Department of Physics

(Division of Science)

Professor Marilyn Gunner, Chair • Department Office: MR 419 • Tel: 212-650-6832

General Information
The City College offers the following undergraduate degree in Physics:

B.S.

Programs and Objectives
The Department of Physics provides a comprehensive program designed to enable students to acquire a basic understanding of the laws of nature and their application, and to prepare them for a career either in physics or in one of the many science and technology oriented professions for which physics is a basic component. The various introductory courses are therefore designed to meet a variety of student needs, including general knowledge, preparation for professional work (engineering, materials science, photonics, premedical, biomedical physics, architecture, teaching, etc.) and preparation for advanced work in physics. A sequence of advanced courses is provided primarily for Physics majors but is also open to other interested students. The aim of these courses is to train students for technical employment in industry or government and for graduate work.

In addition to the Standard Physics Concentration the Department offers an Applied Physics Concentration, a Secondary Education Concentration and a Biomedical Physics Concentration. The Applied Physics Concentration has two tracks: Materials Science or Optics/Photonics.

The Department cooperates in the Program in Premedical Studies (PPS), a program of the Division of the College of Liberal Arts and Science. This allows the student to major in Physics while participating in PPS. The program features a curriculum which integrates a variety of learning experiences specifically preparing participants to meet medical, dental and veterinary school admission requirements as well as those for physician’s assistant and physical therapy advanced degree programs.

Honors
The Research Honors Program is one of several ways for undergraduate students to participate in faculty research projects. Such projects, if judged to be of sufficient quality and quantity, may lead to a degree with honors.

Research
The large active research faculty provides undergraduate research opportunities in many fields of experimental and theoretical physics. Modern laboratories provide excellent training facilities in the areas of laser physics, low temperature physics, biophysics and semiconductor physics. Students can also participate in theoretical physics research, primarily in the areas of condensed matter physics and high energy. Academic credit can be earned for participation in such research projects.

Graduate Courses
Physics majors in their senior year are able to enroll in beginning graduate courses.

Exemption Credit
Qualified students may take exemption examinations for all courses offered by the Department upon application to the Department. Exemption examinations are given at several specified times during the year. In general, a grade of B+ or better is required for exemption with credit and a grade of B- or better for exemption without credit. For some courses, it will be necessary to complete the laboratory component before full credit is given.

Tutoring
Each faculty member designates two office hours per week when she or he will be available to tutor students. In addition, all faculty members teaching multiple section introductory or intermediate courses are available for tutoring of students in all sections of the particular course(s) they are teaching. Detailed tutoring schedules are distributed early in each semester. For the introductory courses there is also a tutoring lab, open about 10 hours per week, staffed by qualified graduate and undergraduate students, where a student in these courses may seek assistance.

Department Activities
Colloquia and Seminars
The Physics Department holds a weekly colloquium in a field of general or current interest in physics, usually given by a distinguished outside speak-er. All Physics graduate students and Physics majors are invited to attend. In addition there are weekly seminars of a more specialized nature in such areas as high-energy physics, condensed matter physics and biophysics and frequent seminars in such areas as astrophysics and light scattering.

Planetarium
The Physics Department maintains a fully equipped planetarium. Programs and shows on an appropriate level are given for elementary schools, junior and senior high schools and the college community as well as other groups upon request. Programs and shows are available both in English and in Spanish.

Job Placement
The Physics Department maintains an up-to-date file of employment opportunities at all levels.

Awards
The Physics Department annually awards one or more Ward medals and the Sidney Millman Scholarship Award for academic excellence, and a Sonkin medal for the best achievement in experimental physics. Physics students may also compete, along with other students for the Hamermesh Scholarship, the Soodak Scholarship, and the Zemansky Introductory Physics Prizes.

Advisement

Undergraduate Majors
Professor Jiufeng Tu
MR 330A, 212-650-5558

Graduate Students
Professor Timothy Boyer
MR 331; 212-650-5585

All other students
Contact the Physics Office (MR 419; 212-650-6832), to be put in touch with an appropriate advisor.

Requirements for Majors
A GPA of 2.0 or higher in the major is required for graduation. The GPA in the major is calculated from courses in the major based in the major department only, and that have been taken at City College or through ePermit, including all courses in excess of the minimum required for the degree.

All Physics majors must complete "Basic Courses for Physics Majors" and either the "Standard Physics Concentration" or one of the "Alternative Concentrations." These courses are in addition to the Science core curriculum requirements:

Basic Courses for Physics Majors

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>PHYS 33500: Electricity and Magnetism 1</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 37100: Advanced Physics Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>PHYS 45100: Thermodynamics and Statistical Physics</td>
<td>3</td>
</tr>
<tr>
<td>Total Credits for Basic Courses</td>
<td>8</td>
</tr>
</tbody>
</table>

Standard Physics Concentration

Required Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 35100: Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 35400: Electricity and Magnetism II</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 45200: Optics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 47100: Advanced Physics Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>PHYS 55100: Quantum Physics I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 55200: Quantum Physics II</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 55600: Current Topics in Physics</td>
<td>1</td>
</tr>
<tr>
<td>Physics Elective: Physics 31500, PHYS 42200, PHYS 45300, PHYS 45400, PHYS 55400</td>
<td></td>
</tr>
<tr>
<td>MATH 39100: Methods of Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 39200: Linear Algebra and Vector Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Total Credits for Standard Physics Concentration</td>
<td>38</td>
</tr>
</tbody>
</table>

Alternative Physics Concentration - (Materials Science and Optics/Photonics Concentrations)

Required Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 32300: Quantum Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 35100: Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 35400: Electricity and Magnetism II</td>
<td>3</td>
</tr>
<tr>
<td>Applied Physics Electives:</td>
<td>15</td>
</tr>
</tbody>
</table>
Materials Science concentration requires PHYS 554000, PHYS 55500 and PHYS 56100. Additional electives may be selected from PHYS 42200, CHEM 26100, CHE 46700 and EE 44100.

Optics/Photonics concentration requires PHYS 45200, PHYS 47100, PHYS 45300 and PHYS 58000. Additional electives may be selected from PHYS 55400 and PHYS 58100.

Mathematics:
- 39100: Methods of Differential Equations 3
- 39200: Linear Algebra and Vector Analysis 3

Total Credits for Applied Physics Concentration: 39

Biomedical Physics Concentration

Required Courses
- PHYS 42200: Biophysics 3
- PHYS 52200: Biomedical Physics 3

One of the following:
- PHYS 32300: Quantum Mechanics (3 cr.)
- PHYS 55100: Quantum Physics I (4 cr.)

MATH 39100: Methods of Differential Equations 3
MATH 39200: Linear Algebra and Vector Analysis 3
CHEM 45900: Biochemistry I 4

Total Credits for Biomedical Physics Concentration: 27-28

Secondary Education Concentration

Major requirements are listed below. Pedagogical requirements are listed in the Department of Education section of this Bulletin.

Required Courses
- PHYS 35100: Mechanics 4
- PHYS 35300: Electricity and Magnetism I 3
- PHYS 35400: Electricity and Magnetism II 3
- PHYS 37100: Advanced Physics Lab I 2
- PHYS 45100: Thermodynamics and Statistical Physics 3
- PHYS 45200: Optics 3
- PHYS 32100: Modern Physics 3

Electives to be chosen in consultation with the advisor 6

Total Credits for Secondary Ed. Concentration: 27

Elective Courses

Students who intend to go on to graduate work in Physics should choose, in consultation with the departmental advisor, free electives from among the following:
- PHYS 31500: Medical Physics (3 cr.)
- PHYS 42200: Biophysics (3 cr.)
- PHYS 45300: Physical Photonics I (Laser Optics) (3 cr.)
- PHYS 45400: Descriptive Astronomy (3 cr.)
- PHYS 52200: Biomedical Physics (3 cr.)
- PHYS 55400: Solid State Physics (3 cr.)
- PHYS 55500: The Physics and Chemistry of Materials (3 cr.)

Any graduate course with designation V0100-V2600 Selected 30000, or 40000 level courses

Additional Requirements

Students who intend to go on to complete some graduate work during the undergraduate years should see the concentration advisor (Prof. J. J. Tu or Prof. N. P. Chang) concerning possible substitutions for some of the above courses.

Note: all the non-introductory courses in physics required for Physics majors are given only once a year. For a student who has completed the required introductory courses (Physics 20700, 20800, Phys 21000, 20200, 20300) the following sequence is therefore recommended for the remaining courses:

<table>
<thead>
<tr>
<th>Physics</th>
<th>Math</th>
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<tbody>
<tr>
<td>Spring PHYS 32100</td>
<td>MATH 39100</td>
</tr>
<tr>
<td>Fall PHYS 35100, PHYS 35300, PHYS 37100</td>
<td>MATH 39200</td>
</tr>
<tr>
<td>Spring PHYS 35400, PHYS 47100, PHYS 55100</td>
<td></td>
</tr>
<tr>
<td>Spring PHYS 45200, PHYS 55200, PHYS 55600</td>
<td></td>
</tr>
<tr>
<td>Spring PHYS 45100, elective</td>
<td></td>
</tr>
</tbody>
</table>

Students who enter this sequence during their sophomore year may thus be free to take physics (or math) electives or graduate courses in their senior year. The latter is especially recommended by the Department. Students who cannot readily fit into this sequence should consult the concentration advisor. All students intending to major in Physics should see the specialization advisor before entering their junior year. Students who do not intend to do graduate work should see Professors Tu or Chang for an individualized program.

General Education Requirements ("PATHWAYS")

In general, students are required to complete 42 credits of General Education coursework, with some adjustments for transfer students. See the General Education Requirements (Pathways) section of the Bulletin for more information. Physics students will satisfy their "Pathways" requirements most efficiently by following these recommendations:

Fixed Core
- English Composition I: FIQWS
- English Composition II: ENGL 21003
- Mathematical and Quantitative Reasoning: MATH 21000
- Life and Physical Sciences: PHYS 20700

Flexible Core
- World Cultures and Global Issues: any of CLAS offerings in this category
- Individual and Society: any of CLAS offerings in this category
- U.S. Experience in its Diversity: any of CLAS offerings in this category
- Creative Expression: any of CLAS offerings in this category
- Scientific World: PHYS 20800

Additional course in Scientific World: CHEM 10401 or EAS 10600

College Option
- Speech 11100, 00380 or Proficiency Examination
- Foreign language – two semesters of college-level study, or exemption on the basis of two years of high-school level study, or demonstrated proficiency
- Philosophy - any of CLAS offerings in this category

Requirements for a Minor in Physics

Students in other departments may minor in physics by taking a minimum of 9 credits in Physics beyond the introductory courses (PHYS 20700, PHYS 20800 or PHYS 20300, PHYS 20400). See an advisor in the Physics Department for guidance.

Physics Course Descriptions

Core Physics Courses
- All courses except ASTR 10000 and ASTR 30500 carry a Physics (PHYS) designation, starting with PHYS 10000.

ASTR 10000: Ideas of Astronomy
- Explores the entire realm of the universe, its origins and history, and establishes our time and place and role in it. Our solar system, our galaxy, the expanding universe of many galaxies will be discussed along with more recent discoveries such as quasars, pulsars and black holes. 3 lect., 1 rec. hr./wk., slides, films, planetarium shows; 3 cr.

PHYS 1000: Ideas of Physics
- A course with two themes: 1. How nature works the interplay of space, time, matter and energy. 2. Structures are born, live out their life cycles, and die. These include us, the stars, and perhaps the universe. This theme may be called the scientific story of genesis. 3 lect., 1 rec. hr./wk., demonstrations, slides, films; 3 cr.

ASTR 30500: Methods in Astronomy
- Designed to fulfill the 30000-level core science requirement, the course covers the fundamental physical laws that underlie the motions of heavenly bodies, including Newtonian mechanics and Einstein’s theory of relativity, planetary, stellar and galactic evolution; the methods, techniques and instruments used by modern astronomy, including the Hubble Space Telescope and planetary space probes. 3 lect., 1 rec. hr./wk., slides, films, planetarium shows, field trips; 3 cr.

Introductory Physics Courses

PHYS 20300-20400: General Physics
- For majors in the life sciences (biology, medicine, dentistry, psychology, physical therapy) and for liberal arts students. Fundamental ideas and laws of physics from mechanics to modern physics. Included are Newton’s laws of motion, electricity and magnetism, heat, optics, relativity, quantum mechanics and nuclear physics. Emphasis is on the basic principles and general laws. Use of mathematics is restricted to elementary algebra and some trigonometry. Students registering for PHYS 20300 or 20400 must also register for and take the Physics 20301 or 20401 Lab during the same semester. PHYS 20300 is prereq., for PHYS 20400 (required for Premed., Predent., Bio-Med., and all Life Science students). Prereq.: MATH 19000. 3 lect., 1 rec., 3 lab., hr., alt. wks.; 4 cr./sem.

PHYS 20305-20405: Laboratory Sections for 20300 and 20400
- Department permission required for registration, which is limited to students having passed lecture part via exemption exam or via equivalent course elsewhere. Not open to students who have previously taken or are planning to register for PHYS 20300 or PHYS 20400. 3 lab. hr. alt. wks.; 1 cr./sem.
PHYS 20700-20800: General Physics
Vectors, equilibrium, rectilinear motion. Newton's laws, gravitation, motion in a plane, work and energy, impulse and momentum, rotation and angular momentum, simple harmonic motion, fluids, heat and thermodynamics, waves and acoustics, electrostatics, magnetism and electromagnetism, direct and alternating current, geometrical and physical optics. Pre- or coreq.: MATH 20200 for PHYS 20700. PHYS 20700 is preq. for PHYS 20800. MATH 20300 is pre- or coreq. for PHYS 20800. (Required for all students in the Physical Sciences, Engineering and Computer Science.) 3 lect., 2 rec. hr./wk., 2 lab/wrkshp hrs. (PHYS 20700), 2 lab. hrs. alt. wks. (PHYS 20800); 4 cr./sem.

PHYS 21900: Physics for Architecture Students
A one-semester course for students of Architecture. Translational and rotational equilibrium. Newton's laws of motion and vibrations. Work, energy and power. Fluids and temperature. Heat and energy transfer. Prereq.: completion of all mathematics requirements through trigonometry or be eligible for MATH 20500. 3 lect., 2 rec. hr./wk.; 4 cr.

PHYS 30000: Elementary Physics
For students in the School of Education. Survey of physics emphasizing the meanings of physical laws, concepts of motion and energy, and physical properties of matter. Topics include concepts of velocity and acceleration; Newton's laws of motion, mass and weight, circular motion, gravitation, work, energy, momentum, electromagnetic properties of matter, and atomic theory (required for students in Elementary Education). 3 lect., 2 lab. or discussion hr./wk.; 3 cr.

PHYS 32100: Modern Physics for Engineers
Introduces historical background, elementary quantum theory, application to one-electron atoms, atomic shell structure and periodic table; nuclear physics, relativity and statistical mechanics. Concepts, quantitative work and problem sets are emphasized. Prereq.: PHYS 20800 or equivalent, MATH 20300 or MATH 20900 (elective for Engineering students). 3 lect. hr./wk.; 3 cr.

PHYS 32300: Quantum Mechanics for Engineers
Basic experiments, wave-particle duality, uncertainty. Wave functions and Schrödinger equation. 1-d problems, bound states, square well, harmonic oscillator, scattering from barriers, tunneling. QM formalism, Dirac notation, operators & eigenvalues, angular momentum. Hydrogen atom. Perturbation theory first order nondegenerate, level splitting. Time-dependent PT, Golden rule, spin. Quantum communication, Bell's theorem. Prereq.: PHYS 20700 and PHYS 20800, MATH 39100 and MATH 39200. 3 hr./wk.; 3 cr.

PHYS 33100: Intelligent Life in the Universe
Problems concerning the existence of and contact with other intelligent life forms. The physical conditions necessary for development and evolution of such forms. The physical limitations on contact with them. 4 hr./wk.; 4 cr.

PHYS 33200: Physics of Science Fiction
The physical basis for the many imaginative and speculative schemes encountered in science fiction: anti-matter, space warps, black holes, anti-gravity, time travel, multi-dimensional universes, parallel universes, quarks, robots, flying saucers, Star Trek, etc. Every lecture is accompanied by a color slide show. No prereq. 3 hr./wk.; 3 cr.

Advanced Physics Courses
PHYS 35100: Mechanics
Newton's laws; Systems of particles; Small oscillations; Central forces and planetary motion; Rotations and rotating coordinate system; Introduction to rigid body motion; Lagrangian dynamics; Introduction to Hamiltonian dynamics. Prereq.: PHYS 20800; pre- or coreq.: MATH 39100 (required for Physics majors). 4 hr./wk.; 4 cr.

PHYS 35300: Electricity and Magnetism I
Review of vector calculus; Electrostatics in vacuum, work & energy, conductors; Laplace's equation and its solution; Electric fields in matter, currents, circuits and dielectrics; magnetostatics, vector potential. Prereq.: PHYS 20800; pre- or coreq.: MATH 39100 and PHYS 35100 or equivalent (required for Physics majors). 3 hr./wk.; 3 cr.

PHYS 35400: Electricity and Magnetism II
Magnetic fields in matter; Electrodynamics, induction, Maxwell's equations; Electromagnetic waves in vacuum and in matter; Guided waves – transmission lines and waveguides; Electromagnetic potentials and radiation; Special relativity. Prereq.: PHYS 35300; pre- or coreq.: MATH 39100 and MATH 39200 (required for Physics majors, except those in the Biomedical Option). 3 hr./wk.; 3 cr.

PHYS 37100: Advanced Physics Laboratory I
Experiments in electricity, magnetism and electronics. Prereq.: PHYS 20800; coreq.: PHYS 35300 (required for Physics majors). 3 lab., 1 conf. hr./wk.; 2 cr.

PHYS 42200: Biophysics
Introduction to the structure, properties, and function of proteins, nucleic acids, lipids and membranes. In depth study of the physical basis of selected systems including vision, nerve transmission, photosynthesis, enzyme mechanism, and cellular diffusion. Introduction to spectroscopic methods for monitoring reactions and determining structure including light absorption or scattering, fluorescence, NMR and X-ray diffraction. The course emphasizes reading and interpretation of the original literature. Prereq.: 1 yr. of Math, 1 yr. of Physics (elective for Physics Majors and Biomedical Engineering students). 3 hr./wk.; 3 cr.

PHYS 45100: Thermodynamics and Statistical Physics
Temperature; equations of state; work, heat and the First Law; irreversibility, entropy and the Second Law; introduction to kinetic theory and statistical mechanics; low-temperature physics; the Third Law. Prereq.: PHYS 35100 and PHYS 35300; coreq.: MATH 39100 (required for all Physics majors). 3 hr./wk.; 3 cr.

PHYS 45200: Optics
Dispersion, reflection and refraction, interference, diffraction, coherence, geometrical optics, interaction of light with matter. Prereq.: PHYS 35400, or similar engineering courses; pre- or coreq.: MATH 39200 (required for all Physics majors, except those in the Biomedical Option). 3 hr./wk.; 3 cr.

PHYS 45300: Physical Photonics I/Laser Optics
Theory and applications of lasers and masers. Physical principles underlying the design of lasers, coherent optics, and non-linear optics. Pre- or coreq.: a course in modern physics (PHYS 55100 or PHYS 32100), a course in electricity and magnetism (PHYS 35400 or EE 33200), Optics (PHYS 45200) is desirable but not required (elective for Physics and Engineering majors). 3 hr./wk.; 3 cr.

PHYS 45400: Descriptive Astronomy
Astronomy for science majors. Stellar astronomy, galactic astronomy, cosmology, and earth and planetary science. Recent discoveries and topics such as pulsars, black holes, radio astronomy, interstellar medium, radio galaxies, quasars, spiral density waves in disc galaxies, black body radiation, intelligent life beyond the earth. Lectures are supplemented by observations and planetarium shows. Prereq.: PHYS 20800 (elective for Physics majors). 3 hr./wk.; 3 cr.

PHYS 47100: Advanced Physics Laboratory II
Experiments in optics, quantum physics and atomic physics. Prereq.: PHYS 35400; pre or coreq.: PHYS 55100 (required for Physics majors). 3 lab., 1 conf. hr./wk.; 2 cr.

PHYS 52200: Biomedical Physics
Methods used in the study of biophysics and biomedical physics. Study of the physical basis of spectroscopic methods including light absorption or scattering, fluorescence, NMR and X-ray diffraction for the study of biomolecules. Biomedical imaging including sonogram, MRI, and tomography will be discussed. Prereq.: PHYS 42200 or the consent of the instructor. 3 hr./wk.; 3 cr.

PHYS 55100: Quantum Physics I
Introductory material: 2-slit experiment, matter waves and addition of amplitudes – superposition principle; Uncertainty principle, properties of matter waves: Boundary conditions and energy level quantization and Schrödinger interpretation – wave equation, application to one dimensional problems, barrier penetration, Bloch states in solids and how bands form in solids; The universality of the Harmonic potential – Simple Harmonic oscillator and applications, One electron atoms, spin, transition rates; Identical particles and quantum statistics; Beyond the Schrödinger equation: Variational methods and WKB. Prereq.: MATH 39100 and MATH 39200. Pre- or coreq.: PHYS 35100, PHYS 35400 (required for Physics majors). 4 hr./wk.; 4 cr.

PHYS 55200: Quantum Physics II
Review of Schrödinger equation, Uncertainty principle. Formalism: Observables, Operators etc.; Application to simple case: 2 level systems, electron in a magnetic field; Angular momentum – Bohr model revisited; Magnetic properties of solids; Time independent perturbation theory and applications; Time dependent perturbation theory: Lasers, Masers etc.; Adiabatic processes: Berry's phase, when does phase matter? Quantum entanglement, Bell's theorem and recent experiments. Prereq.: PHYS 55100 or equivalent MATH 39100, and MATH 39200 (required for Physics majors). 4 hr./wk.; 4 cr.

PHYS 55400: Solid State Physics
(Same as PHYS U4500) Crystal structure and symmetry; crystal diffraction; crystal binding; phonons and lattice vibrations; thermal properties of insula-
acousto-optic devices. Prereq.: PHYS 45300. 3 hr./wk.; 3 cr.

PHYS 55500: The Physics and Chemistry of Materials
(Same as PHYS U6400) Examples, characteristic properties, and applications of important classes of materials (semiconductors, ceramics, metals, polymers, dielectrics and ferroelectrics, super-conductors, magnetic materials); surfaces and interfaces of solids; selected topics in the synthesis, processing and characterization of materials. Prereq.: PHYS 55400 or equivalent, e.g. EE 45400 (required of Physics majors in the Applied Physics/Material Science Concentration, and elective for other Physics majors and for Engineering majors). 3 hr./wk.; 3 cr.

PHYS 55600: Current Topics in Physics
A seminar course on current topics in experimental and theoretical physics, with oral reports by students and faculty (required for Physics majors). 1 hr./wk.; 1 cr.

PHYS 56100: Materials Science Laboratory
Introduction to some of the basic methods for sample preparation and characterization relevant to materials science. Topics include synthesis of semiconductor thin films and high temperature superconductors, contact preparation, measurements of transport properties as a function of temperature, Raman spectroscopy, electron spin resonance (ESR), X-ray diffraction, absorption measurements in UV-visible range. Prereq.: PHYS 32300; coreq.: PHYS 55400 or permission of the instructor. 4 lect. hr./wk. for the first three wks., then 7 lab. hr./wk.; 4 cr.

PHYS 58000: Physical Photonics II

PHYS 58100: Physical Photonics III/Wave Transmission Optics

Honors and Special Physic Courses

PHYS 30100-30300 (Honors I-III): Research Honors Program
The Research Honors Program is one of several ways for undergraduate students to participate in faculty research projects. Such projects, if judged to be of sufficient quality and quantity, may lead to a degree with Research Honors. A written report by the student is required every semester. Students preparing a portion of their work is required at the Honors and Independent Study symposium in the spring of their senior year. In order to graduate "with Research Honors", the student must maintain a "B" average or better in the major subject, submit an Honors paper which is a report in research publication format, and be given a minimum of 6 credits of "A" for this work by the mentor. The student's Research Mentor will provide a written report certifying that the student has fulfilled the criteria established for graduating with Research Honors. Prereq.: Approval of Dean and Department Honors Supervisor is required and should be obtained in the semester prior to the one in which the work will be performed. A "B" average or better in major courses is required in order to take Honors (or Independent Studies) courses. TBA hr./wk.; variable credit, usually 3 cr./sem. A maximum of 12 credits of honors courses count toward the degree.

PHYS 31000: Independent Study
The student will participate in a program of independent study under the direction of a member of the Department with the written approval of the faculty sponsor and the Department Chair. Credit may be from 1-4 credits, as determined in the semester before registration by the instructor with the approval of the Department Chair. Students must have completed at least nine credits with a GPA of 2.5 or higher. A maximum of nine credits of independent study may be credited toward the degree. Independent study is to be used to meet special student needs that are not covered in regular course offerings.

PHYS 31100-32000: Selected Topics in Physics
Courses on contemporary topics to be offered according to the interest of faculty members and students. Consult Department for courses to be offered each academic year. 3 hr./wk.; 3 cr.

Graduate Courses Open to Undergraduates
Qualified students may take, with Departmental approval, any course available in the Master's Program in Physics or the first year of the Doctoral Programs in Physics. These courses are described in their appropriate catalogs.

Faculty

Robert R. Alfano, Distinguished Professor
B.S., Fairleigh Dickinson Univ., M.S.; Ph.D., New York Univ.

Joseph L. Birman, Distinguished Professor
B.S., The City College; M.S., Columbia Univ., Ph.D.; Doc-es-Sciences

Timothy Boyer, Professor
B.A., Yale Univ.; M.A., Harvard Univ., Ph.D.

Ngee-Pong Chang, Professor
B.S., Ohio Wesleyan Univ.; Ph.D., Columbia Univ.

Corey Dean, Assistant Professor
B.Sc., M.Sc., Queens University, Canada; McGill University, Canada, Ph.D.

Harold Falk, Professor
B.S., Iowa State Univ.; Ph.D., Univ. of Washington

Swapan K. Gayen, Professor
B.Sc.(Honors), Univ. of Dacca, M.Sc.; M.S., Univ. of Connecticut, Ph.D.

Joel Gersten, Professor
B.S., The City College; M.A., Columbia Univ., Ph.D.

Daniel M. Greenberger, Professor
B.S., M.I.T.; M.S., Univ. of Illinois, Ph.D.

Marilyn Gunner, Professor and Chair
B.A., SUNY (Binghamton); Ph.D., Univ. of Pennsylvania

Michio Kaku, Semat Professor
B.A., Harvard Univ.; Ph.D., Univ. of California (Berkeley)

Ronald Koder, Associate Professor
B.S., Univ. of Missouri-Columbia; Ph.D., Johns Hopkins Univ.

Joel Kopolik, Professor
B.S., Cooper Union; Ph.D., Univ. of California (Berkeley)

Lia Krusin-Elbaum, Professor
B.S., University of Warsaw; Ph.D., New York University

Michael S. Lubell, Professor
A.B., Columbia Univ.; M.S., Yale Univ., Ph.D.

Hernan Makse, Professor
Licenciatura (Physics), Univ. of Buenos Aires; Ph.D., Boston Univ.

Carlos Andres Meriles, Professor
B.S., FaMAF,Universidad Nacional de Cordoba,Argentina, Ph.D.

V. Parameswaran Nair, Distinguished Professor
B.S., Univ. of Kerala; M.Sc., Syracuse Univ., Ph.D.

Vladimir Petričević, Professor
Dipl. EE., Univ. of Belgrade; M.S. Miami Univ.; Ph.D., CUNY

Alexios P. Polychronakos, Professor
Dipl. EE., National Technicalological Univ. of Athens; M.Sc., California Institute of Technology, Ph.D.

Myriam P. Sarachik, Distinguished Professor
A.B., Barnard College; M.S., Yale Univ., Ph.D.

Myra Stavel, Professor
B.S., Hebrew Univ.; M.Sc., Technion, D.Sc.

Mark Shattuck, Professor
B.A., Wake Forest Univ.; M.S.; Ph.D., Duke Univ.

Frederick W. Smith, Professor
B.A., Lehigh Univ.; Ph.D., Brown Univ.

Brian C. Tiburzi, Assistant Professor
B.A. Amherst College; M.S., University of Washington, Ph.D.
Jiufeng J. Tu, Associate Professor
A.B., Harvard Univ.; A.M.; M.S., Cornell Univ., Ph.D.
Sergey A. Vitkalov, Professor
M.S., Moscow Institute of Physics and Technology
Ph.D., Institute of Solid State Physics, Russian Academy of Sciences

Participating Faculty
Morton M. Denn, Albert Einstein Professor
B.S.E. (Ch.E.), Princeton Univ.; Ph.D., Univ. of Minnesota
Richard N. Steinberg, Professor
B.S., SUNY Binghamton; M.S., Yale Univ., Ph.D.

Professors Emeriti
Adolf Abrahamson
Michael Arons
Robert Callender
Erich Erlbach
Marvin Mittleman
Martin Tiersten