

## Division of Mathematics and Science

Department of Chemistry

Department of Computer Science

Department of Mathematics

Department of Oceanography

Department of Physics



## Chemistry Department

### Chemistry Major

The chemistry major at the Naval Academy provides midshipmen with training in all of the discipline's traditional fields, leading to a bachelor of science degree certified by the American Chemical Society.

All chemistry majors take required courses in organic, inorganic, analytical and physical chemistry and biochemistry. In addition to the required courses, midshipmen may take advanced courses in each of these subject areas along with related areas such as polymer chemistry, explosives and propellants, forensics and environmental chemistry. Senior capstone or research projects enable midshipmen to investigate topics of particular interest to them under the guidance of a faculty member.

Chemistry is an experimental science, and many hours are devoted to laboratory work. The chemistry department at the Naval Academy has one of the finest undergraduate chemistry laboratory facilities in the nation, with modern spaces and a wide array of instrumentation. Skilled technicians maintain the laboratories, assist the faculty and help midshipmen solve practical problems in the labs. Faculty have a wealth of experience, not only in their academic understanding of chemistry but also in the practical application of chemistry in the Navy and Marine Corps. Chemistry majors will find that their civilian and military instructors can make the study of chemistry a highlight of their learning experience at the Naval Academy.

The chemistry major gives midshipmen a solid background in scientific principles required for any of the technical disciplines in which they will work as naval officers. It also provides an excellent academic base for graduate studies in such diverse fields as medicine, oceanography, operations research, management and engineering.

#### **Curriculum Requirements** (In addition to the requirements of plebe year)

Professional: NE203, NL302, NL400, NN204, NS310, NS40X;

Mathematics: SM223, SM212;

Science: SP211, SP212;

Humanities: HH215, HH216 and two electives including one at the 300/400 level;

Engineering: EE301, EE302, EN200, EM300, ES300, ES360;

Major: SC225, SC226, SC263, SC264, SC335, SC345, SC363, SC356, SC346, SC364, SC476 or SC496, two major electives, chemistry seminar and one free elective.

## Chemistry and Biology Courses

### BIOLOGY COURSES

**SB201 Biology for the Naval Officer** (3-0-3). Students will learn basic biology in the context of its applications to everyday life and their future duties in the Naval Service. Topics include: diet and nutrition, hormones, genetics and the human genome, genetic engineering, DNA “fingerprinting,” human performance, disease, resistance and immunity. *Note: Students cannot get credit for both SB201 and SB211 or SB201 and SB251.*

**SB211 Biology for the Naval Officer with Lab** (3-2-4). Students will learn basic biology in the context of its applications to everyday life and their future duties in the Naval Service. Topics include: diet and nutrition, hormones, genetics and the human genome, genetic engineering, DNA “fingerprinting,” human performance, disease, resistance and immunity. Laboratories are designed to reinforce and expand upon topics from lecture. *Note: Students cannot get credit for both SB201 and SB211 or SB211 and SB251.*

**SB251 General Biology I** (3-2-4). Fundamental principles of the science of biology are introduced. Topics include metabolism, cell structure and function, classical and molecular genetics, evolution and ecology. The perspective of the course is from life as a whole, with a focus on the position of humans in the overall scheme.

**SB252 General Biology II** (3-2-4). This course provides students with a solid foundation in human physiology. Lectures focus on the mechanisms of body function along with complementary concepts in biochemistry, cell biology, genetics, and developmental biology. Laboratory sessions cover the same topics as well as anatomy and histology. *Prereq: SB251.*

**SB338 Molecular and General Genetics** 3-0-3. Students in this course will study the inheritance of traits, starting with basic (Mendelian) genetics and ending with modern molecular biology. The course will examine incomplete dominance, epistasis, pleiotropy, transformation, cloning, genetic engineering, imprinting, and experimental techniques. *Colisted as SC338. Prereq: SB251 or SC335.*

**SB341 Advanced Physiology** 3-0-3. The molecular mechanisms and genetics of normal physiological regulation as well as the physiology of some common pathological states such as heart disease and kidney failure will be investigated. The major body systems, including cardiovascular, pulmonary, renal, reproductive, and digestive, along with their control by the nervous and endocrine systems are studied. *Prereq: SB252 or equivalent.*

**SB421 Developmental Biology** (2-2-3). Students in this course will learn about animal development from fertilization through adolescence, focusing on vertebrate development, especially that of humans. In lecture, the molecular and genetic control of development will be emphasized, whereas in laboratory sessions embryology and developmental anatomy will be studied with extensive microscopy. *Prereq: SB211, SB251, or equivalent.*

**SB431 Microbial Chemistry** (2-2-3). This course will explore the interesting and important interactions that occur between microbes and their surroundings, including human hosts and extreme environments. Species of these “simple” organisms have evolved diverse mechanisms to combat assault by antibiotics, heavy metals, pollutants and extreme irradiation. The lab component of the class will include identifying, cultivating and testing organisms with survival mechanisms of interest. *Colisted as SC431. Prereq: SB251 and SC335.*

### CHEMISTRY COURSES

**SC111 Foundations of Chemistry I** (3-2-4). The first in a two-semester sequence presenting the fundamental laws and theories of chemistry. Major topics include chemical stoichiometry, periodic trends, atomic structure, chemical equilibrium, thermodynamics, nuclear chemistry, electrochemistry and kinetics. The lecture material is complemented with experiments designed to develop the student’s laboratory skills. Naval applications of chemistry are introduced throughout the courses to provide an awareness of chemistry in normal Navy operations. *Prereq: none.*

**SC112 Foundations of Chemistry II** (3-2-4). This is the second in the two-course foundations of chemistry sequence. See SC111 for a course description. *Prereq: SC111.*

**SC151 Modern Chemistry** (3-2-4).

A one-semester course for the well-prepared student, satisfying the plebe year chemistry requirement. Students entering this course must have demonstrated their understanding of fundamental chemical concepts by a strong performance on the chemistry validation exam. *Prereq: Placement by department chair.*

**SC221 Chemistry in Modern Warfare** (3-0-3). This course will examine the science behind conventional weapons and weapons of mass destruction. The course will begin by examining high explosives and propellants by studying the structure, synthesis, and properties of these materials. The second part of the course will focus on chemical and biological agents to include history, structure, modes of action, detection, protective measures, and methods of decontamination. *Prereq: SC112.*

**SC225 Organic Chemistry I** (3-0-3). The first of a two-semester sequence of courses focused on the chemistry of covalent compounds of carbon, the “molecules of life.” Many important concepts from general chemistry (stoichiometry, bonding, structure, kinetics and thermodynamics) are used and expanded upon. New concepts include conformational analysis, stereochemistry, reaction mechanisms, and molecular orbital theory. *Prereq: SC112 or SC151; Coreq: SC263.*

**SC226 Organic Chemistry II** (3-0-3). This is the second in the two-course sequence in organic chemistry. See SC225 for a course description. *Prereq: SC225 and SC263; Coreq: SC264.*

**SC263 Integrated Laboratory I - Reactions, Separation and Purification** (0-6-2). This laboratory course emphasizes the theory and practice of separating and purifying chemical substances. Techniques include crystallization, distillation, column chromatography, gas chromatography, high performance liquid chromatography, extraction and sublimation. Identification of chemical substances based on infrared and nuclear magnetic resonance spectroscopy are introduced. *Prereq: SC112 or SC151; Coreq: SC225.*

**SC264 Integrated Laboratory II - Reactions, Chemical and Instrumental Analysis** (2-6-4). The lecture component explores the theory and instrumentation employed in modern chemical analysis by atomic and molecular spectroscopy, mass spectroscopy and gas and liquid chromatography. In the laboratory, qualitative and quantitative methods are applied in the determination of

the products of several important chemical reactions, including a multi-step synthesis. Students also apply these methods in the analysis of simple equilibrium systems and the separation and identification of a two-component unknown. *Prereq: SC225 and SC263; Coreq: SC226.*

**SC311 Marine and Atmospheric Chemistry (3-0-3).** An introduction to chemical processes that influence the chemistry of marine waters and the atmospheric marine boundary layer. The course will begin with the composition of seawater and progress towards an understanding of the biogeochemical cycles of important elements in oceanic systems, including the chemistry of tropospheric ozone and aerosol formation. The impact these processes have on current and future Naval operations will be discussed. *Prereq: SC112.*

**SC325 Advanced Organic Chemistry (3-0-3).** Building on the foundation of SC225-226, this course will apply fundamental topics such as stereochemistry, conformation, structure / bonding and mechanisms to advanced topics such as pericyclic reactions, heterocyclic compounds, and the relationship between structure and function of biochemically important organic compounds. *Prereq: SC226.*

**SC335 Biochemistry (3-0-3).** The chemical basis of life will be examined by studying the relationship between the structure and function of biological macromolecules with an emphasis on proteins and nucleic acids. Metabolic processes involved in energy production, storage and transformation will be studied. Biochemical signaling and biological membranes will also be covered. There will be an overview of modern biochemical experimental methods. *Prereq: SC225.*

**SC336 Biochemistry II (3-0-3).** This course will expand and build on topics from SC335, such as biomolecular structure, bioenergetics and enzyme kinetics, to cover biosynthesis of amino acids, nucleotides and cofactors; photosynthesis and plant metabolic cycles; signal transduction; molecular genetics; regulation of eukaryotic and prokaryotic gene expression. *Prereq: SC335.*

**SC338 Molecular and General Genetics 3-0-3.** Students in this course will study the inheritance of traits, starting with basic (Mendelian) genetics and ending with modern molecular biology. The course will examine incomplete dominance, epistasis, pleiotropy, transformation, cloning, genetic engineering, imprinting, and experimental techniques. *Colisted as SB338. Prereq: SB251 or SC335.*

**SC341 Introduction to Chemical Engineering Processes (3-0-3).** An introductory course designed to prepare students to be able to solve material and energy balances relative to chemical processes utilizing the engineering approach for problem solving. *Prereq: SC112, SP212, SM221.*

**SC345 Physical Chemistry I (3-0-3).** This course explores physical and chemical phenomena with emphasis on thermodynamics. An introduction to kinetics is included. *Prereq: (SC112 or SC151); and SP211 and SM212.*

**SC346 Physical Chemistry II (3-0-3).** A continuation of SC345, with an emphasis on the quantum theory of atomic and molecular structure, including spectroscopy. *Prereq: SC345.*

**SC351 Chemical Structure Determination by X-ray Diffraction (2-2-3).** X-ray diffraction is the most powerful tool for determining the three-dimensional structures of molecules. This course is a practical, hands-on, introduction to modern methods of 3D molecular structure determination by X-ray diffraction. Students will learn the basics of the technique from crystal growth to final structure solution. *Prereq: SC112 and SM212.*

**SC356 Inorganic Chemistry (4-0-4).** The chemistry of the Main Group elements and the transition metals are studied with emphasis on the properties, structures, and reactivities of these elements and their compounds. *Prereq: SC226, SC345.*

**SC363 Integrated Laboratory III - Physical Principles and Quantitative Analysis (2-6-4).** Lecture and laboratory focus on the theory and behavior of molecules and ions in solution. These are explored in the laboratory by classical (volumetric, gravimetric, titrimetric) and modern instrumental (spectroscopic, electrochemical, thermal) methods of analysis. Quantitative laboratory technique is stressed and sampling techniques and statistical analysis of data are introduced. Students apply these techniques in a laboratory analysis of their own design. *Prereq: SC264; Coreq: SC345 unless waived by department chair.*



**SC364 Integrated Laboratory IV - Advanced Laboratory and Seminar (1-6-3).**

This laboratory course emphasizes the theory, structure, synthesis and characterization of inorganic and organometallic compounds through application of a number of advanced techniques. Advanced synthetic methods include photochemical, high temperature and inert-atmosphere reactions. Advanced analytical methods include magnetic susceptibility measurements, EPR, Raman and high-resolution, gas-phase spectroscopy and fast reaction (stopped-flow) kinetics. In addition, a weekly seminar that includes discussions and presentations by faculty, students and distinguished visitors provides exposure to the wide-ranging scope of chemistry. *Prereq: SC363; Coreq: SC346, SC356, unless waived by dept. chair.*

**SC412 Environmental Chemistry (3-0-3).**

Many analytical chemistry techniques can be used to learn more about the chemistry of our environment. In this course students will be exposed to specific applications of these techniques to various environmental systems (i.e. water, air, soil, etc.). Topics to be explored may include the bio- and geochemical cycles, the effect of military activities on the environment and the use of "green chemistry" in industry. *Prereq: SC262 / SC264 or permission of instructor.*

**SC416 Analytical Chemistry in Forensic Investigations (3-0-3).**

This course will address the types of sample collection techniques used in criminal investigations, as well as the chemical and instrumental methods used to determine the presence of substances associated with illicit activities. Emphasis will be placed on specific forensic investigative techniques such as DNA fingerprinting, drug detection, arson investigations (petroleum residues), bombings (explosives residues) and characterization of fibers / paint. *Prereq: SC363.*

**SC421 Introduction to Polymer Chemistry (2-2-3).** The synthesis, characterization and physical chemistry of macromolecules, both man-made and natural, will be presented with the ultimate goal of understanding the relationship between molecular structure and physical properties. Polymer processing, fabrication and recent novel applications, including those related to the Navy, will be presented. Field trips to local polymer research and manufacturing facilities are planned. *Prereq: SC226 and SC264.*

**SC425 Medicinal Chemistry (2-2-3).**

This course will provide a foundation in how pharmacologically active compounds (drugs) work, explore various classes of pharmaceuticals and how they are discovered and review some of the state-of-the-art research being carried out by the military to maximize combat effectiveness. Selected topics will be explored in the laboratory. *Prereq: SC226 and SC335.*

**SC431 Microbial Chemistry (2-2-3).**

This course will explore the interactions that occur between microbes and their surroundings, including human hosts and extreme environments. Species of these "simple" organisms have evolved diverse mechanisms to combat assault by antibiotics, heavy metals, pollutants and extreme irradiation. The lab component of the class will include identifying, cultivating and testing organisms with survival mechanisms of interest. *Colisted as SB431. Prereqs: SB251 and SC335.*

**SC435 Biophysical Chemistry (3-0-3).**

Phenomena such as ligand binding, protein and nucleic acid folding and structure, biomolecular motion, and membrane structure and function will be studied by examining the intermolecular forces, kinetics and thermodynamics that govern them. Relevant experimental techniques will also be discussed. *Prereqs: SC335 and SC345.*

**SC442 The Chemistry of Propellants and Explosives (2-2-3).**

This course will delve into the structural, physical, and chemical properties of energetic materials. Students will investigate the application of energetic materials to military and civilian uses and will explore methods and processes to detect and characterize energetic materials both before and after use. Laboratory experiments investigating energetic materials and their applications are planned. *Prereq: SC226, SC345.*

**SC446 Quantum Chemistry (3-0-3).**

The principles of quantum mechanics are reviewed and used to develop molecular orbital theory which is applied to the structure and properties of molecules. Modern quantum chemistry software will be used for electronic structure calculations. *Prereq: SC346.*

**SC451 Bioinorganic Chemistry (3-0-3).**

This course will shed light on the structure and function of important bioinorganic compounds (hemoglobin, hydroxyapatite, ATP, etc.) using a host of techniques such as X-ray diffraction and NMR spectroscopy. *Prereq: SC335 and SC356 or permission of instructor.*

**SC476 Capstone Project (0-6-3).** Students in this course undertake projects that require them to bring together and apply multiple aspects of their chemistry education. Oral and written progress reports are required at the end of the semester. *Prereq: 1/C standing or approval of department chair.*

**SC495/6 Research (0-6-3).** This course sequence offers midshipmen the opportunity to conduct original research, under the guidance of a faculty member, over multiple semesters. Oral and written progress reports are required each semester. *Prereq: 1/C standing or approval of department chair.*



## Department of Computer Science

### Computer Science Major

The computer science major gives students a strong foundation in the main areas of computer science with a focus on naval applications.

The computer science program at the Naval Academy is accredited by the Computing Accreditation Commission (CAC) of ABET. During their four years at the Academy, computer science majors will complete 46 semester hours of courses in the major which includes three hours of probability and statistics. Upon graduation, they will be awarded a bachelor of science in computer science.

The Computer Science Department has five large computing laboratories. Two of these labs contain high-end desktop personal computers which are used exclusively for instructional support and are networked for local and remote access. The Graphics and Software Engineering Lab contains SUN workstations. They provide the student with experience using the Unix operating system and workstation levels graphics and software tools. The Information Assurance and Advanced Networks Laboratory provides students with advanced opportunities in computer security, computer warfare and advanced networking concepts. The Robotics Laboratory contains manipulator arms, vision systems, desktop computers and mobile robots. These are used for a variety of hands-on projects using mobile robots.

Today's Navy and Marine Corps require junior officers with the highest levels of technical expertise and professional competence. The computer science major will be well equipped to meet the challenges created by rapidly evolving computer technologies.

#### **Curriculum Requirements** (In addition to the requirements of plebe year)

Professional: NE203, NL302, NL400, NN204, NS310, NS40X;

Mathematics: SM223, SM230C

Science: SP211, SP212;

Humanities: HH215, HH216 and two electives including one at the 300/400 level;

Engineering: EN200, EM300, EE301, EE302, ES300, ES360, and a free elective

Major: SI204, SI221, SI262, SI232, SI321, SI333, SI334, SI411, SI454, SI472, and three major electives.

## Computer Science Courses

**SI200 Information Technology for the Junior Officer** (3-2-4). This is a hands-on lab course introducing computer programming and database management. Topics include: web programming using HTML and XHTML, structured and object oriented computer programming using a scripting language (such as JavaScript) or 4th Generation Language (such as Java or C++), and designing, implementing, and querying databases using a Database Management System (such as Access or SQL Server). The course includes a series of Internet computing and programming projects of increasing complexity. No prior knowledge of databases, web programming, or computer programming is assumed. Students may not receive credit for this course and SI250. It may not count as an SCS major elective and IT majors cannot take this course.

**SI204 Introduction to Computer Science** (3-2-4). Introduction to algorithmic development, problem solving and software design. Principles and concepts to provide foundational knowledge and experience upon which later computer science courses will build. This is the first course for computer science majors. *Prereq: none.*

**SI221 Data Structures** (2-2-3). Data representation and information management. Dynamic memory, recursion, lists, strings, stacks, and queues. Storage structures, allocation and manipulation. *Prereq: SI204.*

**SI232 Computer Architecture and Organization** (4-0-4). Performance metrics, instruction set architectures, assembly language, logic design, memory hierarchies. *Prereq: SI204. Coreq: SI262.*

**SI250 Information Systems for the Junior Officer** (2-2-3). The primary emphasis of the course is practical applications of personal computers and the Internet in the fleet/Fleet Marine Force (FMF), with coverage of some special tactical computers as well. Application software is addressed from a junior officer's viewpoint, as an operational unit Branch/Division/Company Officer or as a support staff member. *Prereq: none.*

**SI262 Discrete Structures** (2-0-2). An introduction to the mathematical foundations of computing through logic, set theory, functions, proofs, counting, relations, propositional logic and Boolean algebra. *Coreq: SI204.*

**SI283 Programming for Engineers** (1-2-2). An introduction to a structured programming language and its use in implementing algorithms to solve engineering problems. *Prereq: none.*

**SI305 Computer Programming** (3-0-3). A programming course for non-majors that makes use of top-down design and software engineering methodology to develop structured algorithms for problem-solving. A high-level language is used to implement the algorithmic designs. *Prereq: none, for non-SCS majors.*

**SI321 Advanced Data Structures** (3-2-4). Advanced OO design, including abstract classes, polymorphisms, templates and inheritance. Advanced data structures including trees, heaps, priority queues and graphs. Graph algorithm analysis. *Prereq: SI221 and SI262.*

**SI333 Algorithms and Functional Languages** (4-0-4). Presents techniques for designing and analyzing computer algorithms including divide and conquer, dynamic programming and greedy methods. Introduces classic algorithms for problems such as searching and sorting, graph analysis, file compression and cryptology. Coverage of functional programming paradigm. *Prereq: SI321.*

**SI 334 Software Engineering** (4-0-4). An introduction to the basic principles of software engineering. Structured, object-oriented, and formal approaches are studied, with emphasis on life cycles, object-oriented techniques and team-oriented software development. *Prereq: SI321 and SI411.*

**SI411 Operating Systems** (3-0-3). The study of the operating system as a resource manager. Topics include: process management, interrupt processing, memory management, deadlock handling, files systems, multiprogramming, multiprocessing, data security and protection. *Prereq: SI221 and SI232.*

**SI412 Compiler Construction** (3-0-3). Using formal programming language theory as a foundation, the issues of automated theory, program optimization and language translation are examined. Sections of actual compilers are constructed to study the practical application of theory presented. *Prereq: SI333.*

**SI420 Artificial Intelligence** (3-0-3). A study of the fundamental concepts and techniques in the design and implementation of functionally intelligent machines. Topics include problem-solving using state-space search, problem-reduction techniques, game trees, general problem solver; and knowledge representation using production systems, first-order predicate calculus and natural language. *Prereq: SI333.*

**SI430 Fundamentals of Microcomputer Systems** (2-2-3). Analysis and design of software systems for micro-processors. Includes characteristics and organization of microprocessors, peripheral interface software and applications of software design. *Prereq: SI232 and SI321.*

**SI435 Advanced Software Engineering** (2-2-3). This course presents the latest trends in modern techniques and methods for large-scale software development activities, such as object oriented programming. The use of CASE tools and group design project is stressed. *Prereq: SI334.*

**SI440 Database Organization** (3-0-3). Topics include database systems architecture, the various approaches to database organization including relational, hierarchical and network models; normalization and implementation issues. *Prereq: SI321.*

**SI452 Advanced Computer Architecture** (3-0-3). This course provides an advanced study of the design and evaluation of high performance computer systems. *Prereq: SI232.*

**SI454 Computer Networks** (3-0-3). The course presents major topics in the area of computer networks. It views a computer network as a group of related layers or abstract machines as exemplified by the International Standards Organization (ISO) network reference model and Internet Layer Model. The course presents the basic concepts necessary to understand the design and operation of computer communication networks. *Prereq: SI232, SI321, and SM230C.*

**SI455 Advanced Computer Networks** (3-0-3). This course provides an in-depth technical study of high-speed networking, client-server programming and applications, network firewall architectures and security procedures, and the ATM network. *Prereq: SI454.*

**SI457 Information Assurance (2-2-3).**

The course provides an introduction to the theoretical and practical facets of Information Assurance including secure operating systems, public key cryptography, system and network security, and offensive and defensive information warfare operations. Laboratory work will include student exercises demonstrating information assurance concepts. *Prereq: SI411 and SI454.*

**SI460 Computer Graphics (2-2-3).** A project-based course involving basic concepts, theories and algorithms associated with producing 2D and 3D images on a raster display. Topics include graphics primitives, modeling, viewing, illumination, shading, texture, and event-driven programming using a graphics API. *Prereq: SI262 and SI321.*

**SI462 Advanced Computer Graphics**

(2-2-3). A project-based course involving advanced graphics techniques such as ray-tracing, radiosity, volume rendering, virtual and augmented reality haptics, and pixel shaders. *Prereq: SI460.*

**SI472 Theory of Computing (3-0-3).** Presents the theoretical foundations for computing, including the study of finite state machines, pushdown automata, and Turing machines. *Prereq: SI321.*

**SI475 Robotics and Computer Vision** (2-2-3). Presents the concepts and theories related to computer-driven robotic systems and computer-based vision systems. Students apply acquired knowledge in a laboratory setting by designing, coding, and testing robotics control and vision systems. *Prereq: SI221.*





## Information Technology Major

The Information Technology (IT) major prepares midshipmen as critical catalysts for tomorrow's Naval service, serving as leaders in a network centric world and experts in leveraging leading edge technology to solve operational problems. IT majors bridge the gap between technology and its use in the Navy.

The curriculum has two principal components: a core of 10 courses in information technology and a collection of five courses in a second discipline. The core includes courses in programming, data structures, computer organization, information systems, networks, databases, information assurance, Web and Internet computing, and the history of information technology. A particular emphasis is placed on applications of the concepts introduced in these courses. The second discipline allows midshipmen to diversify their education while introducing them to an area in which they are required to apply their IT skills. A capstone course provides the midshipmen with an opportunity to bring these skills to bear on a problem in the second discipline. In principle, any department can develop a second discipline offering. Among the several second disciplines that have been developed to date are Information Technology Management, Computational Science and Engineering, Environmental Applications, History, National Security Affairs, Microeconomics, Macroeconomics, Linguistics, and Space Operations.

### **Curriculum Requirements** (In addition to the requirements of plebe year)

Professional: NE203, NL302, NL400, NN204, NS310, NS40X;

Mathematics: SM223, SM230C;

Science: SP211, SP212;

Humanities: HH215, HH216, and two additional electives including one at the 300/400 level;

Engineering: EE301, EE302, EM300, EN200, ES300, ES360;

Other: Free elective;

Major: HH220, IT300, IT310, IT320, IT340, IT420, IT430, IT440, SI204, SI221,  
five courses in Second Discipline.

## Information Technology Courses

**IM210 Information Technology Management (3-0-3).** This course provides the necessary background to enable management information systems personnel to understand tradeoffs in information systems hardware, software, and architecture for effective use in a variety of organizational environments. Topics covered include information technology planning and strategy, trends in computer hardware and systems software, telecommunications and network management, control and management of information resources, distributed and client-server technologies, and data representation and visualization. *Prereq: SI204.*

**IM330 Decision Support Systems (3-0-3).** This course focuses on the decision making process using process models, bounded rationality and its implication for satisfying vs. optimizing behavior. It discusses heuristics commonly used by humans and the systematic types of errors that are a consequence of using these heuristics. The A component on modeling technologies will discuss decision analysis techniques such as decision trees, influence diagrams, optimization models and multi-criteria decision-making. This course is a standard in business oriented IT curricula and adds another dimension and set of tools for the IT320 Systems Analysis and Design course. *Prereq: IM210.*

**IM360 Information Resources Management (3-0-3).** This course investigates in depth the relationships between organizational policy and institutional information requirements in the context of competitive strategy. It examines the way information technology is used to influence that strategy and to assess the impact of strategic deployment of information systems. Using actual case studies, it explores organizational use of information technology to influence competitive strategy in relation to the environment, competitors, customers, and suppliers. *Prereq: IM221 or IT221.*

**IM450 Enterprise Computing (2-2-3).** This course develops architectures and concepts for the development of multi-tier (typically 3-tiered) distributed applications for an entire organization or enterprise. This includes a user interface called the client tier or tier 1, a server component which is controlled by the organization and provides for interaction with and data collection from the user (tier 2) and a database component that stores transactions and updates client profiles (tier 3). The course teaches advanced techniques

for network programming as well as server management and programming. *Prereq: IT340 and IT420.*

**IM480 IT Research Seminar (3-0-3).** This course is the culmination of the IT major and brings together the IT core and the IM second discipline in a major capstone experience that ties the two components together in a significant prototype organizational IT system. The concurrent IM450 provides the concept and tools necessary for development of the capstone. The IT 340 Networks course, the IT430 Information Assurance course and the IT420 Database course provide essential knowledge for this capstone project. The student must deliver a working system.

**IT221 Data Structures (2-2-3).** Introduction to object-oriented programming, and data structures including lists, stacks, queues, trees and graphs, and sorting, searching and hashing techniques. *Prereq: SI204.*

**IT300 Computer Architecture and Organization (3-0-3).** An in-depth, non-engineering introduction to concepts and theories related to computer hardware, systems software, and data concepts including operating system design and peripheral connectivity. This course builds an understanding of the planning, design, use, and performance of computer systems. *Prereq: IT221.*

**IT320 Systems Analysis and Design (3-0-3)** Introduction to concepts and methods used in analyzing and designing information technology systems. Topics include: assessing system requirements; interviewing/testing techniques; learning introduction to Computer Aided Software Engineering (CASE) tools and methodologies; Systems

Development Life Cycle, which is a systematic and orderly approach to solving business problems through the implementation of technology developing information Systems Analysis and Design documents, and forming teams that allow students to get hands-on experience in developing Information Systems Analysis and Design documents. Using case studies, the students gain real-life experience in analyzing and designing systems, as well as working in teams. *Prereq: IT340, IT 350, and IT420.*

**IT340 Introduction to Networks (2-2-3).** Analyze and explain the development and use of computer and telecommunications networks in modern society. Evaluate the strengths and weaknesses of network solutions. Identify new and emerging technologies and communications concepts applied in the contemporary network industry and illustrate their application to the delivery of information services. Examine the management implications of networks. A student may not receive credit for both IT340 and SI454. *Prereq: IT221 and IT300.*

**IT350 Web and Internet Programming (2-2-3).** Web site design and management, scripting languages for web development, servers and clients, webs with database support. *Prereq: IT221; Coreq: IT300.*

**IT420 Database Management and Organization (2-2-3).** This course will introduce the principles underlying Database Management Systems (DBMS) with a special emphasis on database management system structure and function when integrated with web-based applications. A student may not receive credit for both IT420 and SI440. *Prereq: IT221 or SI221.*

**IT430 Introduction to Information Assurance (2-2-3).** This course is an introduction to the theoretical and practical facets of Information Assurance (IA) to include: Department of Defense (DoD)/Department of Navy (DoN) policies and directives, Trusted systems, Access mediation, Cryptography, Public Key Infrastructure (PKI), Information Warfare, Network security and Database security. *Coreq: IT340.*





## Department of Mathematics

### Mathematics Major

The mathematics major (<http://www.usna.edu/Math Dept.>) teaches logical and critical thinking; fundamental abilities that are invaluable to naval and marine officers. Mathematics plays a central role in virtually every technical and scientific field and is crucial in modern, accurate models of the environment. Mathematics provides training in analyzing problems, formulating methods of attack, and expressing results in a clear and logical manner. These same skills are applied aboard a ship or submarine, inside a fighter jet and in all military communities. The mathematics major also provides an excellent foundation for graduate work in any technical field as well as in business or law.

The Navy and Marine Corps have a great need for officers with problem-solving capabilities. The preparation the mathematics majors receive in studying problems analytically and in pursuing logical solutions is invaluable in nuclear training, in advanced engineering and in the fleet. Successful completion of the mathematics major provides the background and skills to excel in areas where mathematics is applied.

Elective courses offer the opportunity to study a wide variety of topics such as operations analysis, fluid flows, cryptography, chaos, wavelets, fractals, target motion analysis, submarine tactics, elliptic curves, computer arithmetic, and geometric tomography for medical diagnosis. The mathematics honors program allows selected students to do in-depth research in such fields. The Mathematics Department consists of about 60 faculty members, actively engaged as a whole in state-of-the-art research in mathematics and its applications. About 17 military officers on the faculty bring first-hand experience in applying mathematics and mathematical thinking to specific Naval and Marine Corps problems. The civilian faculty devotes a substantial time to current research in various specialty fields in pure and applied mathematics, as well as in operations research.

#### **Curriculum Requirements** (In addition to the requirements of plebe year)

Professional: NE203, NL302, NL400, NN204, NS310, NS40X;

Science: SP211, SP212;

Humanities: HH215, HH216 and two electives including one at the 300/400 level;

Engineering: EE301, EE302, EN200, EM300, ES300, ES360; plus mathematics, science or engineering elective

Mathematics: SM221 or SM251, SM222;

Major: SM261, SM239, SM291, SM331, SM332, SM339, SM342 or SM362, SM365, plus four major electives including at least one at the 400 level; one free elective.

## General Science Major

The major in general science gives students the opportunity to pursue a broad, scientifically-oriented program in the field of physical applications of mathematics and science. The major permits midshipmen to experience an interdisciplinary technical program without the need for specialization. A bachelor of science degree is awarded.

### Curriculum Requirements (In addition to the requirements of plebe year)

Professional: NE203, NL302, NL400, NN204, NS310, NS40X;

Mathematics: SM221 or SM223, SM230;

Science: SP211, SP212;

Humanities: HH215, HH216 and two electives including one at the 300/400 level;

Engineering: EN200, EM300, EE301, EE302, ES300, ES360, and a free elective;

Major: NP340, SA302, SI202, SB251, SM212, SO231, SO244, SP301, SP411, a free elective, and two math/science/engineering electives.





## Quantitative Economics Major

The major in quantitative economics is interdisciplinary, focusing on applications of mathematics to economic reasoning and economic problems. The major provides students with a broad set of mathematical tools and a solid background in economic theory. About half of the courses required are taken in economics; the other half are in mathematics. The major is jointly administered by the Departments of Mathematics and Economics. A bachelor of science degree is awarded.

**Curriculum Requirements:** (In addition to the requirements of plebe year)

Professional: NE203, NL302, NL400, NN204, NS310, NS40X;

Mathematics: SM223 and SM239;

Science: SP211, SP212;

Humanities: HH215, HH216 and two electives, including one at the 300/400 level.

Engineering: EN200, EM300, EE301, EE302, ES300, ES360, and a free elective

Major: FE210, FE341, FE363, FE445, SM261, SM279, SM339, SA401, SA475E, and five major electives.

## Mathematics and Operations Analysis Courses

### Mathematics Courses

**SM005 Pre-Calculus Mathematics** (4-1-4). Basic review of algebraic and arithmetic operations, analysis of functions and their graphs, and trigonometry. This course may be required in addition to stated graduation requirements for certain midshipmen. *Prereq: Placement by department chair.*

**SM121 Calculus I** (4-0-4). The first of a traditional two-course sequence covering differential and integral calculus of one real variable and infinite series. *Prereq: none.*

**SM122 Calculus II** (4-0-4). Continuation of Calculus I. *Prereq: SM121 or SM131 or SM161.*

**SM131 Calculus I** (3-0-3). The first of a traditional two-course sequence covering differential and integral calculus of one real variable and infinite series for students who have prior differential calculus experience. *Prereq: Placement by department chair.*

**SM161 Calculus with Computers I** (5-0-5). The first of a two-course sequence presenting an algorithmic development of the differential and integral calculus of one real variable and an introduction to programming. *Prereq: Permission of the department chair.*

**SM162 Calculus with Computers II** (5-0-5). Continuation of SM161. *Prereq: SM161.*

**SM202 Elements of Differential Equations** (3-0-3). Linear and simultaneous differential equations, partial differential equations and Fourier series. *Prereq: SM221 or SM223.*

**SM212 Differential Equations** (4-0-4). Linear and simultaneous differential equations, solution by Laplace transform; partial differential equations and Fourier series. *Prereq: SM221 or SM223.*

**SM219 Statistics and Probability** (3-0-3). Nature of statistical methods, description of data, probability, distributions, estimation, tests of hypothesis, correlation, regression. Credit cannot be given for SM219 if credit has been given for SM230 or SM239. *Prereq: SM122 or SM162.*

**SM221 Calculus III with Vector Fields** (4-0-4). Differential and integral calculus of several real variables; vector analysis

including integral theorems. *Prereq: SM122 or SM162.*

**SM222 Differential Equations with Matrices** (4-0-4). A more rigorous treatment of material from SM212, the course uses basic ideas from linear algebra. Intended for mathematics and quantitative economics majors. *Prereq: SM221 or SM223; Coreq: SM261.*

**SM223 Calculus III with Optimization** (4-0-4). Differential and integral calculus of several real variables; vector analysis; optimization techniques for functions of several variables. *Prereq: SM122 or SM162.*

**SM230 Probability with Naval Applications** (3-0-3). An elementary treatment of the basic concepts of probability with an emphasis on naval applications. Sample spaces, discrete and continuous random variables and standard distributions. Selected topics of naval applications of probability theory such as random search, minefields and lateral range curves. Conditional probability and Bayes' theorem. *Prereq: SM122 or SM162.*

**SM233 Introduction to Applied Mathematics** (2-2-3). This course introduces student to several fundamental topics in applied mathematics: simulation and statistical modeling, applications of linear algebra, partial differential equation models, and computational tools and topics. Appropriate computer software will be introduced. *Prereq: SM221 or SM223 and SM261.*

**SM239 Probability and Statistics I** (3-0-3). A more rigorous treatment of material in SM230 for advanced work in mathematics, operations research, science and engineering. Credit cannot be given for both SM230 and SM239. *Prereq: SM221 or SM223.*

**SM259 Mathematical Logic** (3-0-3). Mathematical languages, formal logic, propositional calculus and truth tables, first order predicate calculus, proof theory, axiomatic systems and model theory. Applications to logical networks and nonstandard analysis. *Prereq: SM122 or SM162.*

**SM261 Matrix Theory** (3-0-3). Matrices, transformations, linear equations, vector spaces, characteristic matrix, eigenvalues, orthogonality. *Prereq: SM122 or SM162.*

**SM265 Introduction to Experimental Mathematics** (2-2-3). This course provides an introduction to the idea of mathematics as an experimental science. The topics covered include the introduction of linear algebra and

differential equations, and the use of software packages to solve problems in these fields. The software packages (currently MATLAB and Maple or Mathematica) will be used in subsequent course in the CSE Second Discipline. Numerical, graphical and symbolic computations are included. *Prereq: SM221 or SM223.*

**SM271 Linear Programming** (3-0-3). Simplex and dual simplex methods, minimax theorem, transportation problems and game theory. *Prereq: SM122 or SM162.*

**SM279 Multivariable Calculus** (3-0-3). An introduction to the geometry and analysis of n-dimensional space, including topics on multidimensional curves, inner products, linear functions, real valued functions, Taylor approximations, optimization, inverse function theorem, implicit function theorem, and change of variables in integration. Applications to economics and physics will be discussed. *Prereq: SM221 or SM223 and SM261.*

**SM280 Topics in Mathematics** (1-0-1). An overview and sampling of topics from a variety of mathematical disciplines including both tracks of the mathematics major. Students will be exposed to the power, beauty, and utility of mathematics. *Prereq: SM122 or SM162.*

**SM291 Fundamentals of Mathematics I** (3-0-3). Introduction to mathematical reasoning and the written and oral presentation of mathematical concepts, theory, and application of sets and relations. *Prereq: SM122 or SM162.*

**SM311 Engineering Mathematics I** (3-0-3). Vector analysis, Fourier analysis, partial differential equations, Sturm-Liouville problems, Legendre polynomials, determinants, and matrices. *Prereq: SM212 or SM222.*

**SM311O Engineering Mathematics I** (3-0-3). Vector analysis, Fourier analysis, partial differential equations with emphasis on stream and potential functions, conservation of mass, conservation of linear momentum (Navier-Stokes Equations) in rectangular and rotating coordinate systems. *Prereq: SM212 or SM222.*

**SM311P Mathematical Models for Physics** (3-0-3). A course in mathematics applicable to physics. Includes topics from the following areas: linear (vector) algebra, linear (vector) analysis, boundary value problems and variational calculus. *Prereq: SM212 or SM222.*

**SM312 Engineering Mathematics II** (3-0-3). Laplace and Fourier transforms, selected topics from complex variables. *Prereq: SM212 or SM222.*

**SM313 Engineering Mathematics III** (3-0-3). Fundamental topics from calculus-based probability theory (discrete and continuous random variables, multivariate distributions, expected values, and the Central Limit Theorem) and from linear algebra and matrix theory (matrix operations, Gaussian elimination, linear independence, eigenvalues, and solutions to systems of ordinary differential equations) suitable for applications in engineering. Does not count as a major elective for Mathematics major. *Prereq: SM212 or SM222.*

**SM314 Engineering Mathematics with Statistics** (4-0-4). Basic concepts in probability and statistics, Laplace transforms, Fourier analysis, and complex variables with applications. Does not count as a major elective for Mathematics majors. *Prereq: SM212 or SM222.*

**SM315 Introduction to Partial Differential Equations** (3-0-3). Linear equations, Cauchy problems, Laplace and Poisson equations, boundary value problems, heat equations, Sturm-Liouville problems, and orthonormal expansions. *Prereq: SM212 or SM222.*

**SM316 Engineering Mathematics with Probability and Statistics** (3-0-3). Basic concepts in probability and statistics, Fourier analysis, and complex variables with applications. Does not count as a major elective for the Mathematics major. *Prereq: SM212 or SM222.*

**SM321 Topics in Applied Mathematics** (3-0-3). Junior level topics in applied mathematics. The content will vary in order to keep abreast of new ideas and approaches.

**SM331 Advanced Calculus I** (4-0-4). Real numbers, sequences, limits of sequences, limits of functions, continuity, properties of continuous functions, differentiability, Riemann Integral, series, power series. *Prereq: SM261 and SM291.*

**SM331H Real Analysis I** (4-0-4). Honors versions of SM331 and SM332. *Prereq: Approval of Mathematics Department Honors Committee.*

**SM332 Advanced Calculus II** (4-0-4). Continuation of Advanced Calculus I. See description of SM331 for topics. *Prereq: Advanced Calculus I.*

**SM332H Real Analysis II** (4-0-4). Honors version of SM332. *Prereq: Approval of Mathematics Department Honors Committee.*

**SM334 Elements of Advanced Calculus** (3-0-3). This course is a continuation of SM331. Together the courses cover logic, induction, sequences, limits, real numbers, series, continuity, differentiability, properties of continuous functions, the Riemann Integral, and power series. *Prereq: SM331.*

**SM339 Applied Statistics I** (3-0-3). An applied study of a variety of statistical methods used in obtaining, presenting, summarizing and analyzing statistical information. Included are strategies for data collection and presentation, and techniques of statistical inference for population, parameters based on the concepts of sampling, probability and distribution theory. *Prereq: SM239 and SM261.*

**SM342 Discrete Structures** (3-0-3). Foundations and methods of proof. Combinatorics, graph theory, group theory. Selected topics. *Prereq: SM122 or SM162.*

**SM362 Modern Algebra** (3-0-3). Integers, groups, mappings, rings, fields. *Prereq: SM261 and SM291.*

**SM365 Introduction to Scientific Computing** (4-0-4). Computer arithmetic and errors; algorithms and programs for: iterative solution of equations, linear systems of equations, function approximations, numeric integration, and the numerical solution of ordinary differential equations; an introduction to programming. *Prereq: SM261.*

**SM411 Introduction to Complex Variables** (3-0-3). Algebra and topology of complex numbers. Elementary functions. Complex derivative and integral. Theorems of Cauchy. Analytic functions, conformal mappings, Taylor and Laurent series, singularities, residue theory, analytic continuation. Applications to real analysis and physical problems. *Prereq: SM331.*

**SM415 Mathematical Modeling of the Ocean and Atmosphere** (3-0-3). Vector analysis, Fourier analysis, partial differential equations with emphasis on stream and potential functions, conservation of mass, conservation of linear momentum (Navier-Stokes Equations) in rectangular coordinate systems. use of MATLAB to solve applied problems in oceanography and meteorology. *Prereq: SO414 or permission of instructor.*

**SM421 Topics in Applied Mathematics II** (3-0-3). Senior level topics in applied mathematics. The content will vary in order to keep abreast of new ideas and approaches.

**SM425 Advanced Numerical Analysis** (3-0-3). Numerical solution of equations in one and several variables, direct and iterative algorithms, rate of convergence. Computer methods emphasized. *Prereq: SM212 or SM222 and SM331 or approval of department chair.*

**SM426 Numerical Methods for Differential Equations** (3-0-3). Interpolation and polynomial approximation, numerical integration and differentiation, numerical algorithms for initial value and boundary value problems. *Prereq: SM212 or SM222 and SM331 or approval of department chair.*

**SM439 Topics in Statistics** (3-0-3). Senior level topics in statistics. The content will vary in order to keep abreast of new ideas and approaches. *Prereq: SM339.*

**SM444 Discrete Structures II** (3-0-3). Topics in combinatorics and graph theory, with applications. Latin squares, linear algebra and combinatorics, finite projective planes, topological graph theory, Ramsey theory, trees. *Prereq: SM342.*

**SM461 Linear Algebra** (3-0-3). Vector spaces, linear transformations, Jordan canonical form, inner product spaces. *Prereq: SM261 and SM331.*

**SM462 Algebraic Structures** (3-0-3). Groups, rings, fields, Galois theory. *Prereq: SM362 and SM331.*

**SM463 Topics in Analytical/Discrete Mathematics** (3-0-3). Senior level topics in pure mathematics. The content will vary in order to keep abreast of new ideas and approaches.

**SM464 Topology** (3-0-3). A mathematical analysis of topological spaces, separation axioms, covering properties, and metric spaces. *Coreq: SM332.*

**SM465 Advanced Differential Equations** (3-0-3). Existence and uniqueness of solutions to ordinary differential equations. Stability, oscillation, dynamical systems. *Prereq: SM212 or SM222; Coreq: SM332.*

**SM472 Projects in Mathematics** (3-0-3). This course is a capstone course for the mathematics track of the mathematics major. Students will read and make presentations on topics determined by the instructor. Each student will complete a project on a topic to

be agreed upon by the instructor and student. Students will present their results in writing and orally. *Prereq: 1/C Math Major or approval of the department chair.*

**SM474 Projects in Applied Mathematics** (3-0-3). This course is a capstone course for the applied mathematics track of the mathematics major. Students will read and make presentations on topics determined by the instructor. Each student will complete a project on a topic to be agreed upon by the instructor and student. Students will present their results in writing and orally. *Prereq: 1/C Math Major or approval of the department chair.*

### Operations Analysis Courses

**SA302 Analysis of Naval Tactics** (3-2-4). An introduction to the techniques of modeling and quantitative analysis applied to specific naval operational problems, including search and patrol, screening, anti-air warfare, mining, equipment reliability and decision rules. Does not count as major elective for Mathematics majors. *Prereq: SM239 or SM230.*

**SA367 Introduction to Mathematical Modeling** (3-0-3). Realistic problems, often of military interest, are formulated mathematically and solved using techniques from probability, statistics, calculus and differential equations. The analysis is carried out by students working in small teams and individually. Solutions are presented in oral nontechnical briefings and in written technical reports. *Prereq: SM239 or SM230.*

**SA401 Linear Models and Optimization** (3-0-3). Investigation of fundamentals of linear optimization subject to constraints, including construction and analysis of linear programming and network problems. *Prereq: SM261.*

**SA402 Dynamic and Stochastic Models** (3-0-3). Investigation of quantitative analysis of decision options, including PERT/CPM, dynamic programming, Markov chains and queuing theory. Applications to typical operations are stressed. *Prereq: SM239 or SM230 and SM261.*

**SA410 Applications of Search and Detection Theory** (3-0-3). Considerations in picking a measure of effectiveness (MOE) for use in analyzing decision options and decision criterion are studied. The focus of the course is the analysis of search and detection operations, particularly as they arise in anti-submarine operations, using probability models. Barrier detection, area search and parallel sweep operations models are developed. Additional topics in mine warfare, target coverage models, anti-air warfare, and target motion analysis may be picked for study by the instructor. Credit cannot be given for both SA302 and SA410. *Prereq: SM239 or SM230.*

**SA421 Simulation Modeling** (3-0-3). Discrete simulation of systems using a simulation language. Includes random number generation, validation and verification of simulations, input and output data analysis. Semester projects are done as part of an analysis team. *Prereq: SM339.*

**SA430 Logistics** (3-0-3). Investigation of techniques of operations analysis applicable to the solution of problems in reliability, maintainability, availability and inventory. *Prereq: SM239.*

**SA442 Applied Statistics II** (3-0-3). A continuation of SM339 that includes examination, evaluation and application of advanced statistical methods. Techniques studied include sampling, nonparametric analysis, simple and multiple regression, correlation, analysis of variance and decision theory. *Prereq: SM339.*

**SA475E Research Seminar in Quantitative Economics** (3-0-3). Directed research on a specific topic. Capstone course for Quantitative Economics majors. Emphasis on empirical work using computers. *Prereq: 1/C SQE major.*





## Department of Oceanography

### Oceanography Major

The oceanography major gives future naval officers practical and theoretical knowledge of the ocean environment and builds a sound academic foundation for future graduate study in any technical discipline. An interdisciplinary science major, oceanography involves the study of meteorology, geophysics, physics, chemistry, biology and geology as they relate to the ocean environment. Basic courses in these areas are prerequisites for more advanced oceanography and meteorology courses. Students take courses in sound propagation in the ocean, the study of waves and tides, and the use of satellites in oceanography. A course in advanced biological oceanography offers a glimpse of the undersea world and its marine creatures; synoptic meteorology courses involve hands-on weather forecasting experience using the latest tools available. More than 25 percent of the required course load is within the oceanography specialty. Other courses include advanced mathematics, necessary to describe the complex behavior of fluid environments. A bachelor of science degree is awarded. An honors program with a designated honors degrees available for selected students.

The Naval Academy boasts the most extensive undergraduate oceanographic facilities in the country. Located on a pier adjacent to the mouth of the Severn River, the Hendrix Oceanography Laboratory is a multi-function enclosure featuring a wet laboratory where students study the world's largest estuary, the Chesapeake Bay. Midshipmen have the opportunity to participate in a three-week oceanography cruise during the summer training period. The academy's oceanographic research vessel enables midshipmen to collect samples and oceanographic data afloat and deliver them to the department's shore labs. Another laboratory complex in Rickover Hall houses the geological, biological, chemical, general oceanographic and remote sensing laboratories. A separate meteorological laboratory has an on-line receiver to display charts from the National Oceanic and Atmospheric Administration and the Naval Meteorology and Oceanography Command, direct access to the World Meteorological Organization's data network, a color weather radar display, and a high resolution satellite receiver, all of which can be accessed via computer workstations. Students use all of these facilities in required courses as well as in their electives.

#### **Curriculum Requirements** (In addition to the requirements of plebe year)

Professional: NE203, NL302, NL400, NN204, NS310, NS40X;

Mathematics: SM221, SM219, SM212, SM311O;

Science: SP211, SP212, SP411;

Humanities: HH215, HH216 and two electives including one at the 300/400 level;

Engineering: EN200, EM300, EE301, EE302, ES300, ES360, and a free elective;

Major: SO231, SO234, SO244, SO345, SO414, SO416, plus four major electives.

## Oceanography Courses

**SO221 Introduction to Oceanography** (3-0-3). A descriptive course designed to provide an overview of significant oceanographic factors and their impact on engineering applications. *Prereq: Non-SOC majors only.*

**SO231 General Oceanography I** (3-2-4). A descriptive survey of and introduction to geological, chemical and physical oceanography. Course content spans subjects such as sea floor spreading, properties and composition of seawater and ocean currents and water masses. A historical perspective is provided. Laboratory exercises concentrate on Chesapeake Bay parameters as seasons change. *Prereq: none.*

**SO234 General Oceanography II** (2-2-3). Continues introduction to physical oceanography, with emphasis on the interactions of physical processes in the oceans: geological, biological and chemical. Sediment distribution, characteristics, classification and sedimentation processes; marine volcanism and diagenesis; chemical properties of sea water, marine cycles and distribution of nutrients and gases in the oceans; marine productivity, diversity and the strategies employed by productivity, diversity and the strategies employed by marine organisms are included. *Prereq: SO231.*

**SO244 Basic Atmospheric Processes** (2-2-3). An introductory course designed for oceanography majors, as well as those interested in taking advanced meteorological electives. This course treats the basic meteorological variables and instruments used for atmospheric measurements, physical processes governing the sun-earth-atmosphere thermal system, basic atmospheric thermodynamics, the chemical and temperature structure of earth's atmosphere, cloud and precipitation physical processes, basic atmospheric circulations and accompanying weather and climatic patterns, as well as an introduction to common meteorological data products used in weather analysis and prediction. *Prereq: none.*

**SO335 Oceanographic and Meteorological Quantitative Method** (2-2-3). A course to expose students to products and datasets that are available in oceanography and meteorology and techniques for manipulating the data to arrive at a better quantitative understanding to the oceans and the atmosphere. *Prereq: SM221, SO231 and SO244.*

**SO345 Atmospheric Thermodynamics** (3-2-4). A study of the thermodynamic and kinematic properties of the atmosphere, including the effects of temperature, moisture and wind processes, introduces the forces responsible for atmospheric motions. This course uses thermodynamic diagrams for analyzing vertical profiles of atmospheric variables, as well as conventional and remotely-sensed data to analyze horizontal distributions of meteorological fields. *Prereq: SO244.*

**SO345H Honors Atmospheric Thermodynamics** (3-2-4). Course is an advanced version of SO345 for honor students and includes laboratory exercises which will make extensive use of the Matlab computer system and applications software for meteorology. *Prereq: SO244.*

**SO414 Oceanic and Atmospheric Processes** (3-2-4). Fundamental equations of motion governing the dynamics of quasi-horizontal, inviscid and viscous fluid flow on the rotating earth are developed. Scale analyses of the basic hydrodynamic equations are used to identify forces responsible for motions of interest. Basic numerical modeling techniques for both oceanic and atmospheric processes are introduced. *Prereq: SO345 and SM3110.*

**SO416 Waves and Tides** (2-2-3). The dynamics of surface, internal, and capillary waves; wave statistics and spectrum; principles of wave forecasting; tide generating forces and tidal prediction; seiches, bores and surges are mathematically analyzed. *Prereq: SO414.*

**SO422 Nearshore Oceanography** (2-2-3). Examines the oceanographic regime from the continental shelf break to the intertidal zone and coastal dunes. Concentrates on shallow water wave, surf and beach processes. Includes a discussion of coastal management and engineering procedures. *Prereq: SO231 or SO221.*

**SO426 Polar Oceanography** (2-2-3). A descriptive course which covers the history of polar exploration as well as the physical oceanography and meteorology of the polar regions with particular emphasis on the role of sea ice in global warming studies. Current DoD polar programs will be reviewed including the following: Deep Freeze, International Ice Patrol and Navy operations such as ICEX and TEAMWORK. *Prereq: SO221 or SO231.*

**SO427 Introduction to Estuarine Oceanography** (2-2-3). The physical, geological and biological aspects of the estuarine environment are studied. Laboratory sessions, which include YP cruises and field trips, focus on practical and hands-on applications. Environmental issues such as water quality and pollution are discussed. The use of numerical models as a tool is explored. *Prereq: SO221 or SO231.*

**SO431 Environmental Remote Sensing** (2-2-3). An overview is given of the various platforms and sensors currently in use and planned. The electromagnetic spectrum and radiation laws are explained. Applications exercises give "hands-on" experience with image processing systems. *Prereq: SO221 or SO231.*

**SO432 Geographical Information Systems** (2-2-3). Offers a general presentation of the fundamentals of hydrographic surveying, including geodesy, precise positioning afloat, error theory, depth measurement, tidal observations and shoreline mapping. The course includes practical applications of hydrographic surveying methods. *Prereq: SO221 or SO231.*

**SO441 Synoptic Meteorology** (2-2-3). A practical course in meteorological analysis and forecasting as applied to operational planning. A variety of meteorological datastreams available in the computerized Meteorology Laboratory are used to analyze and predict the current and future state of the atmosphere. *Prereq: SO244.*

**SO442 Tropical Meteorology** (2-2-3). A study of the special processes affecting meteorological analysis and forecasting in the tropics, including satellite imagery analysis, with particular emphasis on hurricane or typhoon prediction, creation, movement and decay. *Prereq: SO244.*

**SO445 Global Climate Change** (2-2-3). Global climate past and present is examined from the modern records using satellites, land/sea observations, ice cores, etc. Different global change model scenarios are presented and discussed for future climate - Earth Watch. Also studied are present day climate topics, such as the Ozone Hole, Greenhouse Effect and El Nino. *Prereq: SO244.*

**SO451 Biological Oceanography (2-2-3).** A study of patterns and concepts of biological production in the ocean. Emphasis is on the integration of the biological and physical environment. Laboratory includes student planned studies and conceptual exercises. All aspects of the course emphasize the use of various knowledge areas to solve a problem. *Prereq: SO234.*

**SO461 Geological Oceanography (2-2-3).** Introduces marine geological/geophysical instrumentation, theory, data collection, analysis, interpretation and applications. Geomorphology, structure, petrology, sedimentation, stratigraphy, origin and development of ocean basins and margins are examined in light of theory of plate tectonics. Practical studies of the Chesapeake Bay are part of the laboratory work. *Prereq: SO234.*

**SO470 Capstone Seminar (3-0-3).** A course for SOC majors to provide guidance on the construction of the Capstone Paper and the oral presentation of the Capstone Paper. The course will include background readings and corresponding discussions, and instruction on scientific writing and presentation. The

course culminates in the production of the Capstone Paper and the oral presentation of the Capstone Paper. Four versions of this course are offered: SO470A Capstone seminar in Biological Oceanography, SO470B Capstone seminar in Geology and Geographical Information Systems, SO470C Capstone seminar in Meteorology, and SO470D Capstone seminar in Physical Oceanography. *Prereq: 1/C Oceanography Major.*

**SO503 Honors Modern Methods in Oceanography and Meteorology (2-2-3).** Statistical methods and techniques applied to research topics, oceanographic and laboratory instrumentation, remote sensing and mathematical modeling. Discussion of current research topics. Prepares students to undertake independent research in oceanography or meteorology. *Prereq: 2/C Honors Oceanography Major.*

**SO505 Honors Independent Research (0-6-3).** Independent research in oceanography or meteorology on a subject of the student's choice, culminating in a written report and a presentation to the faculty. *Prereq: SO503 and SOCH major.*

**SO506 Honors Independent Research (0-6-3).** Independent research in oceanography or meteorology on a subject of the student's choice, culminating in a written report and presentation to the faculty. *Prereq: SO503 and SOCH major.*

**SO513 Honors Oceanic and Atmospheric Processes (3-2-4).** Course is an advanced version of SO414 for honors students. *Prereq: SM311O and S0345H.*

**SO516 Honors Waves and Tides (2-2-3).** Course is an advanced version of SO416 for honor students. *Prereq: SO513 and SOCH major.*





## Department of Physics

### Physics Major

The major program in physics presents fundamental physical concepts and principles in such a manner as to emphasize their general usefulness and lays a strong foundation for further work in a broad range of technical fields. The challenge of physics lies in uniting its laws and definitions, expressed through mathematics, with the integrative reasoning so essential in modeling and solving new problems. A bachelor of science degree is awarded.

Some of the topics treated in the sequence of courses are the origin, propagation and reception of waves of all kinds, field concepts, theory of relativity, mechanics, electromagnetic theory and quantum mechanics. All are studied with the object of developing an open-minded and creative approach to the physical world and problem solving—an approach increasingly important to those who will be the leaders in the Navy of the future. The physics major is excellent background for most of the major career paths in the U.S. Navy and Marine Corps. Recent major graduates have chosen the nuclear power program, Navy air, surface line and the Marine Corps. Opportunities for work toward advanced degrees are available to qualified physics majors prior to graduation, immediately after graduation and later in their careers.

In physics, laboratory work is emphasized and students will have access to eight laboratories for regular coursework and research that include special facilities for acoustics, atomic physics, nuclear physics, laser optics and solid state physics. There are also four faculty research laboratories, a photographic darkroom and well-equipped machine and electronics shops. Major instruments include a Pelletron accelerator, an 8-inch Clark refracting telescope and a 20-inch reflecting telescope, an anechoic chamber, electron magnetic resonance and nuclear magnetic resonance facilities, high resolution spectrographs, x-ray diffractometer, femtosecond and picosecond laser systems, a superconducting magnet, a helium dilution refrigerator, various cryogenic systems and numerous microcomputers for student use in data collection and processing.

#### **Curriculum Requirements** (In addition to the requirements of plebe year)

Professional: NE203, NL302, NL400, NN204, NS310, NS40X;

Mathematics: SM212, SM221;

Humanities: HH215, HH216 and two electives including one at the 300/400 level;

Engineering: EE301, EE302, EN200, EM300, ES300, ES360, mathematics, science or engineering elective

Major: SP221, SP222, SP226, SP324, SP327, SP333, SP342, SP425, SP351, SP352, SP444, plus two physics electives;

Other: Math/Science/Engineering elective and one free elective.

## Physics Courses

**SP211 General Physics I** (3-2-4). The first of a two course sequence emphasizing the fundamental principles of classical physics and introduce a variety of applications. Topics include mechanics, electricity, magnetism, wave motion, fluids, sound and light. Lectures, recitations, hands-on laboratories, and large-scale demonstration lectures are employed. *Prereq:* SC112 or SC151; *Coreq:* (SM221 or SM223) or SM251 or approval of department chair.

**SP212 General Physics II** (3-2-4). Continuation of SP211. See SP211 description for topics. *Prereq:* (SP211 or SP221) or approval of department chair.

**SP221 Physical Mechanics I** (3-2-4). A first course in classical mechanics for physics majors. Newton's laws are applied to particles and systems of particles. Energy and momentum methods are developed. Applications include simple, damped, and driven harmonic motion as well as gravitation and orbital motion. *Coreq:* SM221 or approval of department chair.

**SP222 Electricity and Magnetism I** (3-2-4). A first course in electricity and magnetism for physics majors, with an emphasis on the concepts of fields and potential. The course culminates in the formulation of Maxwell's equations. *Prereq:* SP221 or SP211.

**SP226 Heat, Sound and Light** (3-2-4). A first course on the basic concepts of thermodynamics, acoustics, and optics for physics majors. Topics include heat engines, refrigerators, cosmology, the Doppler effect, beats, shock waves, fluids, lenses, telescopes, polarization, interference and diffraction. *Prereq:* SP211 or SP221.

**SP301 Modern Physics** (3-0-3). An introduction to the theories of relativity and quantum mechanics. Topics include relativistic mechanics, blackbody radiation, wave-particle duality, the Bohr theory, quantum phenomena, nuclear decay and nuclear reactions. *Prereq:* SP212 or SP226.

**SP310 Astronomy** (3-0-3). The fundamentals of astronomy as a physical science, surveying the Universe from the solar systems through stellar, galactic and extragalactic astronomy and cosmology. *Prereq:* SP211 and SP212.

**SP324 Physics of the Atom I** (3-2-4). An introduction to the theory of quantum mechanics, with emphasis on the statistical interpretation. Topics include simple systems, mathematical formalism, hydrogen atom, and angular momentum. *Prereq:* SP327, SP333, SM212; *Coreq:* SP351 or SM311.

**SP327 Twentieth Century Physics** (3-0-3). A study of the development of physics in the twentieth century, with particular attention given to relativity theory, quantum theory, and atomic physics. *Prereq:* SP222 and SP226.

**SP333 Physical Mechanics II** (4-0-4). An intermediate course in physical mechanics for physics majors. Newtonian, Hamiltonian, and Lagrangian mechanics with special emphasis on the central force problem and noninertial reference frames. *Prereq:* (SP221 or SP211) and SM212.

**SP342 Electricity and Magnetism II** (4-0-4). An intermediate course in electromagnetic theory for physics majors. Maxwell's equations are formulated in the notation of vector analysis and applied to various situations. *Prereq:* SP351 or SM311.

**SP351 Problem Solving Methods** (3-0-3). A course in the techniques of mathematics for physics with special emphasis on applications for intermediate mechanics. The course includes a detailed examination of coordinate systems; applied integration, differential equations and Fourier series; linear algebra, introduction vector spaces; vector calculus; and additional topics chosen from geometry, calculus of variation and special applications in physics. *Prereq:* SM212; *Coreq:* SP212 or SP222.

**SP352 Problem Solving Methods II** (3-0-3). A course in the techniques of mathematics for general physics with special emphasis on applications for electromagnetism and quantum mechanics. The course includes applications of vector calculus, further applications of linear vector spaces, boundary value problems, techniques for quantum mechanics, and additional topics chosen from among introductory numerical methods, fundamentals of statistics and special applications in physics. *Prereq:* SP351.

**SP411 Underwater Acoustics and Sonar** (3-0-3). A fundamental study of sound propagation in the ocean environment as it relates to the design and operation of sonar. Topics include wave mechanics, detection theory, Fourier analysis, ray tracing, waveguides, and scattering. *Prereq:* SP212 or SP226.

**SP425 Physics of the Atom II** (3-2-4). A second course in Quantum Mechanics. Topics include distinguishable and identical particles, atomic structure and spectra, perturbation theory, nuclear structure and reactions, and fundamental particles. *Prereq:* SP351 and SM311.

**SP434 Nuclear Physics** (3-2-4). A study of the basic static and dynamic properties of the nucleus and of the interaction of particles and radiation with matter. Emphasis on the experimental techniques. Where appropriate,

quantum mechanical interpretations of the phenomena are given. *Prereq:* SP425.

**SP436 Acoustics** (3-2-4). An introduction to modern acoustics. Topics include vibration and normal modes; coupled oscillators; discrete Fourier transforms; radiation, transmission and detection of sound waves; electroacoustics; psychoacoustics, architectural acoustics, musical acoustics and Sonar. *Prereq:* (SP212 or SP226) and SM212.

**SP438 Optics** (3-2-4). An introduction to modern optics. Topics include polarization, interference, coherence, diffraction, Fourier transforms, holography, optics of solids and basic laser physics. *Prereq:* SP342.

**SP442 Solid State Physics** (3-2-4). An introduction to the physics of condensed matter. Topics include crystalline and noncrystalline solids, band theory, semiconductors, magnetism, and superconductivity. *Prereq:* SP324 or approval of department chair.

**SP444 Thermal Physics** (3-0-3). A presentation of topics in thermal properties of matter and radiation as derived from the laws of quantum mechanics and statistics. *Prereq:* SP425 or approval of department chair.

**SP445 Astrophysics I** (3-0-3). A study of the physics of astronomical objects such as stars and galaxies. *Prereq:* SM212 and (SP301 or SP324) and (SP310 or approval of department chair).

**SP446 Astrophysics II** (3-0-3). This course is a continuation of SP445 (Astrophysics I). It is designed for the first-class astrophysics-track. Students explore the current understanding of extragalactic astrophysics and cosmology. In particular, they study the structure and dynamics of various galactic types, the large-scale structure of the universe and the origin and fate of the universe itself. *Prereq:* SP445.

**SP447 Observational Astrophysics** (2-2-3). This laboratory course is designed to give students hands-on experience with the techniques of modern astrophysical observation, data analysis and interpretation. Observations are made with instruments ranging from binoculars to optical and radio telescopes, and detectors ranging from the human eye and cameras to state-of-the-art charge coupled devices. This data, as well as observations available on-line, are reduced with modern analysis methods, with particular emphasis on image processing. A variety of projects explore the major observational fields of astrometry, photometry, spectroscopy and imaging, and how they provide our fundamental knowledge about the universe. A part of the newly created astro-track within the Physics Department, this course is, in addition, open as an elective to physics and other majors. *Prereq:* SP310.