Physics, Applied Physics, and Astronomy

FACULTY

**Year of initial appointment at Binghamton*

Burr, Charles R., *Bartle Professor*, PhD, 1967, University of California at Los Angeles: Properties of localized magnetic moments in metallic crystals, magnetic resonance, experimental solid state physics. (1970)*

Cotts, Eric J., *Associate Professor and Director of Graduate Studies*, PhD, 1983, University of Illinois: Structure of liquids and solids, thermal and transport properties of condensed matter, surfaces and interfaces. (1987)

Greenberg, Newton I., *Professor and Director of Undergraduate Studies,* PhD, 1961, University of Maryland: Many body problem, nuclear structure theory. (1963)

Nelson, Charles A., *Professor,* PhD, 1968, University of Maryland: Theoretical high-energy physics, quantum field theory, mathematical physics. (1973)

Pompi, Robert L., *Associate Professor and Chair*, PhD, 1968, Cornell University: Experimental solid state, superconducting films, tunneling phenomena. (1968)

Raboy, Sol, *Professor Emeritus*, DSc, 1950, Carnegie Institute of Technology: Experimental nuclear physics, muonic atoms, statistical correlations, nuclear structure by gamma ray spectroscopy, electro-optics. (1965)

Stannard, Carl R., Jr., *Associate Professor*, PhD, 1964, Syracuse University: Physics education and impact on the citizen, medical physics, infrared photoconductivity. (1964)

Suzuki, Masatsugu, *Professor*, PhD, 1977, Tokyo University: Experimental solid state, properties of semimetals, graphite intercalation compounds, high Tc superconductors and low-dimensional magnetic systems. (1986)

Venugopalan, Srinivasa, *Associate Professor*, PhD, 1973, Purdue University: Experimental solid state physics, Raman spectroscopy, liquid crystals. (1981)

Wagner, Peter E., *Professor,* PhD, 1956, University of California at Berkeley: Solid state physics. (1989)

Wu, Tsu-Ming, *Professor* , PhD, 1966, University of Pennsylvania: Many body problems in solid state physics and biophysics, superconductivity, magnetism. (1968)

Yeh, Noel K., *Professor*, PhD, 1966, Yale University: Properties of particles and resonances, biomedical physics, experimental high-energy physics, applied physics. (1969)

UNDERGRADUATE PROGRAMS

Students in the physics concentration receive training in most basic areas of physics and mathematics. The concentration provides a firm foundation in the principles of physics of contemporary interest. The student with such training is prepared to go on to graduate school for additional specialization in physics, engineering or other applied science fields or professions. The undergraduate degree in physics provides an adequate basis for teaching of physics in high schools and research and development work in industry.

Although it is preferable for the potential physics major to start physics courses as a freshman, the structure of the physics curriculum is such that the Harpur College student is able to satisfy the requirements for the BA degree in physics in two years of study following the completion of General Physics and a year of calculus. If the student wishes to complete the requirements for the BS degree, an earlier start than the sophomore year is highly advisable.

The department offers a 3-2 combined physics-engineering program in which students spend three years at Harpur College and two years at an engineering school. Such students receive the BA in physics and the bachelor's degree in engineering after five years from either the Watson School of Engineering and Applied Science or a school outside of Binghamton University.

In cooperation with the Computer Science Department of the Watson School, the department has also established a five-year program leading to the BS in physics and the BS in computer science.

Students not planning to specialize in physics may find some physics courses to be of interest. Among these are the astronomy courses, Physics of Sound, Physics and the Automobile, and Medical Physics, all of which are intended for the nonspecialist, and satisfy the all-college science requirement. General Physics, Sophomore Laboratory, Electronics and various other courses are intended both for the specialist and nonspecialist.

All courses taken to satisfy the requirements for the major in physics may not be taken with the Pass/Fail option when letter grades are available for the courses. Credit by examination is not granted for courses taught by the department apart from the Advanced Placement procedure.

The student will be expected to develop computer skills and apply such skills to the solving of problems encountered within the framework of courses required for the degree.

Course Prerequisites

The Physics Department views the prerequisites listed for physics courses as essential. If a student does not have the prerequisites, or the equivalent, a course may be taken only after successful petition to the departmental undergraduate committee.

BA Degree Program

Students planning to major in physics with a BA degree should take PHYS 121 and 122 (or 131 and 132) and should complete MATH 221, 222 and 323 as quickly as possible. Mathematics should be continued at least through Mathematical Methods in Science I and II (MATH 371-471). In addition, a major in physics normally requires PHYS 227, 323, 327, 331, 332, 341 and 421 (a total of nine full courses in physics). If the student does not possess knowledge of a computer programming language, a course or half course in computer programming should be taken during their first two years. The Watson School has several offerings, such as WTSN 204, that would generate the appropriate level of knowledge required to complete the projects assigned in upper-level physics courses. Prospective physics majors should discuss their programs with a member of the department at their earliest convenience.

Four of the six required 300- and 400- level PHYS courses must be taken in residence at Binghamton University.

BS Degree Programs

The department also offers a bachelor of science degree in physics for those students who want recognition of increased concentration in physics. The BS degree in physics requires PHYS 121 and 122 (or 131 and 132), 227, 323, 327, 331, 332, 341, 411, 421, 422, 427 and 428 (a total of 12 full courses in physics); MATH 221, 222, 323, 371 and 471; and CHEM 111 (or 107 and 108). If the student does not possess knowledge of a computer programming language, a course or half course in computer programming should be taken during their first two years. The Watson School has several offerings, such as WTSN 204, that would generate the appropriate level of knowledge required to complete the projects assigned in upper-level physics courses.

The following is a typical sequence of courses for students who major in physics beginning in their freshman year, with suggested electives shown in brackets.

Six of the nine required 300- and 400- level PHYS courses must be taken in residence at Binghamton University.

	Fall	**Spring**
Freshman	PHYS 131** or 121 MATH 221 ***	PHYS 132** or 122 MATH 222 ***
Sophomore	PHYS 227 PHYS 323 MATH 323	PHYS 331 MATH 371
Junior	PHYS 332 MATH 471 CHEM 111	PHYS 327 PHYS 341 (PHYS 407)
Senior	PHYS 411* PHYS 421 (PHYS 463) (PHYS 474)	PHYS 422* PHYS 427-8* (PHYS 465) (PHYS 470 or 472)

**Required for BS, not required for BA.*
***Offered fall and spring.*
****Computer programming offered fall and spring.*

APPLIED PHYSICS OPTION

For the student planning a career in applied physics, engineering physics, geophysics, material science or other areas of engineering, the department offers the bachelor of science degree in physics with an emphasis in applied physics.

Appropriate choices from among the elective courses that can be used to complete this option will provide preparation for students intending to pursue a career in one of these applied areas. For further details and advice, the student is urged to consult the departmental undergraduate adviser. The program of study for this option represents a modification of the traditional BS in physics.

The requirements of the option are PHYS 121 and 122 (or 131 and 132), 227, 323, 327, 331, 332, 341, 411, 421 and 427; MATH 221, 222, 323, 371 and 471; CHEM 111 (or 107 and 108).

In addition to the above listed courses, 12 credits must be taken from the following list of elective courses: PHYS 407, 422, 428, 463, 465, 467, 469, 470, 472; PHYS/GEOL 450, PHYS/GEOL 451, GEOL 453; ME 311, ME 361; CHEM 444, 484A, 484C, 487.

If the student does not possess knowledge of a computer programming language, a course or half course in computer programming should be taken during their first two years. The Watson School has several offerings, such as WTSN 204, that would generate the appropriate level of knowledge required to complete the projects assigned in upper-level physics courses.

The following is a typical sequence of courses for students who major in physics under this option, beginning in their freshman year.

Six and a half of the required 10 1/2 300- and 400- level PHYS courses must be taken in residence at Binghamton University.

	Fall	Spring
Freshman	PHYS 131* or 121 MATH 221 ***	PHYS 132* or 122 MATH 222 ***
Sophomore	PHYS 323 MATH 323 PHYS 227	PHYS 331 MATH 371
Junior	MATH 471 PHYS 332 CHEM 111	PHYS 341 PHYS 327 required elective**
Senior	PHYS 421 PHYS 411 required elective**	PHYS 427 required elective**

**Offered fall and spring.*
***Select a required elective from list of elective courses.*
****Computer programming offered fall and spring.*

ENGINEERING PHYSICS OPTION

For the student wishing to pursue graduate studies in engineering, the department offers the bachelor of science degree in physics with an emphasis in engineering physics.

Appropriate choices from among the elective courses that can be used to complete this option will provide preparation for students intending to pursue a career in engineering. The program of study for this option represents a modification of the traditional BS in physics.

The requirements of the engineering physics option are identical to the applied physics option listed above, with the exception of the elective courses to be taken. For this option, three elective courses are to be selected from the following: PHYS 407; EE 302, 361; ME 351, 421 and 441. The first three courses will prepare the student for entrance into a graduate EE program. The last three are preparation for a graduate ME program.

For further details and advice, the student is urged to consult the departmental undergraduate adviser.

MATHEMATICAL PHYSICS OPTION

For students interested in pursuing graduate education or careers in mathematical physics, or other theoretically oriented fields of physical science, the department offers an option in mathematical physics that leads to the BS degree in physics. Students interested in this option should contact the undergraduate adviser in the Physics Department as soon as possible.

This option requires 18 courses as follows: PHYS 131 and 132 (or 121 and 122), 323, 331, 332, 341, 411, 421 and 422; MATH 221, 222, 304, 323, 371 (or PHYS 373), 471 (or PHYS 374), and 478; and two PHYS courses above the 400 level. One of these courses may be substituted by a MATH course numbered 375 or above, with the approval of the Physics Department undergraduate adviser.

Students in this option are encouraged to take laboratory courses in physics, as these courses may broaden their opportunities in graduate schools. If the student does not possess computer programming ability, a course or a half course in computer programming should be taken during the first two years. The Watson School's Department of Computer Science has several offerings that can generate the appropriate level of knowledge required to complete projects assigned in upper-level physics courses. Six of the nine 300- and 400- level PHYS courses required for the completion of the degree must be taken in residence at Binghamton University.

The following is a typical sequence of courses for students in the mathematical physics option, beginning in the freshman year.

	Fall	Spring
Freshman	PHYS 131 or 121 MATH 221 ***	PHYS 132 or 122 MATH 222 ***
Sophomore	PHYS 323 MATH 304 MATH 323	PHYS 331 MATH 371 or PHYS 373
Junior	PHYS 332 MATH 471 or PHYS 374	PHYS 341 **
Senior	PHYS 421 PHYS 411 MATH 478	PHYS 422 **

*** Select a required elective.*
**** Computer programming offered fall and spring.*

BA or BS Degree Starting in the Sophomore Year

Prior to the junior year, the student must have taken PHYS 121 and 122 (or 131 and 132), MATH 323 and, if possible, MATH 371. Candidates for the BS degree should have also

completed CHEM 111 (or 107 and 108), and a computer programming course or half course.

The programs for the junior and senior years are identical to those prescribed in the next section for transfer students from two-year colleges.

BA or BS Degree After the Two-Year College

The department has structured its curriculum so that the graduate of a two-year college can complete a BA or BS degree program in two additional years. It is assumed that such students have completed the equivalent of two semesters of general physics and three semesters of calculus by the time of enrollment, as well as a computer programming course. If they have not, an additional semester or two may be necessary. A general physics course with a weekly three-hour laboratory normally satisfies the equivalent of PHYS 121, 122 and 227, although the student must still complete the total required number of physics courses for the degree. If the student is working for the BS degree, it is also important that as many all-college requirements as possible be fulfilled at the two-year school.

The following is a typical sequence of courses for those students who major in physics after transferring from a two-year college.

For the BA degree:

	Fall	**Spring**
Junior	PHYS 227#	PHYS 341
	PHYS 323	PHYS 331
	MATH 371	MATH 471
Senior	PHYS 332	PHYS 327
	PHYS 421	

#Elective if general physics with weekly lab is transferred.

For the BS degree:

	Fall	**Spring**
Junior	PHYS 227#	PHYS 341
	PHYS 323	PHYS 331
	MATH 371	MATH 471
Senior	PHYS 332	PHYS 427
	PHYS 411	PHYS 428+
	PHYS 421	PHYS 422+
	PHYS 327	PHYS 407*

#Elective if general physics with weekly lab is transferred.
**Required for applied physics option.*
+Required for traditional BS.

It is advantageous for the BS candidate to be more advanced in mathematical preparation than is shown here.

The transfer student from a two-year college interested in the BS-mathematical physics program must have completed at least General Physics (PHYS 121, 122 or equivalent), and calculus through ordinary differential equations (or the equivalent of MATH 371) prior to enrollment in Harpur College. The student should also possess computer programming skills.

Honors in Physics

An upperclass student who has demonstrated superior academic ability may seek honors in physics. Honors in physics can be achieved either through research work or coursework.

Research Work: The student enrolls in PHYS 498, Physics Honors, for a full- or half-course load. With departmental approval, the student then works closely with a faculty member on a research project suggested by the faculty member, for a total of at least four credit hours. The results of this project are presented in a senior thesis defended by the student at a departmental seminar. A successful defense demonstrating a superior research competence and mastery of the subject earns the recognition "Distinguished Independent Work in Physics." Further details are available from the department.

Coursework: The student successfully completes two graduate courses: PHYS 521, Analytical Dynamics, and PHYS 522, Electrodynamics I, both with a grade of B or better. In addition, the student completes either PHYS 524, Quantum Mechanics I, with a grade of B or better, or successfully completes a "capstone" project based on a course already taken. The project is a 15- to 20-page paper prepared under a faculty member's supervision while registered for a one-credit independent study. Further details are available from the department.

A chapter of the national physics honor society, Sigma Pi Sigma, exists in the department.

The *George E. Moore Award for Academic Achievement in Physics* is given annually to an outstanding senior physics major. This award was established by colleagues and friends to honor the late George E. Moore, a professor in the department for a number of years.

3-2 Program in Physics and Engineering

The combined engineering program is an educational affiliation between Binghamton and several engineering schools. The 3-2 program

enables a student to devote three years to the study of liberal arts and sciences at Binghamton before transferring to an engineering school for two years of engineering education. This program leads to a BA in physics from Binghamton and a bachelor's degree from the engineering school. The range of engineering specializations available is large so that preparation for almost any engineering career is available in at least one of the engineering schools. In the past, arrangements have been made with SUNY-Buffalo College of Engineering, Columbia University School of Engineering and Applied Sciences, Rochester Institute of Technology College of Engineering, Clarkson College School of Engineering, SUNY Stony Brook College of Engineering, University of Rochester College of Engineering and Applied Science, and the Watson School at Binghamton. Arrangements with other engineering schools are possible and encouraged.

The completion of two sets of requirements in the short period of five years requires careful planning of courses even in the freshman year. Not taking certain crucial courses in the first year may make it difficult to undertake the program in the 3-2 pattern. Though entrance to any given engineering school cannot be guaranteed, our experience has been that careful planning and good academic performance on the part of the student are essential. The student is strongly encouraged to make contact with the chosen engineering school as early as possible so that a careful selection of courses can be made.

Normally, students should take MATH 221 and 222, and PHYS 121 and 122, or 131 and 132, in the first year. If the student does not possess knowledge of a computer programming language, a course or half course in computer programming should be taken during the first two years. The Watson School has several offerings that would generate the appropriate level of knowledge required to complete the projects assigned in upper-level physics courses. The requirements for the BA in physics in the 3-2 combined engineering program are the same as for the normal BA in physics. These include PHYS 131 and 132 (or 121 and 122), 227, 323, 327, 331, 332, 341 and 421. In addition, the following mathematics courses are required: MATH 221, 222, 323, 371 and 471. It is expected that the student will also meet the all-college and other Harpur College requirements. Other elective courses that may be appropriate include CHEM 111, Engineering Graphics, and Statics. Depending on the chosen engineering field and school, still other courses may have to be considered.

The following is a typical sequence of courses when the chosen engineering school is not the Watson School (commonly selected electives are shown in parentheses):

	Fall	**Spring**
Freshman	PHYS 131 or 121 MATH 221 Humanities course (CHEM 111) ***	PHYS 132 or 122 MATH 222 Humanities course ***
Sophomore	PHYS 227 MATH 323 PHYS 323 Soc Sci course	PHYS 331 MATH 371 Hum/Soc Sci Hum/Soc Sci
Junior	PHYS 421 PHYS 332 MATH 471 Hum/Soc Sci	PHYS 327 Soc Sci course PHYS 341 Hum/Soc Sci

****Computer programming offered fall and spring.*

When the chosen engineering school is the University's Watson School, the suggested course sequence is somewhat different. In this case, some Harpur College humanities and social science courses are taken during the fourth and fifth years. The following is a sample course program:

	Fall	**Spring**
Freshman	PHYS 131 MATH 221 Hum/Soc Sci Hum/Soc Sci	MATH 222 PHYS 132 Hum/Soc Sci WTSN 201 (2 cr) WTSN 204 (2 cr)
Sophomore	MATH 323 PHYS 323 CHEM 111 PHYS 227	MATH 371 PHYS 331 Hum/Soc Sci WTSN 273 (2 cr.)
Junior	PHYS 421 PHYS 332 MATH 471 WTSN 260	PHYS 327 PHYS 421 Hum/Soc Sci Hum/Soc Sci

For further information about this program, please contact the director of undergraduate programs in the Department of Physics, Applied Physics, and Astronomy.

BS (Physics) and BS (Computer Science) Five-Year Program

The department, in cooperation with the Department of Computer Science in the Watson School, has established a five-year program

leading to the BS in physics and the BS in computer science. Graduates of this program will be prepared to pursue careers or graduate studies in physics or computer science.

Due to the extensive depth of the program, interested students are urged to contact the undergraduate program director in the Physics Department before their initial registration.

	Fall	Spring
Year I	CS 140	CS 210
	MATH 221	MATH 222
	PHYS 121 or 131	PHYS 122 or 132
	Hum/Soc Sci	Hum/Soc Sci
Year II	CS 220	CS 240
	MATH 323	MATH 314
	PHYS 323	PHYS 227
	Hum/Soc Sci	Hum/Soc Sci
Year IIICS 333		CS 350
	MATH 371	PHYS 331
	CHEM 111	MATH 471
	CS 373	Hum/Soc Sci
Year IV	CS 471	CS elective
	MATH 341	PHYS 327
	PHYS 332	PHYS 341
	Hum/Soc Sci	CS elective
Year V	PHYS 411	PHYS 422
	PHYS 421	PHYS 427/428
	CS elective	Hum/Soc Sci
	Hum/Soc Sci	CS elective
		CS 495

PHYSICS MINOR

Requirements for the minor in physics are as follows: (1) PHYS 131 and 132 or (PHYS 121 and 122) and PHYS 323. (2) Any other three 300- or 400- level courses that must be taken for a letter grade. PHYS 227 can be substituted for one of these courses. The 300- and 400- level courses must be taken in residence at Binghamton University.

GRADUATE PROGRAMS

The Physics, Applied Physics, and Astronomy Department offers two programs of study leading to the master of arts and the master of science degrees in physics. The graduate curriculum provides a broad foundation in basic physical principles and their applications.

Admission

Normally, an applicant for graduate study must have a bachelor's degree and a record that indicates a proficient level of scholarship. Specialization in physics or related fields at the undergraduate level is desirable but not essential for admission. Graduate Record Examination scores for the general and subject tests are helpful in evaluating applicants. Potential applicants are encouraged to contact the director of graduate programs in the department for further information or for answers to specific questions about admission procedures.

Master of Arts Program

This is the "traditional" master's degree program and is recommended for the student planning to transfer into a physics PhD program. With the approval of the departmental graduate committee, students may elect a master's program with or without a thesis requirement. If they elect the MA without a thesis, they are required to pass a written and oral comprehensive examination, offered annually. If they elect the thesis requirement, they are assigned a research subject after consultation with the departmental graduate committee. This research subject is pursued as an independent investigation in depth, in the course PHYS 599, under the direction of the thesis adviser. After submission of the written thesis, the master's candidate must pass an oral examination on the material of the research subject.

The degree of master of arts in physics is normally granted on completion of an approved program, with at least a B average, of 30 credit hours, which includes PHYS 521, 522, 523, 524 and 525, or equivalents. If the thesis option is elected, PHYS 599 (not more than six credits can be counted toward the MA degree) is also required. If an advanced undergraduate or graduate laboratory course is not included in previous coursework, PHYS 527 may be required.

Master of Science Program

This program is for students seeking careers in applied physics or in research and development in industrial laboratories. It is also intended for technical personnel in industry who wish to attain a higher level of understanding of the physical principles on which modern technology is based.

The MS degree requires the completion, with at least a B average, of 30 credit hours of graduate work, and satisfactory performance on a comprehensive examination or the completion and defense of an acceptable thesis. The courses are normally selected from the required courses (shown below) and other graduate courses offered by the department. A number of courses within the Physics Department have been designed with an emphasis in applied physics. A student's selection of courses must have the prior approval of the Graduate Committee.

Under the examination option, the candidate must pass a comprehensive examination prepared by the Graduate Committee, covering

the basic principles of physics and applied physics and the student's special area of interest.

Under the thesis option, no more than six credit hours of PHYS 599 may be counted toward the 30-credit requirement for the degree. After submission of the thesis, the candidate must pass an oral examination on the material pertaining to the research area.

The following courses are normally required as part of the 30-credit requirement:

PHYS 521. Analytical Dynamics
PHYS 522. Electrodynamics I
PHYS 524. Quantum Mechanics I
PHYS 527. Graduate Laboratory
(This requirement may be waived if a comparable course is included in previous coursework.)

The following courses have been designed with an emphasis in applied physics:

PHYS 507. Electronics Laboratory: Analog, Digital and Microprocessors
PHYS 514. Applied Mathematical Physics
PHYS 563. Coherent Optics
PHYS 565. Laser Physics and Quantum Electronics
PHYS 567. Integrated Optics and Electro-Optics
PHYS 569. Nonlinear Optics
PHYS 572. Introduction to Solid State Physics
PHYS 573-574. Applied Solid State Physics and Devices I, II
PHYS 581. Contemporary Topics in Applied Physics

Because of the breadth of the field of applied physics, each student's coursework is carefully planned to tailor the program to meet the individual's particular interests and needs. All students, on entering the program, meet with the director of graduate programs to plan their curriculum, and the department's Graduate Committee oversees students' progress.

COURSE OFFERINGS/ UNDERGRADUATE

NOTE: Unless otherwise noted, all undergraduate courses carry 4 credits and are offered every year.

Astronomy

ASTR 114. THE SUN, STARS AND GALAXIES
Stellar astronomy, neutron stars, black holes and other topics in astrophysics and cosmology. Discussion of observations, techniques and interpretations. Lectures, discussion/laboratory. Observations in scheduled period or in evening, as required. Notes: ASTR 114 satisfies the all-college science requirement. ASTR 115 must be taken in addition to ASTR 114 to satisfy the general education laboratory science requirement.

ASTR 115. OBSERVATIONAL ASTRONOMY LABORATORY *1 credit*
Observations and data analysis involving orbital motion, sidereal and synodic periods, solar rotation, age of star clusters, mass of planets, luminosity and distance to stars, binary stars and spectral classifications. Prerequisite or corequisite: ASTR 114. Note: this course must be taken in addition to ASTR 114 in order to satisfy the General Education laboratory science requirement.

ASTR 497. INDEPENDENT STUDY
Individual research under direct supervision of faculty member. Prior to registration, students must consult instructor and receive approval of problem to be investigated and departmental approval for course credit. Prerequisite: consent of department.

Physics

PHYS 104. PHYSICS OF SOUND LABORATORY
Laboratory course entailing measurements and analysis of vibrational and sound producing systems, including musical instruments. Basics of the physical systems, measurements and analysis, harmonic motion, modes of vibration, waves and wave interference, resonance, use of computer to analyze sound spectra of musical instruments. Corequisite: PHYS 105.

PHYS 105. THE PHYSICS OF SOUND
Phenomena of sound: basic physical properties, reception of sound, analysis of sounds produced by various musical instruments in various environments. Lecture and demonstration laboratory. Necessary physical laws developed and used with minimum of mathematics. PHYS 104 and 105 together satisfy the General Education laboratory science requirement.

PHYS 106. MEDICAL PHYSICS
Physical principles basic to processes in human body and to operation of modern medical instrumentation. Material useful to understanding of many physical aspects of life and medical problems everyone is likely to encounter. Body and medical instruments used as illustrative examples to study topics not covered in normal general physics course, but which are important to physical understanding of body and medical technology. (Fluids, viscosity, heat and thermodynamics, electromagnetic radiation, optics; some topics drawn from material covered in general physics but with less mathematical analysis.) Necessary physical laws developed and used with minimum of mathematics. Lecture, discussion laboratory. Does not satisfy physics requirements for entry to medical school. Intended for science and nonscience students.

PHYS 107. PRINCIPLES OF PHOTOGRAPHY
Physical principles needed to understand photography, used to describe in detail operation of camera and other photographic equipment. Physics of formation of latent image and its development; effect of parameters photographer can control. Properties of light; photographic optics, color, limitations, capabilities of film, lighting techniques. Lectures, discussion/laboratory. Minimum of mathematics; no physics or photographic experience assumed. Note: PHYS 108 must be taken with PHYS 107. Together they satisfy the General Education laboratory science requirement.

PHYS 108. PRINCIPLES OF PHOTOGRAPHY LAB
This is a laboratory course entailing physical measurements in optics, photometry, densitometry, sensitometry, calorimetry, image resolution, etc. Some exercises will be completed outside the classroom using software installed on university microcomputers. Enrollment in PHYS 107,

Principles of Photography, is a corequisite. Use of a 35 mm camera, capable of manual setting of shutter and aperture, is a course requirement. Note: PHYS 107 and 108 together satisfy the General Education laboratory science requirement.

PHYS 115. GREAT IDEAS OF PHYSICS
Freshman honors course for those with the aptitude for scientific reasoning, covering a coherent set of the greatest ideas in physics that have revolutionized our understanding of the laws of nature. Topics vary each semester. Lecture/discussion/seminar. Prerequisites: permission of instructor and aptitude for scientific reasoning as demonstrated in previous high school or college courses, or on standard exams.

PHYS 121. GENERAL PHYSICS I
Principles of physics. Fundamentals of mechanics, kinematics, dynamics and forces, energy, momentum, rotational motion, and heat and thermodynamics. Lecture, laboratory, discussion and demonstrations. Prerequisites: high school trigonometry and algebra.

PHYS 122. GENERAL PHYSICS II
Fundamentals of electricity and magnetism, wave motion and light. Lecture, laboratory, demonstration and discussions. Prerequisite: PHYS 121.

PHYS 131. GENERAL PHYSICS I (CALCULUS BASED)
Fundamentals of mechanics, kinematics, dynamics and forces, energy, momentum, and rotational motion. Heat and thermodynamics. Lectures, discussion, demonstration and laboratory. Prerequisites: high school trigonometry and algebra; MATH 221 or high school AP calculus.

PHYS 132. GENERAL PHYSICS II (CALCULUS BASED)
Fundamentals of electricity, magnetism, light, wave motion and relativity. Lectures, discussion, demonstration, and laboratory. Prerequisite: PHYS 131; corequisite: MATH 222.

PHYS 227. SOPHOMORE LABORATORY
Integrated laboratory experiments from material covered in General Physics I and II. Prerequisites: PHYS 121 and 122, or PHYS 131 and 132, or equivalents.

PHYS 323. MODERN PHYSICS
Introduction to physics of atoms, nuclei, elementary particles. Band theory of conductors; insulators and semiconductors and devices; relativistic kinematics. Prerequisites: an average of C- or better in PHYS 121 and 122, or in 131 and 132; MATH 222.

PHYS 327. JUNIOR LABORATORY
Integrated laboratory experiments drawn from material covered in analytical mechanics, electromagnetic theory and electronics. Prerequisites: PHYS 331, 341 (or as corequisites with departmental approval) and PHYS 323.

PHYS 331. ELECTROMAGNETIC THEORY I
Vector calculus, electrostatic fields in vacuum and material media, magnetostatic fields, boundary-value problems, electromagnetic induction. Prerequisites: PHYS 121 and 122, or 131 and 132, 323, and knowledge of a computer programming language. Prerequisite or corequisite: MATH 323.

PHYS 332. ELECTROMAGNETIC THEORY II
Magnetic fields in matter. Maxwell's equations, propagation of electromagnetic waves in free space and in matter, reflection and refraction, radiation, guided waves, relativistic electrodynamics. Prerequisite: PHYS 331 or equivalent.

PHYS 341. ANALYTICAL MECHANICS
Newtonian dynamics, forced oscillations with damping, Lagrangian formalism, central forces, noninertial frames and rigid body motion. Prerequisites: PHYS 121 and 122, or 131 and 132, 323, and MATH 371, and knowledge of a computer programming language.

PHYS 391. PRACTICUM IN COLLEGE TEACHING
variable credit
Independent study by assisting in teaching a particular physics course. Various assignments directed by the course instructor, including laboratory instruction, construction and reading of tests. May be repeated for a total of no more than eight credits. Credit may be earned in conjunction with a course in which a student is currently enrolled. Does not satisfy major or all-college requirements. Prerequisite: departmental approval and consent of instructor. P/F only.

PHYS 393. PHYSICS COLLOQUIUM *1 credit*
Weekly seminar and colloquia on current topics in physics will be presented by faculty, students and visiting physicists. Attendance required. P/F only. Prerequisite: physics major of at least junior standing.

PHYS 401. SYNTHESIS OF TOPICS OF PHYSICS
2 credits
Provides an integration of the subject matter a physics major is exposed to by means of an overview or synthesis of material in the traditional undergraduate physics curriculum. Prerequisites: physics major with senior standing.

PHYS 407. ELECTRONICS LABORATORY: ANALOG, DIGITAL AND MICROPROCESSORS
Laboratory course in analog, digital and microprocessor electronics. Topics include transistors, operational amplifiers, gates, flip-flops, A/D and D/A conversion and microcomputer basics. Students will build a microcomputer from the chip level and then utilize this microcomputer in several applications. Two four-hour laboratory sessions each week. Prerequisites: Previous experience in a laboratory that deals with electrical measurements and techniques.

PHYS 411. STATISTICAL THERMODYNAMICS
General principles of thermodynamics and kinetic theory. Introduction to statistical mechanics. Prerequisites: PHYS 323 and 341.

PHYS 421. QUANTUM MECHANICS I
Introduction to quantum mechanics. Schroedinger equations applied to one-dimensional problems. Hermitian operators; commuting observables; three-dimensional problems. Angular momentum, spin and abstract vector space. Creation and annihilation operators. Prerequisites: PHYS 323, 331, and 341.

PHYS 422. QUANTUM MECHANICS II
Time-independent perturbation, nondegenerate and degenerate cases. Stark, Zeeman, Paschen-Back effects. Time-dependent perturbation theory. Interaction of radiation with matter. Selection rules. Prerequisite: PHYS 421.

PHYS 427-428. ADVANCED LABORATORY *2 credits*
Representative experiments in various areas of physics;

individual work emphasized. PHYS 427 meets during first half of semester, followed by PHYS 428 in latter half of semester. Prerequisites: PHYS 327 or equivalent, and 421.

PHYS 449 (also GEOL 449). INTRODUCTION TO SOLID EARTH PHYSICS
Application of physical concepts to understanding the solid earth, origin of earth, gravitational and geomagnetic fields and effects, earthquakes and seismic waves, composition and structure of earth's interior; radioactivity and its geothermal consequences: principles of geophysical exploration for natural resources. Application to moon, sun and planets as appropriate. Prerequisites: PHYS 121 and 122, MATH 222, and GEOL 111.

PHYS 450 (also GEOL 450). GEOPHYSICS I
Foundations of seismology. Elasticity theory, wave equation, body and surface waves. Inferences concerning earth's interior. Seismographs, field seismology; data processing. Earthquake occurrence. Lecture and lab (concurrently with GEOL 450). Prerequisites: MATH 371, PHYS 332, and 341.

PHYS 451 (also GEOL 451). GEOPHYSICAL POTENTIAL THEORY
Observations and theory of earth's gravitational and magnetic fields. Potential theory, shape of earth, earth's rotation and tides. Induction equation, dynamo theory and rock magnetism. Computer and field applications; some reading of current literature. Lecture and lab (concurrently with GEOL 551). Prerequisites: MATH 371, PHYS 332 and 341.

PHYS 463. COHERENT OPTICS
Gaussian optics, wave optics, interference, coherence, diffraction, polarization, Fourier optics. Prerequisites: PHYS 331 and differential equations.

PHYS 472. INTRODUCTION TO SOLID STATE PHYSICS
Introductory treatment to selected topics in physics of solids. Topics discussed in terms of simple and concrete models, using classical or elementary quantum-mechanical ideas. Prerequisite: PHYS 421.

PHYS 474. METHODS OF THEORETICAL PHYSICS
Contour integration, conformal mapping, asymptotic expansions, Sturm-Liouville Theory, special functions. Prerequisites: PHYS 331 or 341, MATH 471.

PHYS 497. INDEPENDENT WORK *variable credit*
Individual research under direct supervision of faculty member. Prior to registration, student must consult instructor and receive approval of problem to be investigated and departmental approval for course credit. Prerequisite: consent of department.

PHYS 498. PHYSICS HONORS *variable credit*
Independent work on special problems. To receive the honor "Distinguished Independent Work in Physics," candidate must write and defend a thesis based on research. Prerequisite: consent of department.

COURSE OFFERINGS/ GRADUATE

Astronomy

ASTR 597. INDEPENDENT STUDY IN ASTRONOMY *1-4 credits/semester*
Directed study in a field of astronomy under the guidance of a faculty member. Student must obtain approval of faculty member and department. Limited to MAT and MST students.

Physics

PHYS 501. SEMINAR *2 credits*
Seminar course for prospective teachers. Topics assigned by course instructor: student, after literature search, presents seminars to entire class. Prerequisites: junior courses in analytical mechanics, electricity, magnetism.

PHYS 502. ANALYTICAL MECHANICS FOR SECONDARY SCHOOL EDUCATORS
Introduction to analytical mechanics for students planning to become secondary school educators. Newtonian dynamics, Lagrangian formulations, central forces, forced oscillations with damping, noninertial frames and rigid body motion. Restricted to MAT/MST/MSEd students. Prerequisite: differential equations.

PHYS 503. INTEGRATED LABORATORY EXPERIMENTS FOR SECONDARY SCHOOL EDUCATORS
Laboratory experiments based on material covered in electronics, analytical mechanics, electromagnetic theory and various other topics areas in physics. Restricted to MAT/MST/MSEd students. Prerequisites: Modern Physics, Analytical Mechanics, Electromagnetism I.

PHYS 505. ELECTROMAGNETISM I FOR SECONDARY SCHOOL EDUCATORS
Introduction to electromagnetism for students planning to become secondary school educators. Boundary value problems, electrostatic fields in vacuum and material media, magnetostatic fields, electromagnetic induction. Restricted to MAT/MST/MSEd students. Prerequisite: Differential Equations.

PHYS 506. ELECTROMAGNETISM II FOR SECONDARY SCHOOL EDUCATORS
Introduction to electromagnetism for students planning to become secondary school educators. Magnetic fields in matter. Maxwell's equations. Special topics. Restricted to MAT/MST/MSEd students. Prerequisite: Electromagnetism I.

PHYS 507. ELECTRONICS LABORATORY: ANALOG, DIGITAL AND MICROPROCESSORS
Laboratory course in analog, digital and microprocessor electronics. Topics include transistors, operational amplifiers, gates, flip-flops, A/D and D/A conversion and microprocessor basics. Students will build a microcomputer from the chip level and then utilize this microcomputer in several applications. Two four-hour laboratory sessions each week. Prerequisites: Previous experience in a laboratory that deals with electrical measurements and techniques.

PHYS 508. QUANTUM MECHANICS I FOR SECONDARY SCHOOL EDUCATORS
Introduction to quantum mechanics for students planning to become secondary school educators. Hermitian operators, commuting observables. Rotation of basis states and matrix mechanics. Angular momentum, spin and abstract vector space. Creation and annihilation operators. Schroedinger equations applied to one-dimensional problems. Restricted to MAT/MST/MSEd students. Prerequisites: Modern Physics, Analytical Mechanics, Partial Differential Equations.

PHYS 509. QUANTUM MECHANICS II FOR SECONDARY SCHOOL EDUCATORS
Introduction to quantum mechanics for students planning to become secondary school educators. Bound states of central potentials. Stark, Zeeman, Paschen-Back effects. Time-independent perturbation, nondegenerate and degenerate cases. Time-dependent perturbation theory. Selection rules. Restricted to MAT/MST/MSEd students. Prerequisite: Quantum Mechanics I.

PHYS 511. STATISTICAL THERMODYNAMICS
General principles of thermodynamics, kinetic theory. Introduction to statistical mechanics. Prerequisites: junior course in mechanics and senior course in quantum mechanics or modern physics.

PHYS 514. APPLIED MATHEMATICAL PHYSICS
Applications of complex variables, applications of special functions to industrial problems, Fourier and Laplace transformations, treatment of experimental and engineering data. Prerequisites: undergraduate course in electricity and magnetism or mechanics; differential equations.

PHYS 521. ANALYTICAL DYNAMICS
Methods of Lagrange, Hamilton and Jacobi for particle systems and continuous fields. Canonical transformations, integral invariants, small oscillations, rigid body rotations. Prerequisite: junior course in mechanics.

PHYS 522-523. ELECTRODYNAMICS I AND II
Electrodynamics from standpoint of Maxwell's equations; relativistic formulation, radiation theory, boundary-value problems, wave guides, cavity resonators, classical electron theory. Prerequisites: junior course in electricity and magnetism, senior course in mathematical methods.

PHYS 524-525. QUANTUM MECHANICS I AND II
Foundations of quantum mechanics, representation theory, Schrodinger and Heisenberg pictures, approximation methods, introduction to relativistic quantum mechanics. Prerequisites: senior course in quantum mechanics, senior course in mathematical physics, course in analytical dynamics.

PHYS 527. GRADUATE LABORATORY *2-4 credits*
Representative experiments in various areas of physics; individual work emphasized. Prerequisites: junior laboratory course and course in quantum mechanics.

PHYS 531-532. STATISTICAL MECHANICS I AND II
Foundations and techniques of quantum statistical physics; ensembles, nonequilibrium phenomena, phase transitions. Prerequisites: junior course in thermodynamics and kinetic theory, senior course in quantum mechanics, graduate course in analytical dynamics.

PHYS 537L-547L. LABORATORIES IN APPLIED COHERENT AND APPLIED LASER OPTICS
Laboratory exercises and experiments to illustrate, confirm and measure phenomena studied in PHYS 563 and 565. Corequisite: PHYS 563, 565, respectively.

PHYS 541. PHYSICS WORKSHOP AND WORKSHOP DESIGN *1-4 credits*
Exploration and translation of cognitive science and staff development research into the design and delivery of teacher workshops. Makes use of national and New York State curricular guidelines. Enrollment only by permission of instructor.

PHYS 542. PRACTICUM IN PHYSICS WORKSHOPS

1-4 credits
Independent design and evaluation of inservice workshops for teachers. Work may include proposal writing, preparation and evaluation of workshops. Additional requirements may include attendance at coordination meetings, submission of articles on teaching techniques, etc. Enrollment only by permission of instructor.

PHYS 550 (also GEOL 550). GEOPHYSICS I

fall
Fundamental aspects of solid earth geophysics, emphasis on seismology. Basic differential equations and solutions discussed; features of earth deduced or explained; data acquisition and analysis examined. Prerequisites: mathematical methods, analytical mechanics, electricity and magnetism.

PHYS 551 (also GEOL 551). GEOPHYSICS II
spring
Fundamental nonseismic aspects of solid earth geophysics: gravity, rotational dynamics, tides; equations of state of interior, geothermal heat flow, earth's thermal history, geomagnetic field. Observations and theory emphasized. Prerequisites: analytical mechanics, E & M, math methods.

PHYS 563. COHERENT OPTICS
Gaussian optics, wave optics, interference, coherence, diffraction, polarization, Fourier optics. Prerequisite: PHYS 502.

PHYS 565. LASER PHYSICS AND QUANTUM ELECTRONICS
Quantum mechanical bases, optical resonators, beam characteristics, gain and saturation effects, holography, applications. Prerequisite: PHYS 503.

PHYS 567. INTEGRATED OPTICS AND ELECTRO-OPTICS
Dielectric waveguides, modes of the waveguide, planar slab waveguides, coupled modes, beam couplers, prism couplers, modulation, electro-optic waveguide modulators, monolithic considerations. Prerequisite: undergraduate course in electromagnetic fields.

PHYS 569. NONLINEAR OPTICS
Propagation of electromagnetic waves through linear and nonlinear media, coupled equations, crystal characterizations, second harmonic generation, electro-optic effects, four wave mixing. Prerequisites: undergraduate course in electromagnetism; undergraduate course in differential equations.

PHYS 572. INTRODUCTION TO SOLID STATE PHYSICS
Introductory treatment of selected topics in physics of solids. Simple and concrete models, using classical or elementary quantum-mechanical ideas. Prerequisite: senior level course in quantum mechanics.

PHYS 573-574. APPLIED SOLID STATE PHYSICS AND DEVICES I AND II
Crystal structure, semiconductors, optical and magnetic properties of solids, excitons, superconductivity, Josephson junctions, dielectrics, ferroelectrics, magnetic resonance, electro-optical devices, other aspects of condensed matter. Prerequisite: PHYS 572; PHYS 573 is a prerequisite for PHYS 574.

PHYS 581. CONTEMPORARY TOPICS IN APPLIED PHYSICS
Series of one-credit courses, each devoted to special device or process of current interest to industrial research and development. No course depends on others; any or all may be elected. Topics selected in consultation with potential students and industrial representatives.

PHYS 582. TOPICS IN CONTEMPORARY PHYSICS

2-4 credits/semester
Content varies. May include plasma physics, reactor physics, coherent electromagnetic phenomena, information theory, particle accelerators, superfluidity, biophysics, cryophysics and upper atmosphere physics. Prerequisite: consent of instructor.

PHYS 597. INDEPENDENT STUDY
1-4 credits/semester

PHYS 599. RESEARCH FOR THE DEGREE OF MASTER OF ARTS, MASTER OF SCIENCE IN PHYSICS

1-6 credits
Research and preparation of exposition required for MA/MS degree in physics. Topics assigned by departmental graduate committee, may be either experimental or theoretical.

PHYS 700. CONTINUOUS REGISTRATION
1 credit/semester
Required for maintenance of matriculated status in graduate program. No credit toward graduate degree requirements.

PHYS 707. RESEARCH SKILLS
1-4 credits
Development of research skills required within graduate programs. May not be applied toward course credits for any graduate degree. Prerequisite: approval of relevant graduate program director or department chair.

SEC 593-594. METHODS SEMINAR
(Mathematics; Science; English; Physics; Social Science) Courese offered by discipline. Each seminar divided into two modules of two and four credits respectively. One module offered prior to internship during summer sessions; Coursework relates substantive work to immediate teaching problems; meets methods course requirement for permanent certification. required for MAT degree. Not available for credit toward MA or PhD degree.