 196B.

Restriction: Physics Majors only. Campuswide Honors Collegium students only. Honors Program in Physics students only.

PHYSICS H196C. Honors Thesis in Physics III. 4 Units.

Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Prerequisite: PHYSICS H196B

Overlaps with PHYSICS 196C.

Restriction: Physics Majors only. Campuswide Honors Collegium students only. Honors Program in Physics students only.

PHYSICS 199. Readings on Special Topics. 1-4 Units.

Readings in selected areas of Physics. Topics addressed vary each quarter.

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

PHYSICS 206. Advanced Data Acquisition and Analysis. 4-6 Units.

Introduces students to a variety of practical laboratory techniques, including lock-in, boxcar, coincidence counting, noise filtering, PID control, properties of common transducers, computer interfacing to instruments, vacuum technology, laboratory safety, basic mechanical design, and shop skills. Materials fee.

Same as CHEM 206.

Concurrent with PHYSICS 106.

PHYSICS 207. Applied Physical Chemistry. 4 Units.

Introduction to fundamental concepts in molecular structure and reactivity: theory of bonding, valence and molecular orbitals; structure and reactivity in inorganic chemistry; elements in molecular group theory; nomenclature in organic chemistry; and survey of macromolecules.

Same as CHEM 207.

PHYSICS 208. Math Methods. 4 Units.

Applications of mathematics to physical and chemical problems. Calculus of special functions, complex variables and vectors; linear vector spaces and eigenvalue problems. Differential equations.

Same as CHEM 208.

PHYSICS 211. Classical Mechanics. 4 Units.

Variational principles, Lagrange's equations; applications to two body problems, small oscillation theory, and other phenomena. Hamilton's equations. Hamilton-Jacobi theory. Canonical transformations.

Restriction: Graduate students only.

PHYSICS 212A. Mathematical Physics. 4 Units.

Complex variables and integration; ordinary and partial differential equations; the eigenvalue problem.

Restriction: Graduate students only.

PHYSICS 213A. Electromagnetic Theory. 4 Units.

Electrostatics; magnetostatics; relativity; classical electron theory; fields in vacuum and matter; retardation; radiation and absorption; dispersion; propagation of light; diffraction; geometric optics; theories of the electric and magnetic properties of materials; scattering.

PHYSICS 213B. Electromagnetic Theory. 4 Units.

Electrostatics; magnetostatics; relativity; classical electron theory; fields in vacuum and matter; retardation; radiation and absorption; dispersion; propagation of light; diffraction; geometric optics; theories of the electric and magnetic properties of materials; scattering.

Prerequisite: PHYSICS 213A

PHYSICS 214A. Statistical Physics. 4 Units.

Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics; ideal and imperfect gases; thermodynamic properties of solids; transport theory.

Restriction: Graduate students only.

PHYSICS 214C. Many Body Theory. 4 Units.

Application of field theory methods, perturbative and non-perturbative, to many particle systems; second quantization, Feynman diagrams, linear response theory, and functional integral methods applied to the ground state and at finite temperature.

Prerequisite: PHYSICS 214A and PHYSICS 215A and PHYSICS 215B

Restriction: Graduate students only.

PHYSICS 215A. Quantum Mechanics. 4 Units.

Foundations; Dirac notation; basic operators and their eigenstates; perturbation theory; spin.

Restriction: Graduate students only.

PHYSICS 215B. Quantum Mechanics. 4 Units.

Atomic physics; scattering theory, formal collision theory; semi-classical radiation theory; many body systems.

Prerequisite: PHYSICS 215A

Restriction: Graduate students only.

PHYSICS 220. Electronics for Scientists. 4 Units.

Applications of modern semiconductor devices to physical instrumentation. Characteristics of semiconductor devices, integrated circuits, analog and digital circuits.

Restriction: Graduate students only.

Concurrent with PHYSICS 120.

PHYSICS 222. Continuum Mechanics. 4 Units.

Introduction to the continuum limit and stress and strain tensors. Hydrodynamics of perfect fluids; two-dimensional problems, motion of incompressible viscous fluids, Navier Stokes equations. Basic elasticity theory. Description of viscoelastic materials. Introduction to nonlinear behavior instabilities.

PHYSICS 223. Numerical Methods. 4 Units.

Introduction to theory and practice of modern numerical methods. Techniques are drawn from topics such as solution of differential equations, Monte Carlo methods, Fast Fourier transforms, and evaluation of special functions.

PHYSICS 228. Electromagnetism. 4 Units.

Maxwell's equations, electrodynamics, electromagnetic waves and radiation, wave propagation in media, interference and quantum optics, coherent and incoherent radiation, with practical applications in interferometry, lasers, waveguides, and optical instrumentation.

Same as CHEM 228.

PHYSICS 229A. Computational Methods. 4 Units.

Mathematical and numerical analysis using Mathematica and C programming, as applied to problems in physical science.

Same as CHEM 229A.

Concurrent with PHYSICS 100.

PHYSICS 230A. Biophysics of Molecules and Molecular Machines. 4 Units.

Physical concepts and experimental and computational techniques used to study the structure and function of biological molecules and molecular machines with examples from enzyme action, protein folding, molecular motors, photobiology, chemotaxis, and vision.

Concurrent with PHYSICS 146A.

PHYSICS 230B. Biophysics of Molecules and Molecular Machines. 4 Units.

Physical concepts and experimental and computational techniques used to study the structure and function of biological molecules and molecular machines with examples from enzyme action, protein folding, molecular motors, photobiology, chemotaxis, and vision.

Concurrent with PHYSICS 146B.

PHYSICS 233A. Principles of Imaging. 4 Units.

Linear systems, probability and random processes, image processing, projecting imaging, tomographic imaging.

Same as EECS 202A.

Restriction: Graduate students only.

Concurrent with PHYSICS 147A.

PHYSICS 233B. Techniques in Medical Imaging I: X-ray, Nuclear, and NMR Imaging. 4 Units.

Ionizing radiation, planar and tomographic radiographic and nuclear imaging, magnetism, NMR, MRI imaging.

Prerequisite: EECS 202A

Same as EECS 202B.

Restriction: Graduate students only.

Concurrent with PHYSICS 147B.

PHYSICS 233C. Techniques in Medical Imaging II: Ultrasound, Electrophysiological, Optical. 4 Units.

Sound and ultrasound, ultrasonic imaging, physiological electromagnetism, EEG, MEG, ECG, MCG, optical properties of tissues, fluorescence and bioluminescence, MR impedance imaging, MR spectroscopy, electron spin resonance and ESR imaging.

Prerequisite: EECS 202B

Same as EECS 202C.

Restriction: Graduate students only.

Concurrent with PHYSICS 147C.

PHYSICS 234A. Elementary Particle Physics. 4 Units.

Overview of Standard Model theory and phenomenology. Electromagnetic, strong and weak forces, quark model, interactions with matter, particle detectors and accelerators.

Prerequisite: PHYSICS 215B

PHYSICS 234B. Advanced Elementary Particle Physics. 4 Units.

$SU(3) \times SU(2) \times U(1)$ model of strong, weak, and electromagnetic interactions. K-meson system and CP violation, neutrino masses and mixing, grand-unified theories, supersymmetry, introduction to cosmology and its connection to particle physics.

Prerequisite: PHYSICS 234A and PHYSICS 235A

PHYSICS 234C. Advanced Elementary Particle Physics. 4 Units.

$SU(3) \times SU(2) \times U(1)$ model of strong, weak, and electromagnetic interactions. K-meson system and CP violation, neutrino masses and mixing, grand-unified theories, supersymmetry, introduction to cosmology and its connection to particle physics.

Prerequisite: PHYSICS 234A and PHYSICS 235A

PHYSICS 235A. Quantum Field Theory. 4 Units.

Canonical quantization, scalar field theory, Feynman diagrams, tree-level quantum electrodynamics.

Prerequisite: PHYSICS 215B

Restriction: Graduate students only.

PHYSICS 235B. Advanced Quantum Field Theory. 4 Units.

Pathintegral techniques, loop diagrams, regularization and renormalization, anomalies.

Prerequisite: PHYSICS 235A

Restriction: Graduate students only.

PHYSICS 238A. Condensed Matter Physics. 4 Units.

Bonding in solids; crystal symmetry and group theory, elastic properties of crystals; lattice vibrations, interaction of radiation with matter; cohesion of solids; the electron gas; electron energy bands in solids; ferromagnetism; transport theory; semiconductors and superconductors; many-body perturbation theory.

Prerequisite: PHYSICS 133 and (PHYSICS 214A or CHEM 232A) and (PHYSICS 215B or CHEM 231B)

PHYSICS 238B. Condensed Matter Physics. 4 Units.

Bonding in solids; crystal symmetry and group theory, elastic properties of crystals; lattice vibrations, interaction of radiation with matter; cohesion of solids; the electron gas; electron energy bands in solids; ferromagnetism; transport theory; semiconductors and superconductors; many-body perturbation theory.

Prerequisite: PHYSICS 238A

PHYSICS 238C. Condensed Matter Physics. 4 Units.

Bonding in solids; crystal symmetry and group theory, elastic properties of crystals; lattice vibrations, interaction of radiation with matter; cohesion of solids; the electron gas; electron energy bands in solids; ferromagnetism; transport theory; semiconductors and superconductors; many-body perturbation theory.

Prerequisite: PHYSICS 238B

PHYSICS 239A. Plasma Physics. 4 Units.

Basic concepts, orbits, kinetic and fluid equations, Coulomb collisions, fluctuations, scattering, radiation.

Restriction: Graduate students only.

Concurrent with PHYSICS 135.

PHYSICS 239B. Plasma Physics. 4 Units.

Magnetic confinement, MHD equilibrium and stability, collisional transport.

Prerequisite: PHYSICS 239A

Restriction: Graduate students only.

PHYSICS 239C. Plasma Physics. 4 Units.

Linear waves and instabilities, uniform un-magnetized and magnetized plasmas, non-uniform plasmas.

Prerequisite: PHYSICS 239B

Restriction: Graduate students only.

PHYSICS 240A. Galactic Astrophysics. 4 Units.

The morphology, kinematics, and evolution of our Milky Way and other galaxies. Topics include stellar formation and stellar evolution, end states of stars (supernovae, neutron stars), the distribution of stars, interstellar gas and mass in galaxies. The Local Group.

PHYSICS 240B. Cosmology. 4 Units.

An introduction to modern cosmology set within the context of general relativity. Topics include the expansion history of the Universe, inflation, the cosmic microwave background, density fluctuations, structure formation, dark matter, dark energy, and gravitational lensing.

PHYSICS 240C. Radiative Processes in Astrophysics. 4 Units.

Exploration of radiation mechanisms (electron scattering, synchrotron emission, collisional excitation, and more) and radiative transfer through matter including absorption and emission. Includes such observational astrophysics topics as spectroscopic study of atoms and nuclei, X-rays, and cosmic rays.

PHYSICS 241A. Solar System and Extrasolar Planets. 4 Units.

Formation, evolution, and habitability of planetary systems. Observational and theoretical study of the origin and evolution of the Solar System, present day dynamical state of the Solar System (asteroids, Kuiper Belt Objects, Oort cloud), planetary atmospheres, processes governing planetary climate.

Corequisite: PHYSICS 242

Restriction: Graduate students only.

PHYSICS 241B. Stellar Astrophysics. 4 Units.

Physics of stellar interiors and equations of stellar structure. Stellar atmospheres and absorption processes. Introduction to stellar winds. Thermonuclear reactions, nucleosynthesis, and solar neutrinos. Binary stars and mass accretion. White dwarfs, supernovae, neutron stars, and black holes.

Prerequisite: PHYSICS 211 and PHYSICS 240A

PHYSICS 241C. Extragalactic Astrophysics. 4 Units.

The physics and phenomenology of galaxies; star formation, interstellar medium, and intergalactic medium. Galaxy structure and dynamics. Galaxy evolution, stellar populations, and scaling relations; the relationship between galaxy properties and environment. Galaxy clusters and active galactic nuclei.

Prerequisite: PHYSICS 211 and PHYSICS 240A

PHYSICS 241D. Early Universe Physics. 4 Units.

Includes a thorough quantum treatment of the generation of perturbations during inflation and various topics related to kinetic theory in an expanding Universe. Other topics include the astrophysics and cosmology of weakly interacting particles.

Prerequisite: PHYSICS 234A and (PHYSICS 240B or PHYSICS 255)

PHYSICS 242. Astro Fundamentals. 4 Units.

Introduction to topics in astrophysics including measurement of stellar properties, stellar structure and evolution, stellar remnants and supernovae, the interstellar medium, exoplanets, gravitational lensing, galactic structure, extragalactic distance measurements, and the expanding universe.

Restriction: Graduate students only.

PHYSICS 246. Special Topics in Astrophysics. 4 Units.

Outlines and emphasizes a subarea of astrophysics that is undergoing rapid development.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 247. Special Topics in Particle Physics. 4 Units.

Current topics in particle non-accelerator-based research fields.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 248. Special Topics in Condensed Matter Physics. 4 Units.

Outlines and emphasizes a subarea of condensed matter physics that is undergoing rapid development.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

PHYSICS 249. Special Topics in Plasma Physics. 4 Units.

Outlines and emphasizes a subarea of plasma physics that is undergoing rapid development.

Prerequisite: PHYSICS 239A and PHYSICS 239B

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

PHYSICS 250. Physics and Astronomy Communications Skills. 4 Units.

Fundamentals of effectively communicating research through written and oral platforms. Topics include writing compelling proposals and journal articles for peer review, and the development of engaging oral presentations of science results and significance to a wide range of audiences.

Restriction: Graduate students only.

PHYSICS 255. General Relativity. 4 Units.

An introduction to Einstein's theory of gravitation. Tensor analysis, Einstein's field equations, astronomical tests of Einstein's theory, gravitational waves.

PHYSICS 260A. Seminar in Condensed Matter Physics. 1 Unit.

Seminar designed to acquaint students with recent advances in solid state physics. Lecturers from the Department of Physics and Astronomy (both faculty and graduate students), other UCI departments, and other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 260B. Seminar in Condensed Matter Physics. 1 Unit.

Seminar designed to acquaint students with recent advances in solid state physics. Lecturers from the Department of Physics and Astronomy (both faculty and graduate students), other UCI departments, and other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 260C. Seminar in Condensed Matter Physics. 1 Unit.

Seminar designed to acquaint students with recent advances in solid state physics. Lecturers from the Department of Physics and Astronomy (both faculty and graduate students), other UCI departments, and other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 261A. Seminar in Plasma Physics. 1 Unit.

Advanced topics in plasma physics: wave propagation, nonlinear effects, kinetic theory and turbulence, stability problems, transport coefficients, containment, and diagnostics. Applications to controlled fusion and astrophysics.

Grading Option: Satisfactory/unsatisfactory only.

Restriction: Graduate students only.

PHYSICS 261B. Seminar in Plasma Physics. 1 Unit.

Advanced topics in plasma physics: wave propagation, nonlinear effects, kinetic theory and turbulence, stability problems, transport coefficients, containment, and diagnostics. Applications to controlled fusion and astrophysics.

Grading Option: Satisfactory/unsatisfactory only.

Restriction: Graduate students only.

PHYSICS 261C. Seminar in Plasma Physics. 1 Unit.

Advanced topics in plasma physics: wave propagation, nonlinear effects, kinetic theory and turbulence, stability problems, transport coefficients, containment, and diagnostics. Applications to controlled fusion and astrophysics.

Grading Option: Satisfactory/unsatisfactory only.

Restriction: Graduate students only.

PHYSICS 263A. Seminar in Particle Physics. 1 Unit.

Discussion of advanced topics and reports of current research results in theoretical and experimental particle physics and cosmic rays.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 263B. Seminar in Particle Physics. 1 Unit.

Discussion of advanced topics and reports of current research results in theoretical and experimental particle physics and cosmic rays.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 263C. Seminar in Particle Physics. 1 Unit.

Discussion of advanced topics and reports of current research results in theoretical and experimental particle physics and cosmic rays.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 265A. Seminar in Astrophysics. 1 Unit.

Acquaints students with current research in astrophysics. Lecturers from the Department of Physics and Astronomy and from other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 265B. Seminar in Astrophysics. 1 Unit.

Acquaints students with current research in astrophysics. Lecturers from the Department of Physics and Astronomy and from other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 265C. Seminar in Astrophysics. 1 Unit.

Acquaints students with current research in astrophysics. Lecturers from the Department of Physics and Astronomy and from other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 266. Current Topics in Chemical, Applied, and Materials Physics. 1 Unit.

The subjects covered vary from year to year. Connection between fundamental principles and implementations in practice in science, industry, and technology.

Repeatability: May be repeated for credit unlimited times.

Same as CHEM 266.

PHYSICS 267B. Current Problems in Particle Physics. 4 Units.

Presentation and discussion of current research and theory in particle physics. Lectures given by staff and students.

Repeatability: May be repeated for credit unlimited times.

PHYSICS 267C. Current Problems in Particle Physics. 4 Units.

Presentation and discussion of current research and theory in particle physics. Lectures given by staff and students.

Repeatability: May be repeated for credit unlimited times.

PHYSICS 268. Seminar in Systems Microbiology Research. 1 Unit.

A research and journal club seminar that covers topics on bacteria and phage using approaches and principles from biology, engineering, and physics.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Same as MOL BIO 268, ENGRMSE 267.

Restriction: Upper-division students only. Graduate students only.

PHYSICS 269. Seminar in Teaching Physics. 2 Units.

Techniques for effective teaching. Covers active listening and student engagement, problem-solving skills, peer instruction and collaborative learning, and evaluation. Required of all new Teaching Assistants.

Grading Option: Satisfactory/unsatisfactory only.

PHYSICS 273. Technical Communication Skills. 2 Units.

Development of effective communication skills, oral and written presentations, through examples and practice.

Grading Option: Satisfactory/unsatisfactory only.

Same as CHEM 273.

PHYSICS 291. Research Seminar. 1-4 Units.

Detailed discussion of research problems of current interest in the Department. Format, content, and frequency of the course are variable.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 295. Experimental Research. 4-12 Units.

With the approval of a faculty member, a student may pursue a research program in experimental physics. Typical areas include astrophysics, condensed matter physics, elementary particle physics, and plasma physics.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only. School of Physical Sciences students only.

PHYSICS 296. Theoretical Research. 4-12 Units.

With approval of a faculty member, a student may pursue a research program in theoretical physics. Typical areas include astrophysics, condensed matter physics, elementary particle physics, and plasma physics.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only. School of Physical Sciences students only.

PHYSICS 298. Physics Colloquium. 1 Unit.

Seminar held each week, in which a current research topic is explored. Frequently, off-campus researchers are invited to present the seminar, and on occasion a faculty member or researcher from the Department will speak.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: School of Physical Sciences students only.

PHYSICS 299. Reading of Special Topic. 4-12 Units.

With special consent from a faculty member who will agree to supervise the program, a student may receive course credit for individual study of some area of physics.

Restriction: Graduate students only.

PHYSICS 395. Laboratory Teaching. 1 Unit.

Required of and limited to teaching assistants of undergraduate laboratory courses. Designed to teach the necessary skills required of teaching assistants for these courses.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

PHYSICS 399. University Teaching. 1-4 Units.

Required of and limited to Teaching Assistants.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.