**PHY**

**Physics**

**PHY 112: Light, Color, and Vision**
An introduction to the modern understanding of light, color, and vision, primarily for non-science majors and especially beneficial to students majoring in visual arts or theatre. Topics include the nature of light; the human eye and vision; illusions, color perception, and color theory; optical instruments; the camera and photography; optical phenomena in the atmosphere (mirages, rainbows, halos); and light in modern physics (relativity, lasers). Not for major credit. Not for credit in addition to PHY 122, PHY 126, PHY 132 or PHY 142. Students majoring or planning to major in PHY, AST, CHE, MAT, AMS or engineering may not take this course.

**Prerequisite:** Satisfaction of entry skill in mathematics requirement (Skill 1) or satisfactory completion of D.E.C. C or QPS

**DEC:** E  
**SBC:** SNW  
**3 credits**

**PHY 113: Physics of Sports**
First part of an introduction to physics from the perspective of sports, especially designed for non-science majors. Basic concepts in classical mechanics and fluid dynamics are used to analyze particular actions in football, baseball, soccer, track and field, and other sports. Students learn, for example, about the knuckle ball in baseball and why it is so hard to hit, and why quarterbacks throw a football in a spiral. The concepts of heat, energy, and calories are also discussed. The laboratory component, PHY 115, may be taken concurrently with or after PHY 113. Not for credit in addition to PHY 121, PHY 125, PHY 131 or PHY 141. Students majoring or planning to major in PHY, AST, CHE, MAT, AMS or engineering may not take this course.

**Prerequisite:** Satisfaction of entry skill in mathematics requirement (Skill 1) or satisfactory completion of D.E.C. C or QPS

**DEC:** E  
**SBC:** SNW  
**3 credits**

**PHY 114: Electromagnetism, Waves and Radiation for Sports Science**
Second part of the Physics of Sports sequence. The focus is on electricity, magnetism, optics, acoustics, radiation, and medical imaging. The laboratory component, PHY 116, may be taken concurrently with or after PHY 114.

**Prerequisite:** PHY 113

**PHY 115: Physics of Sports Laboratory**
Laboratory component of PHY 113. Experiments are designed to help students better understand the physics aspects of sports. Students work in groups and conduct experiments indoors and outdoors. Knowledge of first-year college-level mathematics is recommended, but most necessary information is taught in class as needed. May be taken concurrently with or after PHY 113.

**Pre or Corequisite:** PHY 113

**DEC:** E  
**SBC:** SNW  
**1 credit**

**PHY 116: Electromagnetism, Waves and Radiation for Sports Science Laboratory**
Laboratory component of PHY 114. Experiments are designed to help students better understand the physics aspects of sports. Knowledge of first-year college-level mathematics is recommended, but most necessary information is taught in class as needed. May be taken concurrently with or after PHY 114.

**Prerequisites:** PHY 113 and 115  
**Pre- or Corequisite:** PHY 114

**DEC:** E  
**SBC:** SNW  
**1 credit**

**PHY 119: Physics for Environmental Studies**
The principles of physics as they apply to environmental issues. A review of mathematics is followed by a discussion of Newton's laws, conservation principles, topics in fluids and wave motion, optical instruments, and radioactivity. Three lectures and one laboratory session per week. This course is offered as both ENS 119 and PHY 119.

**Prerequisites:** MAT 123; CHE 131

**DEC:** E  
**SBC:** SNW  
**4 credits**

**PHY 121: Physics for the Life Sciences I**
First part of an introduction to physics with applications to biology, primarily for students majoring in biological sciences or pre-clinical programs. Topics include mechanics, fluid mechanics, and thermodynamics. Strong algebra skills and knowledge of the ideas of calculus are required. Three lecture hours and two laboratory hours per week. PHY 121 may not be taken for credit in addition to PHY 125, 131, or 141. This course has been designated as a High Demand/Controlled Access (HD/CA) course. Students registering for HD/CA courses for the first time will have priority to do so.

**Prerequisite:** MAT 125 or MAT 131 or MAT 141 or AMS 151

**DEC:** E  
**SBC:** SNW  
**4 credits**

**PHY 122: Physics for the Life Sciences II**
Second part of an introduction to physics with applications to biology, primarily for students majoring in biological sciences or pre-clinical programs. Topics include electromagnetism, optics, acoustics, and radiation phenomena. Strong algebra skills and knowledge of the ideas of calculus are required. Three lecture hours and two laboratory hours per week. PHY 122 may not be taken for credit in addition to PHY 127, 132, or 142. This course has been designated as a High Demand/Controlled Access (HD/CA) course. Students registering for HD/CA courses for the first time will have priority to do so.

**Prerequisite:** C or higher in PHY 121/123  
**Corequisite:** CHE 132 or CHE 152

**DEC:** E  
**SBC:** SNW  
**4 credits**

**PHY 125: Classical Physics A**
First of a three-part sequence intended for physical-sciences or engineering majors. It focuses on the mechanics of point particles and simple oscillators, and emphasizes motion in one and two dimensions and the concepts of momentum and energy. Calculus is used concurrently with its development in MAT 125. Three lecture hours and one recitation hour per week. Not for credit in addition to PHY 121, PHY 131, or PHY 141. This course has been designated as a High Demand/Controlled Access (HD/CA) course. Students registering for HD/CA courses for the first time will have priority to do so.

**Prerequisite:** MAT 123 or Level 4 on the mathematics placement examination

**Corequisite:** MAT 125 or MAT 131 or MAT 141 or AMS 151

**DEC:** E  
**SBC:** SNW  
**4 credits**

**PHY 126: Classical Physics B**
Second or third of a three-part sequence for physical-sciences or engineering majors. It focuses on the mechanics of rigid bodies, on fluids, waves, thermodynamics, and optics. Three lecture hours and one recitation hour...
per week. Associated Labs (PHY 133 or PHY 134) are offered separately. Not for credit in addition to PHY 132, or PHY 142. This course has been designated as a High Demand/Controlled Access (HD/CA) course. Students registering for HD/CA courses for the first time will have priority to do so.

Prerequisite: C or higher: PHY 125 or 131 or 141 Corequisite: MAT 126, 132, 142, 171 or AMS 161 or level 7 or higher on math placement exam

DEC: E
SBC: SNW
3 credits

PHY 127: Classical Physics C

Second or third of a three-part sequence for physical-sciences or engineering majors. It focuses on electromagnetism using the concepts of vector fields and scalar potentials, and on DC and AC electric circuits. Calculus is used concurrently with its development in MAT 126. Three lecture hours and one recitation hour per week. Associated Labs (PHY 133 or PHY 134) are offered separately. Not for credit in addition to PHY 122, PHY 132, or PHY 142. This course has been designated as a High Demand/Controlled Access (HD/CA) course. Students registering for HD/CA courses for the first time will have priority to do so.

Prerequisite: C or higher: PHY 125 or 131 or 141 Corequisite: MAT 126, 132, 142, 171 or AMS 161 or level 7 or higher on math placement exam

DEC: E
SBC: SNW
3 credits

PHY 131: Classical Physics I

First part of a two-semester physics sequence for physical-sciences or engineering majors who have a strong mathematics background and are ready for a fast learning pace. It covers mechanics, wave motion, kinetic theory, and thermodynamics. Calculus is used concurrently with its development in MAT 131. Three lecture hours and one recitation hour per week. The Laboratory component, PHY 133 (Lab 1), could be taken concurrently. Not for credit in addition to PHY 121, PHY 125, or PHY 141. This course has been designated as a High Demand/Controlled Access (HD/CA) course. Students registering for HD/CA courses for the first time will have priority to do so.

Prerequisite: MAT 123 or level 5 on the mathematics placement examination Corequisite: MAT 125 or MAT 131 or MAT 141 or AMS 151

DEC: E

PHY 132: Classical Physics II

Second part of a two-semester physics sequence for physical-sciences or engineering majors who have a strong mathematics background and are ready for a fast learning pace. It covers electromagnetism, electric circuit theory, and optics. Calculus is used concurrently with its development in MAT 132. Three lecture hours and one recitation hour per week. The Laboratory component, PHY 134, may be taken concurrently. Not for credit in addition to PHY 122, PHY 127, or PHY 142. This course has been designated as a High Demand/Controlled Access (HD/CA) course. Students registering for HD/CA courses for the first time will have priority to do so.

Prerequisite: C or higher in PHY 131 or PHY 141 Corequisite: MAT 132 or MAT 142 or MAT 126 or MAT 171 or AMS 161

DEC: E
SBC: SNW
3 credits

PHY 133: Classical Physics Laboratory I

Two hours of laboratory per week that corresponds to the content of PHY 131 or PHY 125+PHY 126. This course has been designated as a High Demand/Controlled Access (HD/CA) course. Students registering for HD/CA courses for the first time will have priority to do so. This course has an associated fee. Please see www.stonybrook.edu/coursefees for more information.

Prerequisite: C or higher in PHY 125; or pre- or corequisite PHY126 or PHY 131; or corequisite PHY 141

1 credit

PHY 134: Classical Physics Laboratory II

Two hours of laboratory per week that corresponds to the content of PHY 132 or PHY 126+127. This course has been designated as a High Demand/Controlled Access (HD/CA) course. Students registering for HD/CA courses for the first time will have priority to do so. This course has an associated fee. Please see www.stonybrook.edu/coursefees for more information.

Prerequisite: C or higher in PHY 133 Pre- or Corequisite: PHY 126 and PHY 127; or PHY 132; or corequisite PHY 142

1 credit

PHY 141: Classical Physics I: Honors

First part of a demanding two-semester sequence for students with the strongest background, interests, and abilities in science and mathematics. The topics covered in PHY 141 are similar to those in PHY 131 but are treated in more depth in a small-class setting. Students may transfer to PHY 131 at any time during the first half of each semester without penalty. Three lecture hours and one recitation hour per week. PHY 141 may not be taken for credit in addition to PHY 121, PHY 125, or PHY 131. This course has an associated fee. Please see www.stonybrook.edu/coursefees for more information.

Prerequisite: Level 6 on Math Placement, or B or higher in MAT 131 or 141 or AMS 151, or B+ or higher in MAT 125, or instructor permission (priority given to students in Honors or WISE programs) Corequisite: MAT 131 or 141 or 126 or AMS 151; PHY 133

DEC: E
SBC: SNW
3 credits

PHY 142: Classical Physics II: Honors

Second part of a demanding two-semester sequence for students with the strongest background, interests and abilities in science and mathematics. The topics covered in PHY 142 are similar to those in PHY 132, but are treated in more depth in a small-class setting. Students may transfer to PHY 132 at any time during the first half of each semester without penalty. Three lecture hours and one recitation hour per week. PHY 142 may not be taken for credit in addition to PHY 122, PHY 127, or PHY 132. This course has an associated fee. Please see www.stonybrook.edu/coursefees for more information.

Prerequisite: C or higher in PHY 141 or permission of department Corequisite: MAT 132 or 142 or 127 or 171 or AMS 161; PHY 134

DEC: E
SBC: SNW
3 credits

PHY 153: Data Analysis for Physics and Astronomy with Python

An introduction to statistical data analysis with modern techniques, including the Python programming language on Windows computers for students with no prior experience in programming. Topics include concepts and methods to characterize experimental data such as averages, variances, standard deviations, propagation of uncertainties, probability distributions, confidence intervals, hypothesis testing, chi-squared minimization, and straight line
fitting. Emphasis on practical data centric applications—preparation for experimental laboratory work and research. Extensive use of computers outside the classroom will be required. 

Prerequisite: PHY 133 and a grade of C or better in MAT 125 or MAT 131 or MAT 141 or AMS 151 or MAT 171

**SBC:** TECH
3 credits

**PHY 191: Transitional Study**
Laboratory for transfer students to supplement courses taken at another institution. Students take the laboratory portion of a 100-level course for which they have taken the theoretical portion elsewhere.

Prerequisite: Permission of department
1 credit

**PHY 192: Transitional Study**
Laboratory for transfer students to supplement courses taken at another institution. Students take the laboratory portion of a 100-level course for which they have taken the theoretical portion elsewhere.

Prerequisite: Permission of department
1 credit

**PHY 231: Physics for Future Presidents**
A study of key physics ideas that a newly-inaugurated President of the country, or a newly-hired President of a company, needs to know. This course equips the future President with enough knowledge of the physics behind a pressing issue to make an intelligent decision even in the face of conflicting advice about issues including energy, national security, and space exploration. Politics is the art of balancing competing demands, and business involves profitably serving customers, so the economics of many technologies will also be discussed.

Prerequisite: one D.E.C. E or SNW course and one D.E.C. F or SBS course

**SBC:** STAS
3 credits

**PHY 237: Current Topics in World Climate and Atmosphere**
An exploration of current concerns about the greenhouse effect, acid rain, and global ozone loss, in a format accessible to non-science majors. The social and political steps being taken to limit global atmospheric pollution and climate change are discussed. Not for major credit. This course is offered as both ATM 237 and PHY 237.

Prerequisite: one D.E.C. E or SNW course; satisfaction of entry skill in mathematics requirement or level 2+ on the mathematics placement examination

**DEC:** H
**SBC:** STAS
3 credits

**PHY 251: Modern Physics**
A survey of the major physics theories of the 20th century (relativity and quantum mechanics) and their impact on most areas of physics. It introduces the special theory of relativity, the concepts of quantum and wave-particle duality, Schrödinger's wave equation, and other fundamentals of quantum theory as they apply to nuclei, atoms, molecules, and solids. The Laboratory component, PHY 252, must be taken concurrently; a common grade for both courses will be assigned. Three hours lecture and one hour recitation per week.

Prerequisite: PHY 122/124, or PHY 126 and 127, or PHY 132 or PHY 142; and PHY 134; C or higher in MAT 126 or 132 or 142 or 171 or AMS 161 Pre- or Corequisite: MAT 203 or MAT 205 or AMS 261 or MAT 307 Corequisite: PHY 252

**SBC:** STEM+
3 credits

**PHY 252: Modern Physics Laboratory**
Students perform some of the pivotal experiments of the 20th century. The lecture component, PHY 251, must be taken concurrently; a common grade for both courses will be assigned. Two hours of laboratory per week. This course has an associated fee. Please see www.stonybrook.edu/coursefees for more information.

Corequisite: PHY 251
1 credit

**PHY 277: Computation for Physics and Astronomy**
An introduction to computing on UNIX/Linux computers. Fundamentals of using UNIX/Linux to write computer programs for numerical algorithms to solve computational physics and astronomy problems. Assignments are carried out in a high-level compiler programming language such as Fortran 90 or C++ and require extensive use of SINC site computers outside the classroom.

Prerequisite: PHY 125, PHY 126, PHY 127 and PHY 133 & PHY 134; or PHY 131/133, PHY 132/134; or PHY 141/133, PHY 142/134; AMS 151 or MAT 126 or MAT 131 or MAT 141
Advisory Prerequisite: AMS 161 or MAT 127 or MAT 132 or MAT 142 or MAT 171

**SBC:** TECH
3 credits

**PHY 287: Introduction to Research**
An opportunity for students, while still early in their studies, to do research commensurate with their level of preparation. Students work alongside faculty, post-doctoral fellows, and graduate students on ongoing research projects. Students must take the initiative to negotiate the opportunity. BNL and other scientists may be allowed as co-supervisors. May be repeated up to a total of 3 credits.

Prerequisite: Permission of department

**SBC:** EXP+
0-3 credits

**PHY 291: Transitional Study**
A laboratory for transfer students to supplement a course taken at another institution. Students take the laboratory portion of a 200-level course for which they have taken the theoretical portion elsewhere.

Prerequisite: Permission of department
1 credit

**PHY 300: Waves and Optics**
The physics of oscillations and waves, from mechanical waves to light waves to electron waves. Topics include resonance and normal modes of coupled oscillators, the wave equation and wave propagation, interference and diffraction, polarization and imaging, coherence, and lasers. Three lecture hours and one three-hour laboratory per week.

Prerequisite: PHY 132/PHY 134 or PHY 142/PHY 134 or PHY 126/PHY 127/PHY 134 Corequisite: MAT 203 or MAT 205 or AMS 261 or MAT 307

**SBC:** STEM+
4 credits

**PHY 301: Electromagnetic Theory I**
The application of Maxwell's equations to solve time-independent boundary-value problems and to study the interactions of electric and magnetic fields with bulk matter.

Prerequisite: PHY 251 and PHY 277 or permission of department; MAT 203 or MAT 205 or AMS 261 or MAT 307
Advisory Corequisite: MAT 341
3 credits

**PHY 302: Electromagnetic Theory II**
A study of time-dependent electric and magnetic fields as derived from Maxwell's equations. Topics include the interrelations of electric and magnetic fields and their potentials; energy and momentum associated
with electromagnetic fields and the Maxwell vacuum and matter; waveguides and transmission lines; special relativity for electromagnetism; retarded potentials for time-varying sources; and radiation of electromagnetic waves.

Prerequisite: PHY 301

3 credits

PHY 303: Mechanics
An in-depth study of classical mechanics, from the Newtonian to the Lagrangian and Hamiltonian formulations. First, Newtonian mechanics is reviewed and applied to more advanced problems than those considered in PHY 131 or 141. The Lagrangian and Hamiltonian methods are then derived from the Newtonian treatment and applied to various problems.

Prerequisite: PHY 251 and PHY 277 or permission of department; MAT 303 or MAT 305 or AMS 361 or MAT 308

3 credits

PHY 306: Thermodynamics, Kinetic Theory, and Statistical Mechanics
A study of the laws that govern physical systems in thermal equilibrium. In the first part, the concepts of temperature, internal energy, and entropy are analyzed and the first and second laws of thermodynamics are used to connect various properties that are independent of the microscopic details of the system. The second part is devoted to a microscopic study of a system in thermal equilibrium, from the kinetic theory of gases to statistical mechanics and the relation between entropy and probability, with application to simple examples in classical and quantum statistics.

Prerequisites: PHY 251, 277, 300

3 credits

PHY 307: Physical and Mathematical Foundations of Quantum Mechanics

Prerequisites: PHY 122/124, or PHY 126 and PHY 127 and PHY 134, or PHY 132 and PHY 134, or PHY 142 and PHY 134; MAT 132 or MAT 142 or MAT 127 or MAT 171 or AMS 161

Advisory Corequisite: MAT 203 or MAT 205 or AMS 261 or MAT 307

4 credits

PHY 308: Quantum Physics
The concepts, historical development, and mathematical methods of quantum mechanics. Topics include Schrödinger's equation in time-dependent and time-independent forms; one- and three-dimensional solutions, including the treatment of angular momentum and spin. Applications to simple systems, especially the hydrogen atom, are stressed.

Prerequisite: PHY 300, 301, and 303

3 credits

PHY 311: Connections in Science
A selection of the interrelations between physics and other scientific and technological fields, using modern examples from engineering, medicine, and applied mathematics, among others. The course is taught as a seminar and includes guest lecturers, tours of laboratories, and discussion of classic and current research projects. Appropriate for physics and non-physics majors alike.

Prerequisite: PHY 122/124 or PHY 126 and PHY 127 and PHY 134 or PHY 132/134 or PHY 142/134

1 credit

PHY 313: Mystery of Matter
Exploration of our understanding of the basic constituents of matter, and of how that understanding and the tools developed to study them affect aspects of contemporary society. Historical discoveries and their place in social and political institutions of the time are considered, along with issues of government funding and the cost to society. Includes a discussion of developments at Brookhaven National Laboratory and their scientific and social impact. Not intended for Physics majors with U3 or U4 status.

Prerequisite: U3 or U4 standing for non-physics majors; one D.E.C. E or SNW course. All Physics/Astronomy majors need permission of department to enroll, please consult the Director of UG Studies.

DEC: H
SBC: STAS

3 credits

PHY 335: Electronics and Instrumentation Laboratory
Students will design, build and test basic DC and AC circuits which perform a useful function, as viewed by physicists, involving resistors, capacitors, transformers, diodes, transistors and operational amplifiers. Students will measure these circuits using digital multi-meters and digital oscilloscopes. Understanding of analog circuits will be stressed including negative feedback applied to operational amplifiers. Two three-hour laboratories per week.

Prerequisite: PHY 251

SBC: TECH

3 credits

PHY 382: The Quantum Moment: Quantum Mechanics in Philosophy, Culture, and Life (III)
This course explores the implications and influence, real and alleged, of quantum mechanics on fields other than physics. What does quantum mechanics mean, if anything, for philosophy, ethics, and social behavior? At the same time, we shall look into how social and cultural influences may have affected the way that quantum mechanics was formulated, and how it has evolved. We shall review the early history of quantum mechanics, and discuss some of the important debates at the founding of quantum mechanics. Students will not be expected to learn the mathematics in depth, only the introduction provided by the instructors aimed at non-science students. Besides readings, the course will also involve plays, films, and guest speakers. Students will be expected to work on a final project, to be presented in class. This course is offered as both PHI 382 and PHY 382.

Prerequisite: one Physics or Philosophy course and U3 or U4 standing

DEC: H
SBC: STAS

3 credits

PHY 390: Special Topics in Physics
May be repeated once as the topic changes.

Prerequisite: Permission of department

3 credits

PHY 405: Advanced Quantum Physics
Study of quantitative methods of quantum mechanics, including perturbation theory and the WKB approximation, scattering theory, and elements of quantum-information theory. Symmetry principles are stressed and advanced mathematical techniques are used throughout the course.

Prerequisite: PHY 303 and PHY 308; MAT 341

3 credits
PHY 408: Relativity
A development of the special theory of relativity leading to general relativity with applications to cosmology.

Prerequisite: PHY 302 and 303
3 credits

PHY 420: Introduction to Accelerator Science and Technology
This course will introduce students to the field of accelerator science and technology, a very versatile branch of physics and technology. This course is composed of the following parts: introduction of accelerator history and their basic principles, basic beam dynamics in synchrotrons, introduction of challenges in Accelerator physics, and introduction of typical beam measurements and instrumentation.

Prerequisite: PHY 277, PHY 300, PHY 301, PHY 302, and PHY 303
Pre- or corequisite: PHY 335
3 credits

PHY 431: Nuclear and Particle Physics
Students will study a selection of topics from the properties of elementary particles, the strong, weak, and electromagnetic forces, symmetries, particle interaction and decay rates, nuclear structure, nuclear reactions, nuclear forces, the interaction of radiation with matter, accelerators and radiation detectors.

Prerequisite: PHY 308
3 credits

PHY 444: Experiential Learning
This course is designed for students who engage in a substantial, structured experiential learning activity in conjunction with another class. Experiential learning occurs when knowledge acquired through formal learning and past experience are applied to a "real-world" setting or problem to create new knowledge through a process of reflection, critical analysis, feedback and synthesis. Beyond-the-classroom experiences that support experiential learning may include: service learning, mentored research, field work, or an internship.

Prerequisite: WRT 102 or equivalent; permission of the instructor and approval of the EXP+ contract (http://sb.cc.stonybrook.edu/bulletin/current/policiesandregulations/degree_requirements/EXPlus.php)

SBC: EXP+
0 credit, S/U grading

PHY 445: Senior Laboratory
A selection of historically important experiments from atomic and nuclear spectroscopy, particle physics, solid-state and low-temperature physics performed with modern instrumentation. Each student does three experiments, usually with a partner. As students progress, they are encouraged to pursue independent projects, without rigid formats or procedures. The emphasis is on the development of experimental skills and on individual, ethical, professionally acceptable analysis and presentation of results, both orally and in writing. Two three-hour laboratory sessions per week.

Prerequisite: PHY 308 and PHY 335

SBC: ESI, SPK
3 credits

PHY 447: Tutorial in Advanced Topics
Selected readings in advanced topics for upper-division students of unusual ability and substantial accomplishments. Prior to the beginning of the semester, the topic to be studied is selected by the supervising member of the faculty and a reading assignment is planned. Weekly conferences with this faculty member are devoted to discussion of material, resolution of problems encountered, and assessment of the student's progress. May be repeated up to a total of 6 credits.

Prerequisite: Permission of department
1-6 credits

PHY 451: Quantum Electronics
Introduction to modern atomic physics for the laser era. Emphasis on the interaction between atoms and light, as well as on atomic structure and how it affects this interaction. Modern applications such as laser cooling, atom trapping, precision spectroscopy with frequency comb, quantum information, and others will be discussed.

Pre- or corequisite: PHY 405
3 credits

PHY 452: Atomic Physics and Lasers
This course begins with an in-depth introduction to modern atomic physics for the laser era. Emphasis is on the fundamentals of light-matter interactions as well as on atomic structure and how it affects the interaction. The main topics include laser fundamentals, atom trapping, precision spectroscopy with frequency comb, quantum information and others.

Prerequisites: PHY 300 and PHY 308

SBC: TECH
3 credits

PHY 458: Speak Effectively Before an Audience
A zero credit course that may be taken in conjunction with any PHY course that provides opportunity to achieve the learning outcomes of the Stony Brook Curriculum's SPK learning objective.

Pre- or corequisite: WRT 102 or equivalent; permission of the instructor

SBC: SPK
0 credit, S/U grading

PHY 459: Write Effectively in Physics
A zero credit course that may be taken in conjunction with any 300- or 400-level PHY course, with permission of the instructor. The course provides opportunity to practice the skills and techniques of effective academic writing and satisfies the learning outcomes of the Stony Brook Curriculum's WRTD learning objective.

Prerequisite: WRT 102; permission of the instructor

SBC: WRTD
0 credit, S/U grading

PHY 472: Solid-State Physics
A study of the different types of solids, with emphasis on their thermal, electrical, and optical properties. It introduces the concepts of phonons and electronic bands, and applications to metals, semiconductors, superconductors, and magnetism.

Prerequisite: PHY 306 and 308
3 credits

PHY 475: Undergraduate Teaching Practicum
An opportunity for selected undergraduates to collaborate with the faculty in teaching at the introductory level. In addition to working as tutors and as laboratory assistants, students meet once a week with a faculty supervisor to discuss problems they have encountered and to plan future activities. Students are generally assigned to assist in courses they have completed and in which they have excelled. Not for major credit. Can be repeated up to a maximum of 6 credits with a maximum of 3 credits per course taught.

Prerequisite: Permission of department

SBC: EXP+
0-3 credits, S/U grading

PHY 477: Research
An opportunity for students to conduct faculty-supervised research for academic credit. Students must take the initiative to negotiate the opportunity. BNL and other scientists...
may be allowed as co-supervisors. Research proposals must be prepared by the student and submitted for approval by the supervising faculty before the beginning of the credit period. An account of the work and the results achieved is submitted to the supervisor before the end of the credit period. May be repeated, up to a total of 6 credits.

Prerequisite: Permission of department

SBC: TECH

0-6 credits

ESE

Electrical Engineering

ESE 121: Introduction to Audio Systems

Analog and digital audio systems, musical instrument amplifiers and effects, audio instrumentation, samplers, synthesizers, and audio transducers will be studied. Signal and system concepts will be demonstrated using audible examples to develop intuitive and non-mathematical insights. Audio system specifications will be explained and their effects demonstrated.

SBC: TECH

3 credits

ESE 123: Introduction to Electrical and Computer Engineering

Introduces basic electrical and computer engineering concepts in a dual approach that includes: laboratories for hands-on wired and computer simulation experiments in analog and logic circuits, and lectures providing concepts and theory relevant to the laboratories. Emphasizes physical insight and applications rather than theory. This course has an associated fee. Please see www.stonybrook.edu/coursefees for more information.

Pre- or Corequisites: AMS 151 or MAT 125 or 131 or 141; PHY 125 or 131 or 141

SBC: TECH

4 credits

ESE 124: Computer Techniques for Electronic Design I

An extensive introduction to problem solving in electrical engineering using the ANSI C language. Topics covered include data types, operations, control flow, functions, data files, numerical techniques, pointers, structures, and bit operations. Students gain experience in applying the C language to the solution of a variety of electrical engineering problems, based on concepts developed in ESE 123.

Knowledge of C at the level presented in this course is expected of all electrical engineering students in subsequent courses in the major.

Pre- or Corequisites: AMS 151 or MAT 125 or 131 or 141; ESE 123 or equivalent

3 credits

ESE 201: Engineering and Technology Entrepreneurship

The purpose of this course is to bridge the gap between technical competence and entrepreneurial proficiency. Students are not expected to have any formal business background, but have some background in a technical field. These fields can range from the engineering disciplines to computer science, and from biology and chemistry to medicine. Accordingly, the course will provide the necessary exposure to the fundamentals of business, while minimizing the use of business school jargon. Entrepreneurship is considered as a manageable process built around innovativeness, risk-taking and proactiveness. The course focuses on ventures where the business concept is built around either a significant technical advance in an operational process, or in the application of technology to create a new product or service.

Prerequisite: BME 100 or CME 101 or ESG 100 or ESE 123 or MEC 101 or EST 192 or EST 194 or EST 202 or LSE 320

3 credits

ESE 211: Electronics Laboratory A

Introduction to the measurement of electrical quantities; instrumentation; basic circuits, their operation and applications; electronic devices; amplifiers, oscillators, power supplies, wave-shaping circuits, and basic switching circuits.

Prerequisite: ESE 271

Corequisite: ESE 372

2 credits

ESE 218: Digital Systems Design

Develops methods of analysis and design of both combinational and sequential systems regarding digital circuits as functional blocks. Utilizes demonstrations and laboratory projects consisting of building hardware on breadboards and simulation of design using CAD tools. Topics include: number systems and codes; switching algebra and switching functions; standard combinational modules and arithmetic circuits; realization of switching functions; latches and flip-flops; standard sequential modules; memory, combinational, and sequential PLDs and their applications; design of system controllers.

Prerequisite or Corequisite: PHY 127/134 or PHY 132/134 or PHY 142 or ESE 124

SBC: TECH

4 credits

ESE 224: Computer Techniques for Electronic Design II

Introduces C++ programming language for problem solving in electrical and computer engineering. Topics include C++ structures, classes, abstract data types, and code reuse. Basic object-oriented programming concepts as well as fundamental topics of discrete mathematics and algorithms are introduced.

Prerequisite: ESE 124

3 credits

ESE 231: Introduction to Semiconductor Devices

The principles of semiconductor devices. Energy bands, transport properties and generation recombination phenomena in bulk semiconductors are covered first, followed by junctions between semiconductors and metal-semiconductor. The principles of operation of diodes, transistors, light detectors, and light emitting devices based on an understanding of the character of physical phenomena in semiconductors. Provides background for subsequent courses in electronics.

Prerequisites: AMS 361 or MAT 303; PHY 127/134 or PHY 132/134 or PHY 142

3 credits

ESE 271: Electrical Circuit Analysis I


Prerequisites: AMS 161 or MAT 127 or 134 or PHY 132 or PHY 142

4 credits

ESE 290: Transitional Study

A vehicle used for transfer students to remedy discrepancies between a Stony Brook course and a course taken at another institution. For example, it allows the student to take the laboratory portion of a course for which he or she has had the theoretical portion elsewhere. Open elective credit only.

Prerequisite: Permission of department

1-3 credits

ESE 300: Technical Communication for Electrical and Computer Engineers

Topics include how technical writing differs from other forms of writing, the components of technical writing, technical style, report
writing, technical definitions, proposal writing, writing by group or team, instructions and manuals, transmittal letters, memoranda, abstracts and summaries, proper methods of documentation, presentations and briefings, and analysis of published engineering writing. Also covered are the writing of resumes and cover letters.

Prerequisite: WRT 102; ESE or ECE major, U3 standing;
Pre- or Corequisite: ESE 314 or 324 or 380 or 382
3 credits

ESE 301: Engineering Ethics and Societal Impact
The study of ethical issues facing engineers and engineering related organizations and the societal impact of technology. Decisions involving moral conduct, character, ideals and relationships of people and organizations involved in technology, the interaction of engineers, their technology, the society and the environment is examined using case studies.

Prerequisite: U3 or U4 standing; one D.E.C. E or SNW course
DEC: H
SBC: STAS
3 credits

ESE 304: Applications of Operational Amplifiers
Design of electronic instrumentation: structure of basic measurement systems, transducers, analysis and characteristics of operational amplifiers, analog signal conditioning with operational amplifiers, sampling, multiplexing, A/D and D/A conversion; digital signal conditioning, data input and display, and automated measurement systems. Application of measurement systems to pollution and to biomedical and industrial monitoring is considered.

Prerequisite: ESE 372
3 credits

ESE 305: Deterministic Signals and Systems

Pre- or Corequisite: ESE 271
3 credits

ESE 306: Random Signals and Systems
Random experiments and events; random variables, probability distribution and density functions, continuous and discrete random processes; Binomial, Bernoulli, Poisson, and Gaussian processes; system reliability; Markov chains; elements of queuing theory; detection of signals in noise; estimation of signal parameters; properties and application of auto-correlation and cross-correlation functions; power spectral density; response of linear systems to random inputs.

Pre- or Corequisite: ESE 305
4 credits

ESE 311: Analog Integrated Circuits
Engineering design concepts applied to electronic circuits. Basic network concepts, computational analysis and design techniques: models of electronic devices; biasing and compensation methods; amplifiers and filters designed by conventional and computer-aided techniques.

Prerequisite: ESE 372
3 credits

ESE 313: Introduction to Photovoltaics
Introduction to the basic concepts of photovoltaic solar energy conversion, including: 1. The solar resource in the context of global energy demand; 2. The operating principles and theoretical limits of photovoltaic devices; 3. Device fabrication, architecture, and primary challenges and practical limitations for the major technologies and materials used for photovoltaic devices. Students will gain knowledge of: the device physics of solar cells, the operating principles of the major commercial photovoltaic technologies, the current challenges and primary areas of research within the field of photovoltaics, and a basic understanding of the role of photovoltaics in the context of the global energy system.

Prerequisite: ESE 231 or ESG 281 or permission of instructor
3 credits

ESE 314: Electronics Laboratory B
Laboratory course on design and operation of basic building blocks of electronics. The course is coordinated with, and illustrates and expands upon, concepts presented in ESE 372. Emphasis is given to design solutions more relevant to integrated rather than to discreet element electronics. Field effect transistors are given special attention due to their importance in contemporary analog and digital ICs.
Frequency responses of the basic amplifiers and active filters are analyzed. Internal structure and fundamental performance limitations of digital inverter and other gates are studied. This course has an associated fee. Please see www.stonybrook.edu/coursefees for more information.

Prerequisites: ESE or ECE major; ESE 211 and 372 or permission of instructor
3 credits

ESE 315: Control System Design

Prerequisite: ESE 271
3 credits

ESE 319: Electromagnetics and Transmission Line Theory
Fundamental aspects of electromagnetics wave propagation and radiation, with application to the design of high speed digital circuits and communications systems. Topics include: solutions of Maxwell's equations for characterization of EM wave propagation in unbounded and lossy media; radiation of EM energy; guided wave propagation with emphasis on transmission lines theory.

Prerequisite: ESE 271
3 credits

ESE 323: Modern Circuit Board Design and Prototyping
Design, fabricate, and test a prototype device using a custom made circuit board, surface mount components, and a 3D printed enclosure. Topics include printed circuit design, active and passive component selection, design for testability, solid modeling, and 3D printing.

Prerequisite: ESE 211 and ESE 380
3 credits

ESE 324: Electronics Laboratory C
Illustrates and expands upon advanced concepts presented in ESE 372. Experiments include analog circuits such as oscillators, voltage regulators; mixed -signal circuits such...
as data converters, phase-locked loops, and several experiments emphasizing the analog design issues in digital circuits. Laboratory fee required. This course has an associated fee. Please see www.stonybrook.edu/coursefees for more information.

Prerequisites: ESE or ECE major; U3 standing; ESE 211 and 372
2 credits

ESE 325: Modern Sensors
The course focuses on the underlying physics principles, design, and practical implementation of sensors and transducers including piezoelectric, acoustic, inertial, pressure, position, flow, capacitive, magnetic, optical, and bioelectric sensors. Established as well as novel sensor technologies as well as problems of interfacing various sensors with electronics are discussed.
Prerequisite: ESE 372
3 credits

ESE 330: Integrated Electronics
An overview of the design and fabrication of integrated circuits. Topics include gate-level and transistor-level design; fabrication material and processes; layout of circuits; automated design tools. This material is directly applicable to industrial IC design and provides a strong background for more advanced courses.
Prerequisite: ESE 372
3 credits

ESE 333: Real-Time Operating Systems
Introduces basic concepts and principles of real-time operating systems. Topics include structure, multiple processes, interprocess communication, real-time process scheduling, memory management, virtual memory, file system design, security, protection, and programming environments for real-time systems.
Prerequisites: ESE 124; CSE 214; ESE 380 or CSE 220
3 credits

ESE 337: Digital Signal Processing: Theory
Introduces digital signal processing theory sequences, discrete-time convolution, difference equations, sampling and reconstruction of signals, one- and two-sided Z-transforms, transfer functions, and frequency response. Design of FIR and IIR filters. Discrete and fast Fourier transforms and applications.
Prerequisite: ESE 305
3 credits

ESE 340: Basic Communication Theory
Basic concepts in both analog and digital data communications; signals, spectra, and linear networks; Fourier transforms, energy and power spectra, and filtering; AM, FM, and PM; time and frequency multiplexing; discussion of problems encountered in practice; noise and bandwidth considerations; pulse modulation schemes.
Prerequisites: ESE 305 and 306
3 credits

ESE 341: Introduction to Wireless and Cellular Communication
Basic concepts of wireless cellular communications, radio frequency, spectrum reuse, radio channel characterization, path loss and fading, multiple access techniques, spread spectrum systems, channel coding, specific examples of cellular communication systems.
Pre or Co-requisite: ESE 340
3 credits

ESE 342: Digital Communications Systems
Prerequisite: ESE 340
3 credits

ESE 343: Mobile Cloud Computing
Introduction to the basic concepts of mobile cloud computing, including: 1. The mobile computing technology used in modern smart phones; 2. The cloud computing technology used in existing data centers; 3. The synergy of mobile and cloud computing and its applications; 4. Programming on smart phone utilizing data center services. Students will gain knowledge of: the fundamental principles of mobile cloud computing, the current challenges and primary areas of research within the field of mobile cloud computing, and a basic understanding of the role of mobile cloud computing in the context of everyday living.
Prerequisite: ESE 224, CSE 214, ESE 230 or ISE 208
3 credits

ESE 344: Software Techniques for Engineers
Trains students to use computer systems to solve engineering problems. Includes C/C++ programming languages, UNIX programming environment, basic data structures and algorithms, and object oriented programming.
Prerequisites: ESE 218; CSE 230 or ESE 224
3 credits

ESE 345: Computer Architecture
Starts with functional components at the level of registers, buses, arithmetic, and memory chips, and then uses a register transfer language to manipulate these in the design of hardware systems up to the level of complete computers. Specific topics included are microprogrammed control, user-level instruction sets, I/O systems and device interfaces, control of memory hierarchies, and parallel processing organizations.
Prerequisites for CSE majors: CSE 220 and ESE 218
Pre-requisite for ESE and ECE majors: ESE 380 and ESE 382
3 credits

ESE 346: Computer Communications
Basic principles of computer communications. Introduction to performance evaluation of protocols. Protocols covered include those for local, metropolitan, and wide area networks. Introduction to routing, high speed packet switching, circuit switching, and optical data transport. Other topics include TCP/IP, Internet, web server design, network security, and grid computing. Not for credit in addition to CSE/ISE 316. This course is offered as both CSE 346 and ESE 346.
Pre- or corequisite for ESE and ECE majors: ESE 306
Pre- or corequisite for CSE majors: AMS 310 or 311
3 credits

ESE 347: Digital Signal Processing: Implementation
Fundamental techniques for implementing standard signal-processing algorithms on dedicated digital signal-processing chips. Includes a review of discrete-time systems, sampling and reconstruction, FIR and IIR filter design, FFT, architecture and assembly language of a basic signal processing chip, and an introduction to adaptive filtering.
Prerequisites: ESE 337, or ESE 305 and 380
4 credits

ESE 350: Electrical Power Systems
Fundamental engineering theory for the design and operation of an electric power system. Modern aspects of generation, transmission, and distribution are considered with appropriate inspection trips to examine...
examples of these facilities. The relationship between the facilities and their influence on our environment is reviewed. Topics include power system fundamentals, characteristics of transmission lines, generalized circuit constants, transformers, control of power flow and of voltage, per unit system of computation, system stability, and extra-high voltage AC and DC transmission.  
Prerequisite: ESE 271  
3 credits

ESE 352: Electromechanical Energy Converters  
Basic principles of energy conversion; DC, induction, and synchronous rotary converters; the three-phase system and symmetrical components; the relationships between voltage, current, flux, and m.m.f.; equivalent circuits and operating characteristics of rotary converters; and analysis of saturation effects.  
Prerequisite: ESE 372  
3 credits

ESE 355: VLSI System Design  
Introduces techniques and tools for scalable VLSI design and analysis. Emphasis is on physical design and on performance analysis. Includes extensive laboratory experiments and hands-on use of CAD tools.  
Prerequisite: ESE 218  
4 credits

ESE 356: Digital System Specification and Modeling  
Introduces concepts and tools for scalable digital system design and analysis. Emphasis is on physical design and on performance analysis. Includes extensive laboratory experiments and hands-on use of CAD tools.  
Prerequisites: ESE 124 and ESE 380  
3 credits

ESE 358: Computer Vision  
Introduces fundamental concepts, algorithms, and computational techniques in visual information processing. Covers image formation, image sensing, binary image analysis, image segmentation, Fourier image analysis, edge detection, reflectance map, photometric stereo, basic photogrammetry, stereo, pattern classification, extended Gaussian images, and the study of human visual system from an information processing point of view.  
Prerequisites for ESE and ECE majors: ESE 305; ESE 224 or CSE 230

Prerequisites for CSE majors: CSE 214 and 220  
3 credits

ESE 360: Network Security Engineering  
An introduction to computer network and telecommunication network security engineering. Special emphasis on building security into hardware and software working with software. Topics include encryption, public key cryptography, authentication, intrusion detection, digital rights management, firewalls, trusted computing, encrypted computing, intruders and viruses. Not for credit in addition to CSE 408.  
Pre- or corequisite: ESE/CSE 346 or CSE/ISE 310  
3 credits

ESE 363: Fiber Optic Communications  
Design of single and multi-wavelength fiber optic communications systems. Topics include analysis of optical fibers, optical transmitters and receiver design, optical link design, single-wavelength fiber optic networks with analysis of FDDI and SONET/SDH, and wavelength division multiplexing.  
Prerequisite: ESE 372  
4 credits

ESE 364: Mixed-Signal Systems-On-Chip  
Introduces basic concepts and key circuits of radio-frequency systems. Taught within the design and construction of a transceiver for wireless communications, the course covers fundamental principles which apply to all radio devices. Essential theoretical background, with additional emphasis on practical implementation using commercially-available integrated circuits for double-balanced mixers, oscillators, and power amplifiers. Basic components and circuits; key elements of radio electronics, including filters, matching networks, amplifiers, oscillators, mixers, modulators, detectors, and antennae. Computer simulation via Pspice and Puff is emphasized as an integral part of the design process.  
Prerequisite: ESE 372  
3 credits

ESE 365: VLSI System Design  
Introduces techniques and tools for scalable VLSI design and analysis. Emphasis is on physical design and on performance analysis. Includes extensive laboratory experiments and hands-on use of CAD tools.  
Prerequisite: ESE 218  
4 credits

ESE 366: Design using Programmable Mixed-Signal Systems-on-Chip  
This course focuses on development of mixed-signal embedded applications that utilize systems on chip (SoC) technology. The course discusses design issues such as: implementation of functionality; realizing new interfacing capabilities; and improving performance through programming the embedded microcontroller and customizing the reconfigurable analog and digital hardware of SoC.  
Prerequisites: ESE 380 and ESE 372; ESE 224 or CSE 230  
4 credits

ESE 372: Electronics  
The pertinent elements of solid-state physics and circuit theory are reviewed and applied to the study of electronic devices and circuits, including junction diodes, transistors, and gate and electronic switches; large- and small-signal analysis of amplifiers; amplifier frequency response; and rectifiers and wave-shaping circuits.  
Prerequisite: ESE 271  
Corequisite for ESE and ECE majors: ESE 211  
4 credits

ESE 373: RF Electronics for Wireless Communications  
Introduces basic concepts and key circuits of radio-frequency systems. Taught within the design and construction of a transceiver for wireless communications, the course covers fundamental principles which apply to all radio devices. Essential theoretical background, with additional emphasis on practical implementation using commercially-available integrated circuits for double-balanced mixers, oscillators, and audio power amplifiers. Basic components and circuits; key elements of radio electronics, including filters, matching networks, amplifiers, oscillators, mixers, modulators, detectors, and antennae. Computer simulation via Pspice and Puff is emphasized as an integral part of the design process.  
Prerequisite: ESE 372  
3 credits

ESE 380: Embedded Microprocessor Systems Design I  
Fundamental concepts and techniques for designing electronic systems that contain a microprocessor or microcontroller as a key component. Topics include system level architecture, microprocessors, ROM, RAM, I/O subsystems, address decoding, PLDs and programmable peripheral ICs, assembly language programming and debugging. Hardware-software trade-offs in implementation of functions are considered. Hardware and software design are emphasized equally. Laboratory work involves design, implementation, and testing of microprocessor controlled circuits.  
Prerequisite: ESE or ECE major; ESE 218 or permission of instructor.  
4 credits

ESE 381: Embedded Microprocessor Systems Design II  
A continuation of ESE 380. The entire system design cycle, including requirements definition and system specifications, is covered. Topics include real-time requirements, timing, interrupt driven systems, analog data conversion, multi-module and multi-language systems. The interface between high-level language and assembly language is covered. A complete system is designed and prototyped in the laboratory.  
Prerequisites: ESE 271 and 380  
4 credits

ESE 382: Digital Design Using VHDL and PLDs  
Digital system design using the hardware description language VHDL and system
implementation using complex programmable logic devices (CPLDs) and field programmable gate arrays (FPGAs). Topics include design methodology, VHDL syntax, entities, architectures, testbenches, subprograms, packages, and libraries. Architecture and characteristics of PLDs and FPGAs are studied. Laboratory work involves writing the VHDL descriptions and testbenches for designs, compiling, and functionally stimulating the designs, fitting and timing simulation of the fitted designs, and programming the designs into a CPLD or FPGA and bench testing.

Prerequisite: ESE or ECE major; ESE 218 or permission of instructor

3 credits

ESE 476: Instructional Laboratory Development Practicum
Students work closely with a faculty advisor and staff in developing new laboratory experiments for scheduled laboratory courses in electrical and computer engineering. A comprehensive technical report and the instructional materials developed must be submitted at the end of the course. May be used as a technical elective for electrical and computer engineering majors. May be repeated as an open elective.

Prerequisites: U4 standing; minimum cumulative g.p.a. of 3.0 and minimum grade of A- in the course for which the students will develop material; permission of department and instructor

SBC: EXP+

3 credits

ESE 440: Engineering Design I
Lectures by faculty and visitors on typical design problems encountered in engineering practice. During this semester each student will choose a senior design project for Engineering Design II. The project incorporates appropriate engineering standards and multiple realistic constraints. A preliminary design report is required. Not counted as a technical elective. Laboratory fee required.

Prerequisites: ESE or ECE major, U4 standing; two ESE technical electives (excluding ESE 390 and 499); ESE 300. Students may need additional prerequisites depending on the design project undertaken.

3 credits

ESE 441: Engineering Design II
Student groups carry out the detailed design of the senior projects chosen during the first semester. The project incorporates appropriate engineering standards and multiple realistic constraints. A comprehensive technical report of the project and an oral presentation are required. Not counted as a technical elective. Laboratory fee required.

Prerequisite: ESE 440

3 credits

ESE 475: Undergraduate Teaching Practicum
Students assist the faculty in teaching by conducting recitation or laboratory sections that supplement a lecture course. The student receives regularly scheduled supervision from the faculty instructor. May be used as an open elective only and repeated once.

Prerequisites: U4 standing; a minimum g.p.a. of 3.00 in all Stony Brook courses, and a grade of B or better in the course in which the student is to assist; permission of department.

SBC: EXP+

3 credits

ESE 476: Instructional Laboratory Development Practicum
Students work closely with a faculty advisor and staff in developing new laboratory experiments for scheduled laboratory courses in electrical and computer engineering. A comprehensive technical report and the instructional materials developed must be submitted at the end of the course. May be used as a technical elective for electrical and computer engineering majors. May be repeated as an open elective.

Prerequisites: U4 standing; minimum cumulative g.p.a. of 3.0 and minimum grade of A- in the course for which the students will develop material; permission of department and instructor

SBC: EXP+

3 credits

ESE 488: Internship in Electrical/Computer Engineering
An independent off-campus engineering project with faculty supervision. May be repeated but only three credits of internship electives may be counted toward the non-ESE technical elective requirement.

Prerequisites: ECE or ESE major; U3 or U4 standing; 3.00 g.p.a. minimum in all engineering courses; permission of department

SBC: EXP+

3 credits

ESE 494: Honors Seminar on Research
An introduction to the world wide research enterprise with special emphasis on research in the United States. Topics include research funding, publications, patents, career options, theory versus experiment, entrepreneurship and presentation skills.

Prerequisite: Acceptance into the ECE or ESE Honors programs or permission of instructor.

1 credit

ESE 495: Honors Research Project
A research project, for students in the honors program, conducted under the supervision of an electrical and computer engineering faculty member.

Prerequisites: ESE 494, permission of department and acceptance into the ECE or ESE Honors programs

3 credits

ESE 499: Research in Electrical Sciences
An independent research project with faculty supervision. Permission to register requires a 3.00 g.p.a. in all engineering courses and the agreement of a faculty member to supervise the research. May be repeated but only three credits of research electives (AMS 487, BME 499, CSE 487, MEC 499, ESM 499, EST 499, ISE 487) may be counted toward non-ESE technical elective requirements.

Requirements: U4 standing; 3.00 g.p.a. minimum in all engineering courses, permission of department

0-3 credits