

Key to Course Listings

Catalog numbers are part of a University-wide numbering system. Generally, courses numbered 100 to 199 are introductory, 200-299 are intermediate, and 300-499 are advanced (upper-level).

Reorganized or renumbered courses are denoted by a parenthetical number in boldface following the course number. When renumbering or reorganization has left the SUBJECT unchanged, only the previous catalog number is given; if the SUBJECT has also changed, the previous SUBJECT name and course number appear. A reorganized or renumbered course cannot be repeated for credit without special permission.

Cross-listed courses are sponsored by more than one department or program and may be elected in any of the participating units. Cross-listings appear in boldface and are denoted by a slash between the participating units.

Course titles appear in boldface after the catalog number.

Prerequisites appear in italics after the course title. Some prerequisites are advisory. They suggest the assumed background or level of academic experience, and students should be guided by these statements. Some prerequisites are mandatory and are enforced at the point of registration. The *Course Guide* and the *LS&A Bulletin* indicate the cases when prerequisites are enforced.

Prerequisites are of three types:

- *Courses*. Unless otherwise stated, the phrase "or equivalent" may be considered an implicit part of the prerequisite for any course. When a student has satisfactorily completed a course(s) at the required level of competency and when that course is believed to be substantially equivalent to one listed as a prerequisite, the student must consult the instructor or department. If equivalency is determined to have been satisfied, election may be approved by issuance of electronic permission.
- *Class standing* (first year, sophomore, junior, senior). A course might be appropriate for "first and second year students only," or for "juniors and seniors."
- *Permission of instructor*. The phrase "or permission of instructor" may be considered an implicit part of the statement of prerequisites for any course. When permission is a stated requirement, or when a student does not have the stated prerequisite for a course but can give evidence of sufficient background, the student should obtain approval from the instructor or department concerned and an electronic permission issued.

The Credit Symbol, an Arabic numeral in parentheses, denotes the credits earned for the course. Credit is granted in semester hours. Except for small seminars where the reading and/or writing requirements are intensive, one credit represents no less than one hour of class meeting time each week of the term, and usually represents two hours of work outside of class for each class hour.

Area distribution designation is approved by the LS&A Curriculum Committee on a yearly basis. A course may be approved with the designation natural science (*NS*), social science (*SS*), humanities (*HU*), mathematical and symbolic analysis (*MSA*), creative expression (*CE*), interdisciplinary (*ID*), or excluded from distribution (*Excl*).

Courses meeting certain college requirements are so listed. Language other than English (*LR*) courses may be used toward meeting the Language Requirement. The First-Year Writing Requirement may be met by courses designated (Introductory Composition). Courses approved with the designation "Language Requirement" or "Introductory Composition" may not be used as part of an area distribution plan. If an introductory language course is designated "Excluded" (*Excl*), it may not be used to satisfy the LS&A language requirement. (*BS*) means that the course may be used toward the 60 approved credits required for the B.S. degree. Courses meeting or partially meeting the Quantitative Reasoning

requirement are designated (*QR/1*) or (*QR/2*). Courses with standard approval for meeting the Race & Ethnicity (*R&E*) requirement are so indicated. Other courses may meet the R&E or QR requirements on a term-by-term basis and are listed on the LS&A website (<http://www.lsa.umich.edu/>).

Experiential, Independent Study, and Tutorial courses are so designated. (See Experiential and Directed Reading/Independent Study Courses in *Chapter IV*.)

Repetition of a course that varies in content from term to term is permitted only under certain conditions. When a department or program has a policy about the repetition of a course for credit, that policy is included in the course listing. The general statement "May be repeated for credit with permission" usually means "With permission of a concentration advisor." In all other instances, a student must get permission from both the department or program and the Academic Standards Board to repeat a course for credit. Generally, a course may be elected for credit once only.

Excluded combinations of course elections are designated in the listing of affected courses.

Special Grading pattern for a course is indicated in the course listing. Some LS&A courses are offered *mandatory credit/no credit*. (See Non-Graded Courses in *Chapter IV*.)

The Term Symbol, a Roman numeral, denotes the term(s) some courses are offered. The University year is divided into three terms: Fall (I), Winter (II), and Spring-Summer (III). The Spring-Summer Term is further divided: Spring-Half (IIIa) and Summer-Half (IIIb).

Courses That Count Toward Graduate Programs

Courses Approved for Regular Rackham Graduate Credit. All courses taken in fulfillment of Rackham degree requirements must be approved for Rackham graduate credit. Be certain that any courses you plan to take--especially those numbered in the 400s--are approved for Rackham credit before you enroll in them. The Graduate School policy on courses is as follows: Courses at the 400 level and above are acceptable for graduate credit if they have been approved by the Graduate School.

If you are uncertain whether or not a course is approved for Rackham credit, check with the department offering the course or with the Rackham Course Approval Officer (764-8221).

If you elect a course that has not been approved for Rackham graduate credit, the course will appear on your university transcript with the notation "Not for Graduate Credit." The course grade will appear on the transcript, but it will not be averaged into your cumulative grade point average or your credit toward program (CTP) total.

Courses Not Approved for Graduate Credit. Courses at the 300 level and below are not acceptable for graduate credit, without exception. Undergraduate level foreign language courses may occasionally be used in fulfillment of some departmental foreign language requirements.

Under unusual circumstances you may petition to receive graduate credit for a course not normally approved for graduate credit (*e.g.*, such as an undergraduate course where you will be expected to perform more advanced work than the undergraduates). Because there is no guarantee of approval, you should submit your petition to the Graduate School's Office of Academic Records and Dissertations (OARD) before taking the course. Your petition must be endorsed by the course instructor and by the graduate chair of your department or program, and it must include an explanation for requesting the exception. You will be expected to perform graduate level work in the course, and the petition must show how this will be accomplished. You may obtain a petition form from your department, from OARD, or online.

Applied Physics Program

Applied Physics

Applied Physics APPPHYS 320

LSA

Applied Physics Program

Applied Physics

<http://www-applied.physics.lsa.umich.edu/>

Undergraduate and Graduate Courses

530 **APPPHYS 530 / EECS 530.**

Electromagnetic Theory I.

(3,3;3,3) : May not be repeated for credit.

(Excl). (BS).

PHYSICS 438 or EECS 330. CAEN lab access fee required for non-Engineering students. I.

Maxwell's equations, constitutive relations and boundary conditions. Potentials and the representation of electromagnetic fields. Uniqueness, duality, equivalence, reciprocity and Babinet's theorems. Plane, cylindrical and spherical waves. Waveguides and elementary antennas. The limiting case of electro- and magneto-statics.

540 **APPPHYS 540 / EECS 540.**

Applied Quantum Mechanics.

(3,3;3,3) : May not be repeated for credit.

(Excl). (BS).

Permission of instructor. CAEN lab access fee required for non-Engineering students. I.

Introduction to nonrelativistic quantum mechanics. Summary of classical mechanics, postulates of quantum mechanics and operator formalism, stationary state problems (including quantum wells, harmonic oscillator, angular momentum theory and spin, atoms and molecules, band theory in solids), time evolution, approximation methods for time independent and time dependent interactions including electromagnetic interactions, scattering.

541 **APPPHYS 541 / EECS 541.**

Applied Quantum Mechanics II.

(3,3;3,3) : May not be repeated for credit.

(Excl). (BS).

APPPHYS 540. CAEN lab access fee required for non-Engineering students. II.

Continuation of nonrelativistic quantum mechanics. Advanced angular momentum theory, second quantization, non-relativistic quantum electrodynamics, advanced scattering theory, density matrix formalism, reservoir theory.

672 **APPPHYS 672 / NERS 572.**

Plasma and Controlled Fusion II.

(3,3;3,3) : May not be repeated for credit.

(Excl). (BS).

NERS 571. CAEN lab access fee required for non-Engineering students.

Waves in non-uniform plasmas, magnetic shear; absorption, reflection, and tunneling gradient-driven microinstabilities; BGK mode and nonlinear Landau damping; macroscopic instabilities and their stabilization; non-ideal MHD effects.

Graduate Courses

514 **APPPHYS 514.**

Applied Physics Seminar.

(1-2,1-2;1-2,1-2) : May be repeated for credit.

(Excl).

Graduate standing. This course has a grading basis of "S" or "U."

Seminar designed to familiarize students with current research problems.

518 **APPPHYS 518 / PHYSICS 518.****Microcomputers in Experimental Research.**

(3,3) : May not be repeated for credit.

(Excl). (BS).

Graduate standing.

A laboratory course designed to give students hands-on experience with modern techniques of data acquisition, handling, and analysis, and graphical presentation of results using micro-computers. Several experiments will be carried out which illustrate how to interface research instrumentation in a variety of commonly encountered laboratory situations.

529 **APPPHYS 529 / PHYSICS 529.****Techniques of Experimental Physics.**

(3,3) : May not be repeated for credit.

(Excl). (BS).

Graduate standing.

The goal of this course is to get you acquainted with the concept of modern physics experiment and to help you learn important experimental skills and data analysis techniques. Apart from developing an appreciation of experimental approaches used in many areas of modern physics you will also gain familiarity with:

- Finding and studying previously published results and references;

- Designing experimental procedures;

- Choosing adequate instruments;

- Observing and measuring physical phenomena;

- Performing statistical analysis of the data with understanding of statistical and systematic errors;

- Documenting experimental procedures;

- Reaching conclusions and publishing experimental results;

- Presenting your results in public.

537 **APPPHYS 537 / EECS 537.****Classical Optics.**

(3,3;3,3) : May not be repeated for credit.

(Excl). (BS).

EECS 330 or 334. CAEN lab access fee required for non-Engineering students.

A theory of electromagnetic, physical, and geometrical optics. Classical theory of dispersion. Linear response, Kramers-Kronig relations, and pulse propagation. Light scattering. Geometrical optics and propagation in inhomogeneous media. Dielectric waveguides. Interferometry and theory of coherence. Diffraction, Fresnel and Fraunhofer. Gaussian beams and ABCD law.

546 **APPPHYS 546 / EECS 546.****Ultrafast Optics.**

(3,3;3,3) : May not be repeated for credit.

(Excl). (BS).

APPPHYS 537. CAEN lab access fee required for non-Engineering students.

Propagation of ultrashort optical pulses in linear and nonlinear media, and through dispersive optical elements. Laser mode-locking and ultrashort pulse generation. Chirped-pulse amplification. Experimental techniques for high time resolution. Ultrafast optoelectronics. Survey of ultrafast high field interactions.

550 **APPPHYS 550 / PHYSICS 650 / EECS 538.****Optical Waves in Crystals.**

(3,3) : May not be repeated for credit.

(Excl). (BS).

EECS 434. Graduate Standing. CAEN lab access fee required for non-Engineering students.

Propagation of laser beams: Gaussian wave optics and the ABCD law. Manipulation of light by electrical, acoustical waves; crystal properties and the dielectric tensor; electro-optic, acousto-optic effects and devices. Introduction to nonlinear optics; harmonic generation, optical rectification, four-wave mixing, self-focusing, and self-phase modulation.

- 551 **APPPHYS 551 / PHYSICS 651 / EECS 539.**
Lasers.
 (3,3) : May not be repeated for credit.
 (Excl). (BS).
EECS 537 or 538. Graduate Standing. CAEN lab access fee required for non-Engineering students.
 Complete study of laser operation: the atom-field interaction; homogeneous and inhomogeneous broadening mechanisms; atomic rate equations; gain and saturation; laser oscillation; laser resonators, modes, and cavity equations; cavity modes; laser dynamics, Q-switching and mode-locking. Special topics such as femto-seconds lasers and ultrahigh power lasers.
- 552 **APPPHYS 552 / EECS 552.**
Fiber Optical Communications.
 (3,3;3,3) : May not be repeated for credit.
 (Excl). (BS).
EECS 434 or 538. CAEN lab access fee required for non-Engineering students.
 Principles of fiber optical communications and networks. Point-to-point systems and shared medium networks. Fiber propagation including attenuation, dispersion and nonlinearities. Topics covered include erbium-doped amplifiers, Bragg and long period gratings, fiber transmission based on solitons and non-return-to-zero, and time- and wavelength-division-multiplexed networks.
- 601 **APPPHYS 601 / PHYSICS 540.**
Advanced Condensed Matter.
 (3,3) : May not be repeated for credit.
 (Excl). (BS).
Graduate standing.
 A unified description of equilibrium condensed matter theory (using Green's functions); critical phenomena, Anderson localization and correlated electron theory.
- 611 **APPPHYS 611 / PHYSICS 611 / EECS 634.**
Nonlinear Optics.
 (3,3) : May not be repeated for credit.
 (Excl).
EECS 537 or 538 or 530. Graduate standing. CAEN lab access fee required for non-Engineering students.
 Formalism of wave propagation in nonlinear media; susceptibility tensor; second harmonic generation and three-wave mixing; phase matching; third order nonlinearities and four-wave mixing processes; stimulated Raman and Brillouin scattering. Special topics: nonlinear optics in fibers, including solitons and self-phase modulation.
- 619 **APPPHYS 619 / PHYSICS 619.**
Advanced Solid State Physics.
 (3,3) : May not be repeated for credit.
 (Excl).
Graduate standing.
 After a review of semiconductor physics, the course will focus on quantum transport in semiconductor heterostructures. Topics such as electronic structure of III-V semiconductors, heterojunctions and band gap engineering, quantum wells, superlattices, resonant tunneling structures, two-dimensional electron gas, quantum point contacts, quantum dots and other mesoscopic structures, ballistic transport, coherent transport, and integer and fractional quantum Hall effects will be covered.
- 644 **APPPHYS 644 / PHYSICS 644.**
Advanced Atomic Physics.
 (3,3) : May not be repeated for credit.
 (Excl).
Graduate standing.
 Laser atom interactions: Absorption, emission, and saturation, theory of line width, multiphoton absorption, stimulated and spontaneous Raman scattering; single photon, multiphoton and above-threshold ionization; Rydberg physics; AC stark shifts and ponderomotive effects; multichannel quantum defect theory; Floquet theory; Mechanical effects of light on atoms (atom traps, molasses), atom interferometry.

- 715 **APPPHYS 715.**
Independent Research.
(1-5,1-5) : May not be repeated for credit.
(Excl). (INDEPENDENT).
Permission of Program Director. Graduate Standing.
Intended for individualized student research under faculty supervision. Must be arranged with the faculty member and approved by the program.
- 990 **APPPHYS 990.**
Dissertation/Precandidate.
(1-8,1-4) : May be repeated for credit.
(Excl). (INDEPENDENT).
Election for dissertation work by doctoral student not yet admitted as a Candidate. Graduate Standing. This course has a grading basis of "S" or "U."
Election for dissertation work by doctoral student not yet admitted as a Candidate.
- 995 **APPPHYS 995.**
Dissertation/Candidate.
(8,4) : May be repeated for credit.
(Excl). (INDEPENDENT).
Graduate School authorization for admission as a doctoral Candidate (Prerequisites enforced at registration). This course has a grading basis of "S" or "U."
Graduate School authorization for admission as a doctoral Candidate. N.B. The defense of the dissertation (the final oral examination) must be held under a full term Candidacy enrollment period.