

## University of California, Berkeley

### GRADUATE COURSE DESCRIPTIONS

#### Graduate Courses

**C201. Introduction to Nano-Science and Engineering. (3)** Three hours of lecture per week. Prerequisites: Major in physical science such as chemistry, physics, etc., or engineering; consent of advisor or instructor. A three-module introduction to the fundamental topics of Nano-Science and Engineering (NSE) theory and research within chemistry, physics, biology, and engineering. This course includes quantum and solid-state physics; chemical synthesis, growth fabrication, and characterization techniques; structures and properties of semiconductors, polymer, and biomedical materials on nanoscales; and devices based on nanostructures. Students must take this course to satisfy the NSE Designated Emphasis core requirement. Also listed as Bioengineering C280, Materials Science and Engineering C261, and Nanoscale Science and Engineering C201. (F,SP)

**C202. Astrophysical Fluid Dynamics. (4)** Students will receive no credit for Physics C202 after taking Astronomy 202. Three hours of lecture per week. Principles of gas dynamics, self-gravitating fluids, magnetohydrodynamics and elementary kinetic theory. Aspects of convection, fluid oscillations, linear instabilities, spiral density waves, shock waves, turbulence, accretion disks, stellar winds, and jets. Also listed as Astronomy C202. (F,SP)

**C203. Computational Nanoscience. (3)** Three hours of lecture and one hour of discussion per week. Prerequisites: Graduate standing or consent of instructor. A multidisciplinary overview of computational nanoscience for both theorists and experimentalists. This course teaches the main ideas behind different simulation methods; how to decompose a problem into "simulatable" constituents; how to simulate the same thing two different ways; knowing what you are doing and why thinking is still important; the importance of talking to experimentalists; what to do with your data and how to judge its validity; why multiscale modeling is both important and nonsense. Also listed as Nanoscale Science and Engineering C242. (F,SP)

**205A. Advanced Dynamics. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 105 or equivalent. Lagrange and Hamiltonian dynamics, variational methods, symmetry, kinematics and dynamics of rotation, canonical variables and transformations, perturbation theory, non-linear dynamics, KAM theory. (F)

**205B. Advanced Dynamics. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 205A. Continuous systems, dissipative systems. Attractors. Emphasis on recent developments, including turbulence. (SP)

**C207. Radiation Processes in Astronomy. (4)** Students will receive no credit for C207 after taking Astronomy 201. Three hours of lecture per week. *Prerequisites: Physics 105, 110A; 110B concurrently; open to advanced undergraduates with GPA of 3.70.* An introduction to the basic physics of astronomy and astrophysics at the graduate level. Principles of energy transfer by radiation. Elements of classical and quantum theory of photon emission; bremsstrahlung, cyclotron and synchrotron radiation. Compton scattering, atomic, molecular and nuclear electromagnetic transitions. Collisional excitation of atoms, molecules and nuclei. Also listed as Astronomy C207. (F,SP)

**209. Classical Electromagnetism. (5)** Three hours of lecture and one hour of discussion per week. Prerequisites: 110A-110B or consent of instructor. Maxwell's equations, gauge transformations and tensors. Complete development of special relativity, with applications. Plane waves in material media, polarization, Fresnel equations, attenuation, and dispersion. Wave equation with sources, retarded solution for potentials, and fields. Cartesian and spherical multipole expansions, vector spherical harmonics, examples of radiating systems, diffraction, and optical theorem. Fields of charges in arbitrary motion, radiated power, relativistic (synchrotron) radiation, and radiation in collisions. (F)

**211. Equilibrium Statistical Physics. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 112 or equivalent. Foundations of statistical physics. Ensemble theory. Degenerate systems. Systems of interacting particles. (SP)

**212. Nonequilibrium Statistical Physics. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 112 and 221A-221B, or equivalents. Time dependent processes. Kinetic equations. Transport processes. Irreversibility. Theory of many-particle systems. Fluctuation phenomena. (SP)

**216. Special Topics in Many-Body Physics. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 221A-221B or equivalent recommended. Quantum theory of many-particle systems. Applications of theory and technique to physical systems. Pairing phenomena, superfluidity, equation of state, critical phenomena, phase transitions, nuclear matter. (SP)

**221A. Quantum Mechanics. (5)** Three hours of lecture and one hour of discussion per week. Prerequisites: 137A-137B or equivalent. Basic assumptions of quantum mechanics; quantum theory of measurement; matrix mechanics; Schroedinger theory; symmetry and invariance principles; theory of angular momentum; stationary state problems; variational principles; time independent perturbation theory; time dependent perturbation theory; theory of scattering. (F)

**221B. Quantum Mechanics. (5)** Three hours of lecture and one hour of discussion per week. Prerequisites: 221A. Many-body methods, radiation field quantization, relativistic quantum mechanics, applications. (SP)

**226. Particle Physics Phenomenology. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 221A-221B or equivalent or consent of instructor. Introduction to particle physics phenomena. Emphasis is placed on experimental tests of particle physics models. Topics include Quark model spectroscopy; weak decays; overview of detectors and accelerators; e+e- annihilation; parton model; electron-proton and neutrino-proton scattering; special topics of current interest. (F)

**C228. Extragalactic Astronomy and Cosmology. (3)** Three hours of lecture per week. A survey of physical cosmology - the study of the origin, evolution, and fate of the universe. Topics include the Friedmann-Robertson-Walker model, thermal history and big bang nucleosynthesis, evidence and nature of dark matter and dark energy, the formation and growth of galaxies and large scale structure, the anisotropy of the cosmic microwave radiation, inflation in the early universe, tests of cosmological models, and current research areas. The course complements the material of Astronomy 218. Also listed as Astronomy C228. (F)

**231. General Relativity. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 209 or equivalent, or consent of instructor. An introduction to Einstein's theory of gravitation. Tensor analysis, general relativistic models for matter and electromagnetism, Einstein's field equations. Applications, for example, to the solar system, dense stars, black holes, and cosmology. (SP)

**232A. Quantum Field Theory I. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 221A-221B or equivalent or consent of instructor (concurrent enrollment in 226 is recommended). Introduction to quantum field theory: canonical quantization of scalar, electromagnetic, and Dirac fields; derivation of Feynman rules; regularization and renormalization; introduction to the renormalization group; elements of the path integral. (F)

**232B. Quantum Field Theory II. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 232A or equivalent or consent of instructor. Renormalization of Yang-Mills gauge theories: BRST quantization of gauge theories; nonperturbative dynamics; renormalization group; basics of effective field theory; large N; solitons; instantons; dualities. Selected current topics. (SP)

**233A. Standard Model and Beyond I. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 232A or equivalent or consent of instructor (concurrent enrollment in 232B is recommended). Introduction to the standard model of particle physics and its applications: construction of the standard model; Higgs mechanism; phenomenology of weak interactions; chiral Lagrangian; QCD and scaling violation. (SP)

**233B. Standard Model and Beyond II. (4)** Course may be repeated for credit with consent of instructor. Three hours of lecture and one hour of discussion per week. Prerequisites: 233A or equivalent or consent of instructor. Advanced topics in the standard model and beyond: open problems in the standard model; supersymmetric models; grand unification; neutrino physics; theories with flat and warped extra dimensions; models at the TeV scale; low string/gravity scale. Selected current topics. (F)

**234A. String Theory I. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 232A or equivalent or consent of instructor. 232B is recommended. Perturbative theory of the bosonic strings, superstrings, and heterotic strings: NSR and GS formulations; 2d CFT; strings in background fields; T-duality; effective spacetime supergravity; perturbative description of D-branes; elements of compactifications and string phenomenology; perturbative mirror symmetry. (F)

**234B. String Theory II. (4)** May be repeated for credit with consent of instructor. Three hours of lecture and one hour of discussion per week. Prerequisites: 234A or equivalent or consent of instructor. Nonperturbative aspects of string theory. Topics selected from black holes; black branes; Bekenstein-Hawking entropy; D-branes; string dualities; M-theory; holographic principle and its realizations; AdS/CFT correspondence; gauge theory/gravity dualities; flux compactifications; cosmology in string theory; topological string theories. Selected current topics. (SP)

**238. Advanced Atomic, Molecular, and Optical Physics. (4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 110A, 130, 137A-137B, and 138; or consent of instructor. Contemporary topics in atomic, molecular, and optical physics are presented at an advanced level. These topics may include one or several of the

following, at the discretion of the instructor: mechanical effects of light-atom interactions, ultra-cold atomic physics, molecular physics, resonance optics of multi-level atoms, and probing particle physics with atoms and molecules. (F,SP)

**240A-240B. Quantum Theory of Solids. (4;4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 141A-141B and 221A-221B or equivalents, or consent of instructor; 240A is prerequisite to 240B. Excitations and interactions in solids; crystal structures, symmetries, Bloch's theorem; energy bands; electron dynamics; impurity states; lattice dynamics, phonons; many-electron interactions; density functional theory; dielectric functions, conductivity and optical properties; excitons; electron-phonon interactions, polarons; Fermi surfaces; magnetoresistance; quantum Hall effect; transport processes, Boltzmann equation; superconductivity, BCS theory; many-body perturbation theory, Green's functions. (F, SP)

**242A-242B. Theoretical Plasma Physics. (4;4)** Three hours of lecture and one hour of discussion per week. Prerequisites: 142. Analysis of plasma behavior according to the Vlasov, Fokker-Planck equations, guiding center and hydromagnetic descriptions. Study of equilibria, stability, linear and nonlinear electromagnetic waves, transport, and interaction with radiation. Rigorous kinetic theory. (F, SP)

**250. Special Topics in Physics. (2-4)** Course may be repeated for credit with consent of instructor. Prerequisites: Consent of instructor. Topics will vary from semester to semester. See Department of Physics announcements. (F,SP)

**251. Introduction to Graduate Research in Physics. (1)** One hour of lecture per week. Must be taken on a satisfactory / unsatisfactory basis. Prerequisites: Graduate standing in Department of Physics or consent of instructor. A survey of experimental and theoretical research in the Department of Physics, designed for first-year graduate students. One regular meeting each week with supplementary visits to experimental laboratories. Meetings include discussions with research staff. (F)

**C254. High Energy Astrophysics. (3)** Three hours of lecture per week. Prerequisites: C207, formerly Astronomy 201, or consent of instructor. C202, formerly Astronomy 202, recommended. Basic physics of high energy radiation processes in an astrophysics environment. Cosmic ray production and propagation. Applications selected from pulsars, x-ray sources, supernovae, interstellar medium, extragalactic radio sources, quasars, and big-bang cosmologies. Also listed as Astronomy C254. (F)

**C285. Theoretical Astrophysics Seminar. (2)** Two hours of lecture per week. Must be taken on a satisfactory / unsatisfactory basis. The study of theoretical astrophysics. Also listed as Astronomy C285. (F,SP)

### **Graduate Seminars**

**290B. Experimental Astrophysics Seminar. (2)** Course may be repeated for credit. Two hours of seminar per week. Must be taken on a satisfactory / unsatisfactory basis.

**C290C. Cosmology. (2)** Course may be repeated for credit. Two hours of seminar per week. Must be taken on a satisfactory / unsatisfactory basis. Prerequisites: For undergraduate students, consent of instructor required. Previous background in cosmology recommended. Astronomy C290C. (F,SP)

**290E. Experimental Particle Physics Seminar. (2)** Course may be repeated for credit. Two hours of seminar per week. Must be taken on a satisfactory/unsatisfactory basis.

**290F. Experimental Atomic, Molecular and Optical Physics Seminar. (2)** Course may be repeated for credit. Two hours of seminar per week. Must be taken on a satisfactory/unsatisfactory basis.

**290K. Experimental Condensed Matter Physics Seminar. (2)** Course may be repeated for credit. Two hours of seminar per week. Must be taken on a satisfactory/unsatisfactory basis.

**290P. Theoretical Particle Physics Seminar Seminar. (2)** Course may be repeated for credit. Two hours of seminar per week. Must be taken on a satisfactory/unsatisfactory basis.

**290S. Theoretical Condensed Matter Physics Seminar. (2)** Course may be repeated for credit. Two hours of seminar per week. Must be taken on a satisfactory/unsatisfactory basis.

**290Z. Theoretical Particle Physics Seminar. (2)** Course may be repeated for credit. Two hours of seminar per week. Must be taken on a satisfactory/unsatisfactory basis.

**295. Special Study for Graduate Students. (1-4)** Must be taken on a satisfactory/unsatisfactory basis. Prerequisites: Graduate standing. This course is arranged to allow qualified graduate students to investigate possible research fields or to pursue problems of interest through reading or non-laboratory study under the direction of faculty members who agree to give such supervision. (F,SP)

**299. Research. (1-12)** Must be taken on a satisfactory/unsatisfactory basis. Prerequisites: Graduate standing. (F,SP) Staff

**602. Individual Study for Doctoral Students. (1-8)** Course may be repeated for credit. Course does not satisfy unit or residence requirements for doctoral degree. Must be taken on a satisfactory/unsatisfactory basis. Prerequisites: For qualified graduate students. Individual study in consultation with the major field adviser intended to provide an opportunity for qualified students to prepare themselves for the various examinations required of candidates for the Ph.D. (F,SP)

### *Professional Courses*

**301. Advanced Professional Preparation: Supervised Teaching of Physics. (1-2)** Course may be repeated for credit. One hour of independent study per week. Must be taken on a satisfactory/unsatisfactory basis. Prerequisites: 375. Discussion, problem review and development, guidance of physics laboratory experiments, course development. (F,SP)

**375. Professional Preparation: Supervised Teaching of Physics. (2)** Course may be repeated for credit. Two hours of lecture per week. Must be taken on a satisfactory/unsatisfactory basis. Prerequisites: Graduate standing or consent of instructor; may be taken concurrently with Physics 301. Mandatory for first time GSIs. Topics include teaching theory, effective teaching methods, educational objectives, alternatives to standard classroom methods, reciprocal classroom visitations, and guided group and self-analysis of videotapes. (F)