APPLIED PHYSICS

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Lecturer: John Irwin (Spring)
Consulting Professors: Richard G. Brewer, John D. Fox, Bernardo A. Huberman, Stuart S. P. Parkin, Daniel Rugar
Consulting Associate Professor: Subramanian Subbiah
Visiting Professor: Norna A. Robertson

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 1, 2002. Graduate students normally enter the department only in Autumn Quarter.

UNDERGRADUATE PROGRAM

MINORS

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

Required Applied Physics courses are:

Course No. & Subject	*Units*
150. Applied Quantum Mechanics I	4
151. Applied Quantum Mechanics II	4
152. Applied Statistical Mechanics	4

Breadth Applied Physics courses (choose a minimum of three) are:

106A. Laboratory Seminar II: Atom-Light Interactions (Enroll in Physics 106A)	3
172. Physics of Solids I (Enroll in Physics 172)	3
173. Materials Physics in the Real World	3
192. Introductory Biophysics	3
195. Waves and Diffraction in Materials (Enroll in Mat. Sci. & Engr. 195)	4
196. Scattering Physics	4
198. Introduction to Synchrotron Radiation	3
231A. Introduction to Laser Physics (Enroll in Elect. Engr. 231)	3
231B. Laser Dynamics (Enroll in Elect. Engr. 232)	3

Prerequisites for the minor include the Physics 50 series (or equivalent), the Mathematics 40 series and Mathematics 130 (or equivalents), and preferably Mathematics 103 and 132. Applied Physics 150, 151, and 152 provide an extra 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 (Applied Physics 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: Applied Physics 207, 208, 304, 305; Electrical Engineering 410; Physics 201, 202, 203, 301; Materials Science and Engineering 171, 172, 173
   c) 18 units of additional advanced courses in science and/or engineering, not including Directed Study (Applied Physics 290), Dissertation Research (Applied Physics 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).

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

79Q. Stanford Introductory Seminar: Energy Options in the 21st Century—Preference to sophomores. Options for meeting energy related needs of the 21st century. The underlying science and the tradeoffs involved in increasing energy consumption while respecting the environment. Topics: energy sources, sinks, and the earth's energy balance; energy technologies, e.g., superconducting motors, generators, transmission lines, heat engines, nuclear fission and fusion plants, hydrogen and fossil fuels, and renewable sources (solar, wind, water); transportation technologies, e.g., high mileage automobiles (fuel cells, internal and external engines, batteries), and levitated trains.
3 units, Spr (Geballe)

106A. Laboratory Seminar II: Atom-Light Interactions—(Enroll in Physics 106A.)
3 units, Win (Vuletic)

150. Applied Quantum Mechanics I—(Graduate students enroll in Electrical Engineering 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)

151. Applied Quantum Mechanics II—(Graduate students enroll in Electrical Engineering 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)

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)

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

173. Materials Physics in the Real World—Bridges the gap between introductory condensed matter physics and experimental materials physics. Emphasis is on real materials and the tools an experimentalist has on hand to investigate these systems. Growth and characterization techniques; analysis of real data; review of experimental results for canonical materials, principally focusing on magnetic and electronic properties; superconductivity and density waves; metal insulator transitions; magnetism; relation to contemporary challenges. Prerequisite: Physics 172 or equivalent introductory condensed matter physics course.
3 units, Spr (Fisher)

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, Spr (Doniach) alternate years, not given 2002-03

195. Waves and Diffraction in Solids—(Enroll in Materials Science and Engineering 195.)
4 units, Win (Clemens)

196. Scattering Physics—For undergraduates; see 218. Prerequisites: 150, 151, and Physics 172 or equivalent.
4 units, Spr (Greven)

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, alternate years, given 2002-03

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. Development of students' lab projects during the last three weeks of 208. Limited enrollment. Prerequisites: some undergraduate-level device and circuit exposure.

207. *3 units, Win (Fox)*
208. *3 units, alternate years, given 2002-03*

210. Advanced Particle Mechanics—(Enroll in Physics 210.)
3 units, Aut (Kallosh)

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

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

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, Aut (Doniach) alternate years, not given 2002-03

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, Spr (Shen)

217. Waves and Diffraction in Solids—(Enroll in Materials Science and Engineering 205.)
3 units, Win (Clemens)

218. Scattering Physics—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, e.g., Heisenberg chains and planes; and magnetic fluctuations in high-temperature superconductors. "Global" scattering probes are contrasted with "local" probes, e.g., nuclear magnetic resonance (NMR) and muon spin resonance (muSR). Prerequisites: 150, 151, and Physics 172 or equivalent.
3 units, Spr (Greven)

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

220,221. Classical Electrodynamics—(Enroll in Physics 220, 221.)
220. *3 units, Win (Laughlin)*
221. *3 units, Spr (Laughlin)*

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

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

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 (Yamamoto) given 2002-03

230A,B. Quantum Mechanics—(Enroll in Physics 230, 231.)
230A. *3 units, Aut (Kachru)*
230B. *3 units, Win (Kachru)*

231A. Lasers I—(Enroll in Electrical Engineering 231.)
3 units, Aut (Feyer)

231B. Laser Dynamics—(Enroll in Electrical Engineering 232.)
3 units, Win (Feyer)

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

268. Introduction to Modern Optics—(Enroll in Electrical Engineering 268.)
3 units, Aut (Hesselink) alternate years, not given 2002-03

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. Prerequisites (can be taken concurrently): Physics 120 and 121, and Physics 130 and 131 or 150 and 151, or equivalents.
3 units, Win (Manoharan)

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)

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.
any quarter (Staff)

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)

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

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: Electrical Engineering 231 and 232, or consent of instructor.

3 units, Win (Byer)

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, Electrical Engineering 231 and 232, or consent of instructor.

3 units, Spr (Byer) not given 2002-03

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, RMA 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, Win (Doniach) alternate years, not given 2002-03

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, Win (Ruth) alternate years, not given 2002-03

346. Introduction to Nonlinear Optics—(Enroll in Electrical Engineering 346.)

3 units, Spr (S. Harris)

366. Introduction to Fourier Optics—(Enroll in Electrical Engineering 366.)

3 units, alternate years, given 2002-03

372. Condensed Matter Theory I—Fermi liquid theory, many-body perturbation theory, response function, functional integrals, interaction of electrons with impurities.

3 units, Aut (Zhang) alternate years, not given 2002-03

373. Condensed Matter Theory II—Superfluidity and superconductivity. Quantum magnetism. Prerequisite: 372.

3 units, Win (Zhang) alternate years, not given 2002-03

377. Literature of Condensed Matter Physics—(Enroll in Physics 377.)

3 units, Aut (Shen)

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 multiphoton 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, Aut (S. Harris) alternate years, not given 2002-03

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, Win (Yamamoto) alternate years, not given 2002-03

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, alternate years, given 2002-03

390. Dissertation Research

any quarter (Staff)

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, alternate years, given 2002-03

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. Course may be repeated. Offered occasionally.

453A. Particle Beam Optics Using Lie Algebra Methods—Introduction to advanced classical mechanics concepts and Lie operator fundamentals. Lie operator methods as tools for the design of optical systems containing nonlinearities. Example applications from the PEP-II B-factory and Final Focus Test Beam beamlines at SLAC. Extensions of these methods to wave optics.

3 units, Spr (Irwin)

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 ChE 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)

463. Special Topics in Astrophysics—(Enroll in Physics 463.)
3 units (Staff)

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)

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. Course may be repeated. Offered occasionally

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 (Greven)

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)

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