ENGINEERING AND APPLIED SCIENCE

Director of undergraduate studies: Vincent Wilczynski, 238 DL, 432-4221, vincent.wilczynski@yale.edu

Courses in Engineering and Applied Science fall into three categories: those intended primarily for students majoring in one of the several engineering and applied science disciplines; those designed for students majoring in subjects other than engineering, the applied sciences, and the natural sciences; and those designed to meet common interests of students majoring in engineering, the applied sciences, or the natural sciences.

In the first category, the departments of Biomedical Engineering, Chemical and Environmental Engineering, Computer Science, Electrical Engineering, and Mechanical Engineering and Materials Science offer courses intended primarily for majors in engineering and applied science disciplines. Courses in these departments may also be relevant for students with appropriate backgrounds who are majoring in chemistry, physics, biology, geology and geophysics, and mathematics. For information about majors in engineering and their related courses, see under Biomedical Engineering (http://catalog.yale.edu/ycps/subjects-of-instruction/biomedical-engineering), Chemical Engineering (http://catalog.yale.edu/ycps/subjects-of-instruction/chemical-engineering), Computer Science (http://catalog.yale.edu/ycps/subjects-of-instruction/computer-science), Electrical Engineering (http://catalog.yale.edu/ycps/subjects-of-instruction/electrical-engineering), Environmental Engineering (http://catalog.yale.edu/ycps/subjects-of-instruction/environmental-engineering), and Mechanical Engineering (http://catalog.yale.edu/ycps/subjects-of-instruction/mechanical-engineering).

The School of Engineering and Applied Science (http://seas.yale.edu) is responsible for courses in the other two categories: technology for students majoring in subjects other than engineering, the applied sciences, and the natural sciences; and topics common to students majoring in engineering, the applied sciences, and the natural sciences. Courses for non–science majors are intended for all students seeking a broad perspective on issues of scientific and technological import, and they introduce students who may be planning careers in law, business, or public service to concepts and methods of engineering and applied science. Courses for science and engineering majors include topics in applied mathematics and computation.

Courses without Prerequisites in Engineering

* ENAS 100b / APHY 100b / EVST 100b / G&G 105b / PHYS 100b, Energy Technology and Society Daniel Prober
  The technology and use of energy. Impacts on the environment, climate, security, and economy. Application of scientific reasoning and quantitative analysis. Intended for non–science majors with strong backgrounds in math and science. Enrollment limited to 24. For application instructions, visit the course site on Canvas @ Yale.  QR, SC

ENAS 101a / ENVE 101a / EVST 105a / MENG 101a, Energy, Engines, and Environment Staff
  Energy sustainability and global warming; thermodynamic fundamentals; engines (combustion technologies, fossil-fuel pollution, carbon capture and sequestration). Wind, solar, biomass, and other renewable energy sources. Designed for freshmen and sophomores in science and engineering and for non–science majors. Prerequisite: A score of 4 or 5 on Advanced Placement examinations in mathematics and/or science.  SC

ENAS 110b / APHY 110b, The Technological World Owen Miller
  An exploration of modern technologies that play a role in everyday life, including the underlying science, current applications, and future prospects. Examples include solar cells, light-emitting diodes (LEDs), computer displays, the global positioning system, fiber-optic communication systems, and the application of technological advances to medicine. For students not committed to a major in science or engineering; no college-level science or mathematics required. Prerequisite: high school physics or chemistry.  QR, SC

* ENAS 118a, Introduction to Engineering, Innovation, and Design Vincent Wilczynski and Lawrence Wilen
  An introduction to engineering, innovation, and design process. Principles of material selection, stoichiometry, modeling, data acquisition, sensors, rapid prototyping, and elementary microcontroller programming. Types of engineering and the roles engineers play in a wide range of organizations. Lectures are interspersed with practical exercises. Students work in small teams on an engineering/innovation project at the end of the term. Priority to freshmen.  RP

* ENAS 120a / CENG 120a / EVST 120a, Introduction to Environmental Engineering Jordan Peccia
  Introduction to engineering principles related to the environment, with emphasis on causes of problems and technologies for abatement. Topics include air and water pollution, global climate change, hazardous chemical and emerging environmental technologies. Prerequisites: high school calculus and chemistry or CHEM 161, 165 or CHEM 163, 167 (may be taken concurrently) or permission of instructor.  QR, SC

ENAS 335a / EP&E 204a, Professional Ethics Mercedes Carreras
  A theoretical and case-oriented approach to ethical decision making. Concepts, tools, and methods for constructing and justifying solutions to moral problems that students may face as professionals.  SO

* ENAS 344b / MUSI 371b, Musical Acoustics and Instrument Design Lawrence Wilen and Konrad Kaczmarek
  Practical study of musical acoustics. The physics and design of musical instruments, with attention to all aspects of sound, from the origin of the vibration in the instrument to the perception by the listener. Student teams design and construct novel instruments and produce
relevant applications. Requires a basic knowledge of physics, including concepts of kinetic and potential energy and Newton’s laws. QR, HU, SC RP

**ENAS 360b / ENVE 360b, Green Engineering and Sustainable Design**  
Staff  
Study of green engineering, focusing on key approaches to advancing sustainability through engineering design. Topics include current design, manufacturing, and disposal processes; toxicity and benign alternatives; policy implications; pollution prevention and source reduction; separations and disassembly; material and energy efficiencies and flows; systems analysis; biomimicry; and life cycle design, management, and analysis. Prerequisites: CHEM 161, 165 or 163, 167 (or CHEM 112, 113, or 114, 115), or permission of instructor.

**Applied Mathematics and Computation Courses**

**ENAS 130b, Introduction to Computing for Engineers and Scientists**  
Marshall Long  
An introduction to the use of the C and C++ programming languages and the software packages Mathematica and MATLAB to solve a variety of problems encountered in mathematics, the natural sciences, and engineering. General problem-solving techniques, object-oriented programming, elementary numerical methods, data analysis, and graphical display of computational results. Prerequisite: MATH 115 or equivalent. Recommended preparation: previous programming experience. QR

**ENAS 151a or b / APHY 151a or b / PHYS 151a or b, Multivariable Calculus for Engineers**  
Staff  
An introduction to multivariable calculus focusing on applications to engineering problems. Topics include vector-valued functions, vector analysis, partial differentiation, multiple integrals, vector calculus, and the theorems of Green, Stokes, and Gauss. Prerequisite: MATH 115 or equivalent. QR RP

**ENAS 194a or b / APHY 194a or b, Ordinary and Partial Differential Equations with Applications**  
Staff  
Basic theory of ordinary and partial differential equations useful in applications. First- and second-order equations, separation of variables, power series solutions, Fourier series, Laplace transforms. Prerequisites: ENAS 151 or equivalent, and knowledge of matrix-based operations. QR RP

**ENAS 397a / EENG 397a, Mathematical Methods in Engineering**  
J. Rimas Vaišnys  
Exploration of several areas of mathematics useful in science and engineering; recent approaches to problem solving made possible by developments in computer software. Mathematica and Eureqa are used to investigate and solve problems involving nonlinear differential equations, complex functions, and partial differential equations. Prerequisites: MATH 222, and ENAS 194 or MATH 246, or equivalents; familiarity with computer programming. QR

* **ENAS 430b / CENG 430b, Renewable Energy Technologies**  
André Taylor  
Using renewable energy technologies to address real-world energy problems in underdeveloped regions, with an international hands-on learning experience during spring break. Topics include: solar energy and battery technologies; how next generation solar cells and batteries are developed and characterized in the Yale Transformative Materials and Devices (TMD) Laboratory; how solar energy systems are installed commercially on Yale’s campus; and an overview of how government policies play a role in renewable energy technologies. Students prepare engineering simulations to tackle sample case studies of real world energy problems and exercise various problem-based practices to define and solve problems related to renewable energy. Class size is limited to six junior and senior undergraduate students. Permission by the instructor is required for registration.

**ENAS 441a / MENG 441a, Applied Numerical Methods for Differential Equations**  
Beth Anne Bennett  
The derivation, analysis, and implementation of numerical methods for the solution of ordinary and partial differential equations, both linear and nonlinear. Additional topics such as computational cost, error estimation, and stability analysis are studied in several contexts throughout the course. Prerequisites: MATH 115, and 222 or 225, or equivalents; ENAS 130 or some knowledge of Matlab, C++, or Fortran programming; ENAS 194 or equivalent. ENAS 440 is not a prerequisite. QR RP

* **ENAS 450b / APHY 450b / MENG 450b, Advanced Synchrotron Techniques and Electron Spectroscopy of Materials**  
Charles Ahn  
Introduction to concepts of advanced x-ray and electron-based techniques used for understanding the electronic, structural, and chemical behavior of materials. Students learn from world-leading experts on fundamentals and practical applications of various diffraction, spectroscopy, and microscopy methods. Course highlights the use of synchrotrons in practical experiments. Prerequisites: physics and quantum mechanics/physical chemistry courses for physical science and engineering majors, or by permission of instructor. QR, SC

**ENAS 467a / EENG 467a, Computer Organization and Architecture**  
Jakub Szefer  
Introduction to computer architecture, including computer organization, microprocessors, caches and memory hierarchies, I/O, and storage. Issues surrounding performance, energy, and security; processor benchmarking. Selected readings from current academic literature. Prerequisite: EENG 201, or with permission of instructor. QR