ENGINEERING AND APPLIED SCIENCE
(EG) {EAS}

SM 001. Engineering Ethics Seminar.

The increasing scale, complexity, and social impact of technology have forced the engineering community to re-examine issues of professional ethics and responsibility. In these seminars students will participate in discussions oriented around a series of real-world case studies involving a wide range of contemporary controversies, including the Challenger disaster, software liability, and intellectual property issues. The goal is to provide students with tools for thinking about the complex ethical issues that they were likely to encounter in their own academic and professional careers.

SM 009. Writing About Science and Engineering. (A)

Using the approaches of such computer scientists as Donald A Norman (The Design of Everyday Things) and Alan Cooper, the father of Visual Basic, this writing seminar will explore issues and ideas related to the creative process and end results of how everyday objects are designed and used, from light switches and telephones to computer software. This seminar is intended for anyone who is interested in thinking about everyday life and its objects and learning about what goes into the design process. We will explore design failures and successes, and learn how attention to the objects in our everday lives and how these were designed changes our perspective toward not only the objects that surround us, but our very lives and culture. Along with readings from Norman and Cooper, readings will also likely be drawn from journals, magazines, newspapers. Students will be expected to write and revise 3 four-to-six page papers, one-page responses, in-class writings and a reading and idea journal.

This is a writing seminar--and as such fulfills the entire Writing Requirement for students in all four undergraduate schools. The seminar contents vary from semester to semester; for a current description, please see the Writing Program web site: www.english.upenn.edu/Writing.

099. Independent Study. (C) Prerequisite(s): Permission via application process.

An opportunity for the student to apply the theoretical ideas and tools learned from other courses through self study of a particular topic supervised by a sponsoring facutly member. To request approval for an independent study course, the student must submit a detailed proposal, signed by the supervising professor, the student's assigned Faculty Advisor, and departmental Undergraduate Chair, to the Office of Academic Programs two weeks prior to the start of the term.

101. Introduction to Engineering. (C)

This course is intended to introduce students to the field of engineering. It will expose students to the engineering disciplines through hands-on laboratory experiences. In addition, the course will provide tutorials on how to use important software packages as well as a "Professional Preparation" module through studies of communication (writing and speaking skills), ethics, leadership and teamwork. This course is ideal for any freshman interested in exploring the possibility of studying engineering at Penn. The course counts as as a engineering requirement in SEAS.

L/L 105. Introduction to Scientific Computing. (A)

This course will provide an introduction to computation and data analysis using MATLAB - an industry standard programming and visualization environment. The course will cover the fundamentals of computing including: variables, functions, flow control, iteration and recursion. These concepts will be illustrated through examples and assignments which show how computing is applied to various scientific and engineering problems. Examples will be drawn from the simulation of physical and chemical systems, the analysis of experimental data, Monte Carlo numerical experiments, image and audio processing, and control of sensors and actuators. This course does not assume any prior programming experience but will make use of basic concepts from calculus and Newtonian physics.

125. (CIS 125) Technology and Policy. (C)

Have you ever wondered why sharing music and video generates such political and legal controversies? Is information on your PC safe and should law enforcement be able to access information you enter on the Web? Will new devices allow tracking of your every move and every purchase? CIS 125 is focused on developing an understanding of existing and emerging technologies, along with the political, societal and economic impacts of those technologies. The technologies are spread across a number of engineering areas and each of them raise issues that are of current concern or are likely to be a future issue.

L/R 205. Applications of Scientific Computing. (C) Prerequisite(s): Prior exposure to computing via courses such as EAS 105, CIS 110, or ESE 112. Math 114, Sophomore standing.

This course will discuss a number of canonical problems and show how numerical methods are used to solve them. Lectures will introduce the underlying theory and the relevant numerical methods. Students will be expected to implement solutions to the problems using MATLAB. The course will use the visualization capabilities of MATLAB to provide students with a geometric interpretation of the key ideas underlying the numerical methods. Topics to be covered will include: The solution of systems of linear systems equations with application to problems such as force balance analysis and global illumination computation. Representing and computing coordinate transformations with applications to problems in graphics, vision and robotics. Transform Coding with applications to the analysis of audio signals and image compression. Analysis of variance and the search for low dimensional representations for high dimensional data sets egs. Google's PageRank algorithm. Least Squares model fitting with applications to data analysis. Analysis of linear dynamical systems with applications to understanding the modes of vibration of mechanical systems. The analysis of stochastic systems governed by state transition matrices.

210. Introduction to Nanotechnology. (A)

280. (BE 280) Bioengineering in the World. (C)

Open to all majors at Penn, this course explores the wide-range of bioengineering applications 'in the world' and then takes these concepts 'into the world' by teaching them to a small group of students at the high school level. Students will learn fundamental concepts behind bioengineering applications such as Gene Therapy, Stem Cells, Neuroengineering, Tissue Engineering, Biomechanics, Imaging, and Medical Devices. They will also develop effective methods for teaching technical concepts. At the high school, the Penn students will perform hands-on activities with the high school students, discuss ethical questions related to each topic, and explore career options.

281. Multimedia Tools and Technology. (C)

285. Teaching Computer Science Basics. (C) Faculty.

L/R 303. (BE 303) Ethics, Social, and Professional Responsibility for Engineers. (A)

Provides an overview of the ethical, social, and professional responsibilities of engineers, as engineering professionals, as members of engineering organizations and as investigators in research. The course will make extensvie use of student group presentations and in the analysis of cases based on real-world problems with ethical dimensions, many drawn from current news. The case studies will vary from year to year, but will be chosen to be relevant to studens interested in different careers in engineering, including research.

349. Ideas to Assets. (M) Prerequisite(s): Sophomore or higher standing.

Not every idea leads to a great product. The process of "crystallizing" a clever idea into a saleable asset demands a mix of creativity, systems thinking, sound business instincts, and the courage to do things differently. Students in this project-centered course will gain the necessary skills and experience from concentrated work on early-stage inventions drawn from Penn's technology portfolio. Is the invention feasible? Patentable? How should it be designed and produced? What will it cost? Is there a market? Does the payoff justify the investment? These and similar questions will be answered through a multifaceted process including analysis, experimentation, design, and/or market research. The projects are not "case studies", but rather involve real, current intellectual property of potential value to the University. Inventors and specialists from the Center for Technology Transfer will be available to collaborate with the student teams. Project work will be complemented by lectures and exercises dealing with the patent process, cost and market estimation, project planning, economic analysis, and the systems approach to new product design.

400. (EAS 500) Technical Communication in Engineering Practice. (C) Prerequisite(s): SEAS undergraduates must have already fulfilled their SEAS Writing Requirement.

Students will learn methods and approaches for written technical communication within the engineering environment. These include strategies for maximum effectiveness in writing technical documentation, reports, instructions, and proposals. Assignments will include self-editing and peer editing techniques, as well as strategies to effectively mentor other writers.

401. (EAS 501) Energy and Its Impacts. (C) Any university student interested in energy and its impacts, preferably at the upper level undergraduate and non-engineering graduate level of maturity. Students taking the course as EAS 501 will be given assignments commensurate with graduate standing.

The objective is to introduce students to one of the most dominating and compelling areas of human existence and endeavor: energy, with its foundations in technology, association to economics, and impacts on ecology and society. This introduction is intended both for general education and awareness and for preparation for careers related to this field. The course spans from basic principles to applications. A review of energy consumption, use, and resources; ecological impacts, sustainability and design of sustainable energy systems; methods of energy analysis; forecasting; electricity generation systems (steam and gas turbine based power plants, fuel cells), energy for transportation (cars, aircraft, and ships); nuclear energy and wastes; renewable energy use: solar, wind, hydroelectric, geothermal, biomass; prospects for future energy systems: fusion power, power generation in space.

402. (EAS 502) Renewable Energy and It's Impact. (C) Prerequisite(s): Any undergraduate and graduate university student interested in renewable energy and its impacts, preferably at the upper level undergraduate and non-engineering graduate level of maturity.

The objective is to introduce students to the major aspects of renewable energy, with its foundations in technology, association to economics, and impacts on ecology and society. This introduction is intended both for general education and awareness and for preparation for careers related to this field. The course spans from basic principles to applications. A review of solar, wind, biomass, hydroelectric, geothermal energy, and prospects for future energy systems such as renewable power generation in space.

499. Senior Capstone Project. (C)

The Senior Capstone Project is required for all BAS degree students, in lieu of the senior design course. The Capstone Project provides an opportunity for the student to apply the theoretical ideas and tools learned from other courses. The project is usually applied, rather than theoretical, exercise, and should focus on a real world problem related to the career goals of the student. The one-semester project may be completed in either the fall or sprong term of the senior year, and must be done under the supervision of a sponsoring faculty member. To register for this course, the student must submit a detailed proposal, signed by the supervising professor, and the student's faculty advisor, to the Office of Academic Programs two weeks prior to the start of the term.

500. (EAS 400) Technical Communication in Engineering Practice. (C) This course is not intended for non-native speakers of English and will not address their specific language needs. Students whose native language is not English should register for EAS 510.

Students will learn methods and approaches for written technical communication within the engineering environment. These include strategies for maximum effectiveness in writing technical documentation, reports, instructions, and proposals. Assignments will include self-editing and peer editing techniques, as well as strategies to effectively mentor other writers.

502. (EAS 402) Renewable Energy and It's Impact. (C) Prerequisite(s): Any undergraduate and graduate university student interested in renewable energy and its impacts, preferably at the upper level undergraduate and non-engineering graduate level of maturity.

The objective is to introduce students to the major aspects of renewable energy, with its foundations in technology, association to economics, and impacts on ecology and society. This introduction is intended both for general education and awareness and for preparation for careers related to this field. The course spans from basic principles to applications. A review of solar, wind, biomass, hydroelectric, geothermal energy, and prospects for future energy systems such as renewable power generation in space.

510. Technical Communication and Academic Wrting for Non-native Speakers of English. (B) Graduate students whose native language is English, but who would benefit from a course in Technical Communication, should take EAS 500.

Students will improve the grammar, word choice and organization of their professional writing by completing weekly writing assignments and a full-length research paper. Students will also give short oral presentations and receive feedback on pronunciation, wording, grammar and organization.

545. Engineering Entrepreneurship I. (C) Prerequisite(s): Third or Fourth year or Graduate standing.

Engineers and scientists create and lead great companies, hiring managers when and where needed to help execute their vision. Designed expressly for students having a keen interest in technological innovation, this course investigates the roles of inventors and founders in successful technology ventures. Through case studies and guest speakers, we introduce the knowledge and skills needed to recognize and seize a high-tech entrepreneurial opportunity - be it a product or service - and then successfully launch a startup or spin-off company. The course studies key areas of intellectural property, its protection and strategic value; opportunity analysis and concept testing; shaping technology driven inventions into customer-driven products; constructing defensible competitive strategies; acquiring resources in the form of capital, people and strategic partners; and the founder's leadership role in an emerging high-tech company. Throughout the course emphasis is placed on decisions faced by founders, and on the sequential risks and determinants of success in the early growth phase of a technology venture. The course is designed for, but not restricted to, students of engineering and applied science and assumes no prior business education.

546. Engineering Entrpreneurship II. (C) Prerequisite(s): EAS 445, 545.

This course is the sequel to EAS 545 and focuses on the planning process for a new technology venture. Like its prerequisite, the course is designed expressly for students of engineering and applied science having a keen interest in technological innovation. Whereas EAS 545 investigates the sequential stages of engineering entrepreneurship from the initial idea through the early growth phase of a startup company, EAS 546 provides hands-on experience in developing a business plan for such a venture. Working in teams, students prepare and present a comprehensive business plan for a high-tech opportunity. The course expands on topics from EAS 545 with more in-depth attention to: industry and marketplace analysis; competitive strategies related to high-tech product/service positioning, marketing, development and operations; and preparation of sound financial plans. Effective written and verbal presentation skills are emphasized throughout the course. Ultimately, each team presents its plan to a distinguished panel of recognized enterepreneurs, investors and advisors from the high-tech industry.

898. CPT Research Practicum. (C)

ENGINEERING MATHEMATICS (ENM)

220. Discrete Dynamical Systems and Chaos. (C) Prerequisite(s): MATH 103, MATH 104 and MATH 114 (Calculus of a Single Variable and some knowledge of Comples Numbers).

This course will cover the mathematics behind the dynamics of discrete systems and difference equations. Topics include: Real function iteration, Converging and Diverging sequences, Periodic and chaotic sequences, Fixed-point, periodic-point and critical-point theories, Bifurcations and period-doubling transitions to chaos, Symbolic dynamics, Sarkovskii's theorem, Fractals, Complex function iterations, Julia and Mandelbrot sets. In the past, mathematics was learned only through theoretical means. In today's computer age, students are now able to enjoy mathematics through experimental means. Using numerous computer projects, the student will discover many properties of discrete dynamical systems. In addition, the student will also get to understand the mathematics behind the beautiful images created by fractals. Throughout the course, applications to: Finance, Population Growth, Finding roots, Differential Equations, Controls, Game and Graph Problems, Networks, Counting Problems and other real-world systems will be addressed.

321. Engineering Statistics. (C)

This course covers the topics in probability and statistics with an emphasize on the application of probability theories and statistical techniques to practical engineering problems. Mathematical derivations of theorems will be presented whenever it is necessary to illustrate the concepts involved, however.

L/R 402. (ENM 502) Numerical Methods and Modeling. (B) Sinno. Prerequisite(s): Knowledge of a computer language, Math 240 and 241; ENM 510 is highly recommended; or their equivalents.

Numerical modeling using effective algorithms with applications to problems in engineering, science, and mathematics, and is intended for graduate and advanced undergraduate students in these areas. Interpolation and curve fitting, numerical integration, solution of ordinary and partial differential equations by finite difference, and finite element methods. Includes use of representative numerical software packages such as MATLAB PDE Toolbox.

427. (MEAM527) Finite Elements and Applications. (C) Prerequisite(s): MATH 241 and PHYS 151.

The objective of this course is to equip students with the background needed to carry out finite elements-based simulations of various engineering problems. The first part of the course will outline the theory of finite elements. The second part of the course will address the solution of classical equations of mathematical physics such as Laplace, Poisson, Helmholtz, the wave and the Heat equations. The third part of the course will consist of case studies taken from various areas of engineering and the sciences on topics that require or can benefit from finite element modeling. The students will gain hand-on experience with the multi-physics, finite element package FemLab.

L/R 502. (ENM 402) Numerical Methods and Modeling. (B) Sinno. Prerequisite(s): Knowledge of a computer language, Math 240 and 241; ENM 510 is highly recommended; or their equivalents.

Numerical modeling using effective algorithms with applications to problems in engineering, science, and mathematics, and is intended for graduate and advanced undergraduate students in these areas. Interpolation and curve fitting, numerical integration, solution of ordinary and partial differential equations by finite difference, and finite element methods. Includes use of representative numerical software packages such as MATLAB PDE Toolbox.

503. Introduction to Probability and Statistics. (A) Prerequisite(s): MATH 240 or equivalent.

Introduction to probability. Expectation. Variance. Covariance. Joint probability. Moment generating functions. Stochastic models and applications. Markov chains. Renewal processes. Queuing models. Statistical inference. Linear regression. Computational probability. Discrete-event simulation.

510. Foundations of Engineering Mathematics - I. (A) Prerequisite(s): MATH 240, MATH 241 or equivalent.

This is the first course of a two semester sequence, but each course is self contained. Over the two semesters topics are drawn from various branches of applied mathematics that are relevant to engineering and applied science. These include: Linear Algebra and Vector Spaces, Hilbert spaces, Higher-Dimensional Calculus, Vector Analysis, Differential Geometry, Tensor Analysis, Optimization and Variational Calculus, Ordinary and Partial Differential Equations, Initial-Value and Boundary-Value Problems, Green's Functions, Special Functions, Fourier Analysis, Integral Transforms and Numerical Analysis. The fall course emphasizes the study of Hilbert spaces, ordinary and partial differential equations, the initial-value, boundary-value problem, and related topics.

511. Foundations of Engineering Mathematics - II. (B) Prerequisite(s): ENM 510 or equivalent.

Vector Analysis: space curves, Frenet - Serret formulae, vector theorems, reciprocal systems, co and contra variant components, orthogonal curvilinear systems. Matrix theory: Gauss-Jordan elimination, eigen values and eigen vectors, quadratic and canonical forms, vector spaces, linear independence, Triangle and Schwarz inequalities, n-tuple space.Variational calculus: Euler-Lagrange equation, Finite elements, Weak formulation, Galerkin technique, FEMLAB. Tensors: Einstein summation, tensors of arbitrary order, dyads and polyads, outer and inner products, quotient law, metric tensor, Euclidean and Riemannian spaces, physical components, covariant differentiation, detailed evaluation of Christoffel symbols, Ricci's theorem, intrinsic differentiation, generalized acceleration, Geodesics.

520. Theory and Computation for ODE/PED-constrained optimization. (A) Prerequisite(s): Basic theory of ordinary and partial differential equations.

This course introduces the basic theory and algorithms for nonlinear optimization for continuum systems. Emphasis will be given in numerical algorithms that are applicable to problems in which the constraints are ordinary or partial differential equations. Such problems have numerous applications in science and engineering. Lectures and homeworks will examine examples related to control, design, and inverse problems in vision, robotics, computer graphics, bioengineering, fluid and solid mechanics, molecular dynamics, and geophysics.

540. Topics In Computational Science and Engineering. Prerequisite(s): Background in ordinary and partial differential equations; proficiency in a programming language such as MATLAB, C, or Fortran.

This course is focused on techniques for numerical solutions of ordinary and partial differential equations. The content will include: algorithms and their analysis for ODEs; finite element analysis for elliptic, parabolic and hyperbolic PDEs; approximation theory and error estimates for FEM.

600. Functional Analysis. (A) Prerequisite(s): ENM 500, ENM 501 or ENM 510, ENM 511 or equivalent.

This course teaches the fundamental concepts underlying metric spaces, normed spaces, vector spaces, and inner-product spaces. It begins with a discussion of the ideals of convergence and completeness in metric spaces and then uses these ideas to develop the Banach fixed-point theorem and its applications to linear equations, differential equations and integral equations. The course moves on to a study of normed spaces, vector spaces, and Banach spaces and operators defined on vector spaces, as well as functional defined between vector spaces and fields. The course then moves to the study of inner product spaces, Hilbert spaces, orthogonal complements, direct sums, and orthonormal sets. Applications include the study of Legendre, Hermite, Laguerre, and Chebyshev polynomials, and approximation methods in normed spaces. The course then concludes with a study of eigenvalues and eigenspaces of linear operators and spectral theory in finite-dimensional vector spaces.

601. Special Topics in Engineering Mathematics - Nonlinear Dynamics and Chaos. (B) Prerequisite(s): Permission of Instructor.

Continuous Dynamical Systems: Nonlinear Equations versus Linear Equations, One-Dimensional Flows: Flows on a Line, Fixed Points and Stability, Linear Stability Analysis, Potentials, Bifurcations, and Flows on the Circle. Two-Dimensional Flows: Linear Systems, Eigenvalues and Eigenvectors, Classification of Fixed Points, Phase Portraits, Conservative Systems, Reversible Systems, Index Theory, Limit Cycles, Gradient Systems, Liaponov Functions, Poincare-Bendixson Theorem, Lienard Systems, Relaxation Oscillations, Weakly Nonlinear Oscillators, Perturbation Theory, Saddle-Node, Transcritical and Pitchfork Bifurcations, Hopf Bifurcations, Global Bifurcations of Cycles, Hysteresis, and Poincare Maps. Three-Dimensional Flows: The Lorenz Equations, Strange Attractors and Chaos, The Lorenz Map.

Discrete Dynamical Systems: One-Dimensional Maps, Chaos, Fixed Points and Cobwebs, The Liapunov Exponent, Universality and Feigenbaum's Number, Renormalization Theory, Fractals, Countable and Uncountable Sets, The Cantor Middle-Thirds Set, Self-Similar Fractals and Their Dimensions, The von Koch Curve, Box Dimension and Multifractals.

BIOTECHNOLOGY (BIOT)

700. Biotechnology Seminar. (C)

This is a seminar course where students hear different perspectives in the biotechnology and pharmaceutical industry. Speakers will discuss their experiences in business startups, technology transfer, bioinformatics, pharmaceutical houses, and academics.

899. Independent Study. (C)