APPLIED PHYSICS

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Consulting Professors: Richard G. Brewer, John D. Fox, Bernardo A. Huberman, Stuart S. P. Parkin, Daniel Rugar
Consulting Associate Professor: Subramanian Subbiah
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* Recalled to active duty.

Department Offices: Applied Physics 101
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Courses given in Applied Physics have the subject code APPPHYS. For a complete list of subject codes, see Appendix B.

The Department of Applied Physics offers qualified students with backgrounds in physics or engineering the opportunity to do graduate course work and research in the physics relevant to technical applications and natural phenomena. These areas include accelerator physics, biophysics, condensed matter physics, nanostructured materials, optoelectronics, photonics, quantum optics, space science and astrophysics, synchrotron radiation and applications. Student research is supervised by the faculty members listed above and also by various members of other departments such as Biological Sciences, Chemistry, Electrical Engineering, Materials Science and Engineering, Physics, SLAC, and faculty of the Medical School who are engaged in related research fields. Research activities are carried out in research laboratories including the Geballe Laboratory for Advanced Materials, the Edward L. Ginzton Laboratory, the Hansen Experimental Physics Laboratory, the Stanford Linear Accelerator Center, and the Stanford Synchrotron Radiation Laboratory.

The number of graduate students admitted to Applied Physics is limited. Applications should be received by January 2, 2003. Graduate students normally enter the department only in Autumn Quarter.

UNDERGRADUATE PROGRAM

MINORS

The following minor program is intended for undergraduate nonphysics science and engineering majors seeking to broaden and deepen their knowledge of modern physics, with an applied flavor. The minor consists of two required 4-unit courses, covering quantum mechanics and statistical physics, and a minimum of four breadth courses. The total number of units required for the minor is not less than 21 units and not more than 36 units.

Required courses are:

Course No. & Subject	*Units*
APPPHYS 150. Applied Quantum Mechanics I	4
APPPHYS 152. Applied Statistical Mechanics	4
or PHYSICS 70. Modern Physics	4
or PHYSICS 170. Thermodynamics, Kinetic Theory, and Statistical Mechanics	4

Breadth courses (choose a minimum of four) are:

APPPHYS 151. Applied Quantum Mechanics II	4
APPPHYS 192. Introductory Biophysics	3
APPPHYS 196. Scattering Physics	4
APPPHYS 198. Introduction to Synchrotron Radiation	3
APPPHYS 270. Materials Physics in the Real World	3
EE 231. Introduction to Lasers	3
EE 232. Laser Dynamics and Statistical Mechanics	3
MATSCI 195. Waves and Diffraction in Materials	4
PHYSICS 107. Intermediate Physics Laboratory Seminar II: Analysis	4
PHYSICS 171. Thermodynamics, Kinetic Theory,	3
PHYSICS 172. Physics of Solids I	3

Prerequisites for the minor include the PHYSICS 50 series (or equivalent), the MATH 40 series and MATH 130 (or equivalents), and preferably MATH 103 and 132. APPPHYS 150, 151, and 152 provide a one-hour section each week for students who need to develop the necessary mathematical and physical background.

All courses fulfilling the minor must be taken for a letter grade, except when letter grades are not offered.

The minor declaration deadline is no later than the last day of the quarter two quarters before the quarter of degree conferral. For example, a student graduating Spring Quarter must declare the minor no later than the last day of Autumn Quarter of the senior year.

GRADUATE PROGRAMS

Admission requirements for graduate work in Applied Physics include a bachelor's degree in physics or an equivalent engineering degree. Students entering the program from an engineering curriculum should expect to spend at least an additional quarter of study acquiring the background to meet the requirements for advanced degrees in Applied Physics.

MASTER OF SCIENCE

The University's basic requirements for the master's degree are discussed in the "Graduate Degrees" section of this bulletin. The minimum requirements for the degree are 45 units, of which at least 39 units must be graduate-level courses in applied physics, engineering, mathematics, and physics. The required program consists of the following:

1. Courses in physics and mathematics to overcome deficiencies, if any, in undergraduate preparation.
2. Basic graduate courses (letter grade required):
   a) Advanced Mechanics—one quarter, 3 units: PHYSICS 210
   b) Electrodynamics—two quarters, 6 units: PHYSICS 220, 221
   c) Quantum Mechanics—two quarters, 6 units: PHYSICS 230, 231
3. 30 units of additional advanced courses in science and/or engineering. 15 of the 30 units may be any combination of advanced courses, Directed Study (APPPHYS 290), and 1-unit seminar courses, to complete the requirement of 45 units. At least 15 of these 30 units must be taken for a letter grade.
4. A final overall grade point average (GPA) of 'B' is required for courses used to fulfill degree requirements.

There are no department or University examinations, and a thesis is not required. If a student is admitted to the M.S. program only, but later wishes to change to the Ph.D. program, the student must apply to the department's Admissions Committee.

DOCTOR OF PHILOSOPHY

The University's basic requirements for the Ph.D. (residency, dissertation, examination, and so on) are discussed in the "Graduate Degrees" section of this bulletin. The program leading to a Ph.D. in Applied Physics consists of course work, research, qualifying for Ph.D. candidacy, a research progress report, a University oral examination, and a dissertation as follows:

1. *Course Work:*
   a) Courses in Physics and Mathematics to overcome deficiencies, if any, in undergraduate preparation.
   b) Basic graduate courses* (letter grades required):
      1) Advanced Mechanics—one quarter: PHYSICS 210
      2) Statistical Physics—one quarter: PHYSICS 212
      3) Electrodynamics—two quarters: PHYSICS 220, 221
      4) Quantum Mechanics—two quarters: PHYSICS 230, 231
      5) Laboratory—one quarter: APPPHYS 207, 208, 304, 305; EE 410; MATSCI 171, 172, 173; PHYSICS 301.

c) 18 units of additional advanced courses in science and/or engineering, not including Directed Study (APPPHYS 290), Dissertation Research (APPPHYS 390), and 1-unit seminar courses. Only 3 units at the 300 or above level may be taken on a satisfactory/no credit basis.
d) 96 units of additional courses to meet the minimum residency requirement of 135. Directed study and research units as well as 1-unit seminar courses can be included.
e) A final average overall grade point average (GPA) of 'B' is required for courses used to fulfill degree requirements.
f) Students are normally expected to complete the specified course requirements by the end of their third year of graduate study.

2. *Research:* may be conducted under the supervision of a member of the Applied Physics faculty or appropriate faculty from other departments.
3. *Ph.D. Candidacy:* satisfactory progress in academic and research work, together with passing the Ph.D. Candidacy Qualifying Examination, qualifies the student to apply for Ph.D. candidacy which must be completed before the third year of graduate registration. The examination consists of a seminar on a suitable subject delivered by the student before the faculty academic adviser (or an approved substitute) and two other members of the faculty selected by the department.
4. *Research Progress Report:* normally before the end of the Winter Quarter of the fourth year inclusive of pertinent graduate study prior to Stanford, the student arranges to give an oral research progress report of approximately 30 minutes, of which a minimum of 10 minutes should be devoted to questions from the Ph.D. reading committee.
5. *University Ph.D. Oral Examination*: consists of a public seminar in defense of the dissertation, followed by private questioning of the candidate by the University examining committee.
6. *Dissertation:* must be approved and signed by the Ph.D. reading committee.

* Requirements for item 1b may be totally or partly satisfied with equivalent courses taken elsewhere, pending the approval of the Graduate Study Committee.

ASSISTANTSHIPS

Research assistantships are available for Ph.D. candidates. Information on applying for financial aid is included in the admission packet received from Graduate Admissions, the Registrar's Office.

COURSES

(AU) indicates that the course is subject to the University Activity Unit limitations (8 units maximum).

APPPHYS 27N. Lasers: The Light Fantastic—(Enroll in CHEM 27N.) Stanford Introductory Seminar.
2 units, Win (Moerner)

APPPHYS 138. Matlab and Maple for Science and Engineering Applications—(Enroll in CS 138.)
3-4 units, Win (Moler)

APPPHYS 150. Applied Quantum Mechanics I—(Same as EE 222; graduate students register for EE 222.) For undergraduates. Introduction to quantum mechanics, emphasizing applications in modern devices and systems. Topics: Schrödinger's equation, eigenfunctions and eigenvalues, operator approach to quantum mechanics, solutions of simple problems (including quantum wells, harmonic oscillators, simple periodic structures), tunneling, calculation techniques (including matrix diagonalization, perturbation theory, variational method), time-dependent perturbation theory (including application to optical absorption), fundamental postulates of quantum mechanics. Prerequisites: PHYSICS 51 and 55, or PHYSICS 65, or equivalents.
3 units, Aut (Miller)

APPPHYS 151. Applied Quantum Mechanics II—(Same as EE 223; graduate students register for EE 223.) For undergraduates. Continuation of 150, including more advanced topics: spin and identical particles; effective mass theory for semiconductors; annihilation and creation operators; density matrices; introductory quantum optics; and other topics in electronics, optoelectronics, and optics. Prerequisite: 150.
3 units, Win (Miller)

APPPHYS 152. Applied Statistical Mechanics—For undergraduates. The principles of statistical mechanics and quantum statistical physics. Fundamental concepts of equilibrium and non-equilibrium systems and noise processes. Density matrix, master equations, Langevin equations, fluctuation-dissipation theorem. Illustrative in-class problem solving sessions elucidate the central ideas and methods.
4 units, Spr (Kapitulnik)

APPPHYS 172. Physics of Solids I—(Enroll in PHYSICS 172.)
3 units, Win (I. R. Fisher)

APPPHYS 192. Introductory Biophysics—For advanced undergraduates or beginning graduates. Introduction to quantitative models used in molecular biophysics. Topics: overview and the relation of structure to function. Chemical equilibria, cooperativity, and control: elementary statistical mechanics, affinity plots, allostery, models of hemoglobin-oxygen binding, bacterial chemotaxis. Macromolecular conformations: polymer chain models, protein folding, taxonomy of globular proteins, general principles of sequence selection. Chemical kinetics. Multiple barriers: CO-myoglobin kinetics, ion diffusion through channels and ion selectivity, spectroscopy of ion channels-acetylcholine receptor. Supramolecular kinetics: conversion of chemical energy to mechanical force, myosin and kinesin, actin polymers. Nerve impulse propagation: membrane potentials, voltage sensitive ion gates, Hodgkin Huxley equations, propagation of the nerve impulse.
3 units (Doniach) alternate years, given 2003-04

APPPHYS 195. Waves and Diffraction in Solids—(Enroll in MATSCI 195.)
4 units, Win (Clemens)

APPPHYS 196. Scattering Physics—(For undergraduates; see 218.)
4 units (Greven) not given 2002-03

APPPHYS 198. Introduction to Synchrotron Radiation—For students using such radiation for basic and applied research and students in accelerator physics concentrating on source developments and the study of particle beam characteristics and stability. Electromagnetic radiation from relativistic electron beams, derived from first principles. Coherent and incoherent synchrotron radiation, free electron lasers; undulator and wiggler radiation with linear and elliptical polarization. Recommended: electromagnetism, optics, and special relativity.
3 units (Staff) alternate years, given 2003-04

APPPHYS 207,208. Laboratory Electronics—Combined lecture/lab emphasizing analog and digital electronics for lab research. RC and diode circuits. Transistors. Feedback and operational amplifiers. Active filters and circuits. Pulsed circuits, voltage regulators, and power circuits. Precision circuits, low-noise measurement, and noise reduction techniques. Circuit simulation tools. Principles of synchronous demodulation and applications of lock-in amplifiers. Combinatorial and synchronous digital circuits. Design using programmable logic. Analog/digital conversion. Microprocessors and real time programming. Current lab interface protocols. Emphasizes techniques commonly used for lab measurements. Limited enrollment. Prerequisites: some undergraduate-level device and circuit exposure.
207. *3 units, Win (Fox)*
208. *3 units, Spr (Fox) alternate years, not given 2003-04*

APPPHYS 210. Advanced Particle Mechanics—(Enroll in PHYSICS 210.)
3 units, Win (Kallosh)

APPPHYS 211. Biophysics of Sensory Transduction—(Enroll in BIOSCI 211.)
4 units, Spr (S. Block)

APPPHYS 212. Statistical Mechanics—(Enroll in PHYSICS 212.)
3 units, Spr (Fetter)

APPPHYS 215. Numerical Methods for Physicists and Engineers—Review of basic numerical techniques with additional advanced material: derivatives and integrals; linear algebra; linear least squares fitting, FFT and wavelets, singular value decomposition, linear prediction; optimization, nonlinear least squares, maximum entropy methods; deterministic and stochastic differential equations, Monte Carlo methods.
3 units (Doniach) alternate years, given 2003-04

APPPHYS 216. X-Ray and VUV Physics—Introduction to current x-ray and VUV physics research and classical concepts in photon science. Photon-electron interactions; x-ray absorption and Compton scattering. X-ray spectroscopy; EXAFS, SEXAFS, edge structure, magnetic circular dichroism, and linear dichroism. Photoemission spectroscopy and many-electron effects: angle-resolved and integrated photoemission, resonance photoemission, spin-polarized photoemission. Photoelectron diffraction and holography. X-ray interactions with condensed matter: diffraction and scattering. Photon sources: synchrotron, wigglers, and undulators. Photon and electron detectors and analyzers. Offered occasionally. Prerequisite: reasonable familiarity with quantum mechanics.
3 units (Shen) not given 2002-03

APPPHYS 217. Waves and Diffraction in Solids—(Enroll in MATSCI 205.)
3 units, Win (Clemens)

APPPHYS 218. Scattering Physics—(Same as APPPHYS 196.) Introduction to scattering techniques, including neutron, x-ray, and light scattering. Probing of phase transitions and excitations in condensed matter. Emphasis is on magnetic scattering from experimental model systems and from novel materials. Topics: low-dimensional magnets such as Heisenberg chains and planes; and magnetic fluctuations in high-temperature superconductors. Global scattering probes are contrasted with local probes, such as nuclear magnetic resonance (NMR) and muon spin resonance (muSR). Prerequisites: 150, 151, and PHYSICS 172 or equivalent.
3 units (Greven) not given 2002-03

APPPHYS 219. Back of the Envelope Physics—(Enroll in PHYSICS 216.)
3 units, Aut (Wagoner)

APPPHYS 220. Classical Electrodynamics—(Enroll in PHYSICS 220.)
3 units, Win (Zhang)

APPPHYS 221. Classical Electrodynamics—(Enroll in PHYSICS 221.)
3 units, Spr (Zhang)

APPPHYS 222. Applied Quantum Mechanics I—(Enroll in EE 222.)
3 units, Aut (Miller)

APPPHYS 223. Applied Quantum Mechanics II—(Enroll in EE 223.)
3 units, Win (Miller)

APPPHYS 225. Quantum Information—Fundamental concepts of quantum theory: linear superposition, entanglement, non-locality and projective measurement. Two photon interference and Bell's inequality. Fundamental limit in quantum measurement: quantum nondemolition measurement, non-linear measurement and quantum Zero effect. Quantum key distribution and teleportation: information, energy dissipation and reversible computer. Quantum algorithm, physical implementation and scaling law. Quantum hardware. Decoherence of quantum systems and quantum error correction codes.
3 units, Spr (Yamamoto) given 2002-03

APPPHYS 230A. Quantum Mechanics—(Enroll in PHYSICS 230.)
3 units, Aut (Chu)

APPPHYS 230B. Quantum Mechanics—(Enroll in PHYSICS 231.)
3 units, Win (Chu, Vuletic)

APPPHYS 231A. Introduction to Lasers—(Enroll in EE 231.)
3 units, Aut (Fejer)

APPPHYS 231B. Laser Dynamics—(Enroll in EE 232.)
3 units, Win (Fejer)

APPPHYS 248. Fundamentals of Noise Processes—(Enroll in EE 248.)
3 units, Aut (Yamamoto)

APPPHYS 268. Introduction to Modern Optics—(Enroll in EE 268.)
3 units, Aut (Byer)

APPPHYS 270. Materials Physics in the Real World—Bridges the gap between an introductory condensed matter physics course and an experimental materials physics course. Emphasis is on experimental techniques and canonical materials. Origin of magnetism in solids; long range order in solids; crystal growth techniques; measurement of thermodynamic and transport properties; review of experimental results for canonical materials, focusing on magnetic and electronic properties; topics in magnetism, superconductivity and density waves; relation to contemporary challenges. Prerequisite: PHYSICS 172 or MATSCI 209, or equivalent introductory solid state course.
3 units, Spr (Fisher)

APPPHYS 272. Solid State Physics I—Introduction to the properties of solids. Theory of free electrons, classical and quantum. Crystal structure and methods of determination. Electron energy levels in a crystal: weak potential and tight-binding limits. Classification of solids: metals, semiconductors, and insulators. Types of bonding and cohesion in crystals. Lattice dynamics, phonon spectra, and thermal properties of harmonic crystals. Pre- or corequisites: PHYSICS 120 and 121, and PHYSICS 130 and 131 or 150 and 151, or equivalents.
3 units, Win (Manoharan)

APPPHYS 273. Solid State Physics II—Electronic structure of solids. Electron dynamics and transport. Semiconductors and impurity states. Surfaces. Dielectric properties of insulators. Electron-electron, electron-phonon, and phonon-phonon interactions. Anharmonic effects in crystals. Electronic states in magnetic fields and the quantum Hall effect. Magnetism, superconductivity, and other related many-particle phenomena. Prerequisite: 272.
3 units, Spr (Manoharan)

APPPHYS 280. Phenomenology of Superconductors I—Introduction to the phenomenology of superconductors and their applications from a unified point of view based on superconductivity as a phase-coherent macroscopic quantum phenomena. Topics include the superconducting pair wave function, London and Ginzburg Landau theories, their physical content, the Josephson effect and superconducting quantum interference devices, s- and d-wave superconductivity, the response of superconductors to currents, magnetic fields, and rf electromagnetic radiation.
3 units, Aut (Beasley)

APPPHYS 281. Phenomenology of Superconductors II—Continuation of 280. Advanced topics in the phenomenology of superconductors. Topics include vortex states of matter, collective pinning, fluctuation effects, effects of dimensionality, the Kosterlitz-Thouless transition, Josephson junction arrays, quantum effects and the superconductor/insulator transition.
3 units, Win (Beasley)

APPPHYS 290. Directed Studies in Applied Physics—Special studies under the direction of a faculty member for which academic credit may properly be allowed. May include lab work or directed reading.
1-15 units, any quarter (Staff)

APPPHYS 291. Practical Training—Opportunity for practical training in industrial labs. Arranged by student with the research adviser's approval. A brief summary of activities is required, approved by the research adviser.
3 units, Sum (Staff)

APPPHYS 301. Astrophysics Laboratory—(Enroll in PHYSICS 301.)
3 units, Sum (Staff)

APPPHYS 304. Lasers Laboratory—Laser theory and practice. Lectures on the theoretical and descriptive background for lab experiments, detectors and noise, lasers (helium neon, beams and resonators, argon ion, cw dye, titanium sapphire, semiconductor diode, and the Nd:YAG). Measurements of laser threshold, gain, saturation, and output power levels. Laser transverse and axial modes, linewidth and tuning, Q-switching and modelocking. Limited enrollment. Prerequisites: EE 231 and 232, or consent of instructor.
3 units, Win (Byer)

APPPHYS 305. Nonlinear Optics Laboratory—Emphasis is on laser interaction with matter. Laser devices provide the radiation required to explore the linear and nonlinear properties of matter. Experiments on modulation, harmonic generation, parametric oscillators, modelocking, stimulated Raman and Brillouin scattering, Coherent Anti-Stokes scattering, other four wave mixing interactions such as wavefront conjugation and optical bistability. Optical pumping and spectroscopy of atomic and molecular species. Limited enrollment. Prerequisites: 304, EE 231 and 232, or consent of instructor.
3 units, Spr (Byer) not given 2002-03

APPPHYS 315. Methods in Computational Biology—Introduction to genome data bases; linear programming methods in genome sequence comparisons; Hidden Markov models; exons, introns, and single nucleotide polymorphisms. Introduction to cluster analysis methods; applications to genetic microarrays. Computational methods in protein, RNA and DNA structure and dynamics: simplified representations, distance geometry methods, protein structure prediction methods. Molecular dynamics methods: applications to protein and RNA folding and unfolding and other conformational changes using massively parallel algorithms.
3 units (Doniach) alternate years, given 2003-04

APPPHYS 324. Introduction to Accelerator Physics—Introduction to the physics of particle beams in linear and circular accelerators. Topics: transverse beam dynamics, acceleration, longitudinal beam dynamics, synchrotron radiation, collective instabilities, and nonlinear effects. Introduction to current research topics.
3 units (Staff) alternate years, given 2003-04

APPPHYS 346. Introduction to Nonlinear Optics—(Enroll in EE 346.)
3 units, Spr (S. Harris)

APPPHYS 366. Introduction to Fourier Optics—(Enroll in EE 366.)
3 units, Spr (Hesselink) alternate years, not given 2003-04

APPPHYS 372. Condensed Matter Theory I—Fermi liquid theory, many-body perturbation theory, response function, functional integrals, interaction of electrons with impurities.
3 units (Zhang) alternate years, given 2003-04

APPPHYS 373. Condensed Matter Theory II—Superfluidity and superconductivity. Quantum magnetism. Prerequisite: 372.
3 units (Zhang) alternate years, given 2003-04

APPPHYS 377. Literature of Condensed Matter Physics—(Enroll in PHYSICS 377.)
3 units (Shen) not given 2002-03

APPPHYS 383. Introduction to Atomic Processes—Atomic spectroscopy, matrix elements using the Coulomb approximation, summary of Racah algebra, oscillator and line strengths, Einstein A coefficients. Radiative processes, Hamiltonian for two- and three-state systems, single- and multi-photon processes, linear and nonlinear susceptibilities, density matrix, brightness, detailed balance, and electromagnetically induced transparency. Inelastic collisions in the impact approximation, interaction potentials, Landau-Zener formulation. Continuum processes, Saha equilibrium, autoionization, and recombination.
3 units (S. Harris) alternate years, given 2003-04

APPPHYS 387. Quantum Optics and Measurements—Fundamental postulates in quantum mechanics and basic concepts of quantum optics: Heisenberg's uncertainty principle, von Newmann's projection hypothesis, quantum non-demolition measurements, quantum states of light, cavity quantum electrodynamics, nonlocality and quantum entanglement. Second quantization of bosonic and fermionic fields; Glauber, Fock, Dicke, and Bloch states, first- and second-order coherence, quantum interference. Reservoir theory of open systems: Markoff and Born approximations, density operator master, Fokker-Planck, quantum Langevin, stochastic differential equations, quantum Monte-Carlo wavefunction method.
3 units (Yamamoto) alternate years, given 2003-04

APPPHYS 388. Mesoscopic Physics and Nanostructures—Optical properties of semiconductor nanostructures: interband and intraband optical transitions, excitons and polaritons, semiconductor Bloch equations, bosonization, exciton BEC, exciton laser. Transport properties in mesoscopic and atomic systems: electron optics vs. photon optics, Landauer-Büttiker formula, noise in diffusive and dissipative transport, nonequilibrium Green's function, electron entanglement, Coulomb blockade, single electronics, and spin dynamics in semiconductor quantum dots. Partly Journal Club format with presentations by students on assigned topics.
3 units, Win (Yamamoto) alternate years, not given 2003-04

APPPHYS 390. Dissertation Research
1-15 units, any quarter (Staff)

APPPHYS 392. Topics in Molecular Biophysics—Concepts from statistical mechanics are applied to problems in contemporary molecular biology: allosteric transitions; protein folding; molecular recognition; actin polymers and gels; molecular motors; lipids and membrane proteins; ion channels. Some of the basic models used to quantitate fundamental biomolecular functions. Prerequisites: elementary statistical mechanics and chemical kinetics.
3 units (Doniach) alternate years, given 2003-04

APPPHYS 453. Special Topics in Accelerator Physics—Research level discussions of current topics in accelerator physics. Content varies each quarter and year, depending on the interests of staff and students. May be repeated for credit. Offered occasionally.

APPPHYS 453A. Accelerator Physics of Linear Colliders—For graduate or advanced undergraduate students interested in either accelerator physics or high-energy physics. Introduction to the accelerator physics and technologies required to construct a linear collider. Particle sources and storage rings used for beam preparation, the rf generation and acceleration, and the beam dynamics in the main linacs and the final focus systems. Normal and superconducting approaches along with concepts for even higher energy colliders. Prior knowledge of accelerator physics not necessary. Prerequisite: good background in classical mechanics and E&M.
3 units, Win (Raubenheimer)

APPPHYS 453B. Collective Instabilities in Accelerators—A beam in an accelerator can become unstable if its intensity is too high. Topics include the physical mechanism causing these instabilities; establishing the framework by introducing the concepts of wakefield and impedance; various instability mechanisms with a special emphasis on the underlying physical principles; new types of instabilities encountered in modern high performance accelerators such as the fast ion and the electron cloud instabilities.
3 units, Spr (Chao)

APPPHYS 459. Frontiers in Interdisciplinary Biosciences—(Cross-listed in multiple departments in the schools of Humanities and Sciences, Engineering, and Medicine; students should enroll directly through their affiliated department, otherwise enroll in CHEMENG 459.) An introduction to cutting-edge research involving interdisciplinary approaches to bioscience and biotechnology; for specialists and non-specialists. Organized and sponsored by the Stanford BioX Program. Three seminars each quarter address a broad set of scientific and technical themes related to interdisciplinary approaches to important issues in bioengineering, medicine, and the chemical, physical, and biological sciences. Leading investigators from Stanford and throughout the world present the latest breakthroughs and endeavors that cut broadly across many core disciplines. Pre-seminars introduce basic concepts and provide background for non-experts. Registered students attend all pre-seminars in advance of the primary seminars, others welcome. Prerequisite: keen interest in all of science, engineering, and medicine with particular interest in life itself. Recommended: basic knowledge of mathematics, biology, chemistry, and physics.

1 unit, Aut, Win, Spr (Robertson)

APPPHYS 463. Special Topics in Astrophysics—(Enroll in PHYSICS 463.)

3 units (Staff) not given 2002-03

APPPHYS 470. Condensed Matter Seminar—Discussion of current research and literature in condensed matter physics offered by faculty, students, and outside specialists. (AU)

1 unit, Aut, Win, Spr (Staff)

APPPHYS 473. Special Topics in Condensed Matter Physics—Research level discussions of current topics in condensed matter physics. Content varies each quarter and year, depending on the interests of staff and students. May be repeated for credit. Offered occasionally.

APPPHYS 473A. Condensed Matter Physics—Students undertake background study prior to each weekly seminar offered through 470 as an introduction to topics of contemporary interest in condensed matter physics, critique each seminar for success in oral communication, and present a one-hour seminar on a contemporary topic for critique by the class. Corequisite: 470.

2 units, Spr (Beasley)

APPPHYS 473B. Physics of Strongly Correlated Electron Systems—Kondo impurities, slave bosons, and heavy fermions; the one dimensional electron gas: spinons, holons, and anyons; 2D electron gas; fractional quantum Hall effect; charge-transfer compounds, Hubbard and t-J models, flux phase states; d-wave BCS state, pseudo gap, spin-charge separation and stripe states.

3 units, Win (Doniach)

APPPHYS 483. Optics and Electronics Seminar—Weekly presentations and discussions of current research topics in lasers, quantum electronics, optics, and photonics by faculty, students, and invited speakers. (AU)

1 unit, Aut, Win, Spr (Staff)

This file has been excerpted from the *Stanford Bulletin, 2002-03*, pages 240-244. Every effort has been made to insure accuracy; late changes (after print publication of the bulletin) may have been made here. Contact the editor of the *Stanford Bulletin* via email at arod@stanford.edu with changes, corrections, updates, etc.