ENGINEERING MATHEMATICS
(EG) {ENM}

375. Biological Data Science I - Fundamentals of Biostatistics. (C) Prerequisite(s): Sophomores and Juniors only.

The purpose of this course is to provide students with skills to analyze and interpret small and large biological data sets. Fundamentals in probability and statistics will be taught through the use of homework problems, case studies and projects focused on computational analysis of biological data. Topics covered include: Populations and samples; random variable; discrete and continuous probability distributions; exploratory data analysis; descriptive statistics; confidence intervals; expectations; variances; central limit theorem; independence; hypothesis testing; fitting probability models; pvalues; goodness-of-fit tests; correlation coefficients; non-parametric tests; ANOVA; linear regression; bootstrapping; and maximum likelihood estimation.

512. Nonlinear Dynamics and Chaos. (C) Prerequisite(s): MATH 240 or ENM 510, Senior or Master's standing in engineering.

This course covers the essential mathematics behind continuous and discrete nonlinear dynamical systems with applications in Physics, Biology, Chemistry and Engineering. It covers one-dimensional, two-dimensional, three-dimensional and n-dimensional flows for continuous systems and one-dimensional flows for discrete systems. It also covers Cantor's set theory and Fractals.

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.

L/R 251. Analytical Methods for Engineering. (B) Prerequisite(s): MATH 240 or equivalent along with sophomore standing in SEAS, or permission of the instructor(s).

This course introduces students to physical models and mathematical methods that are widely encountered in various branches of engineering. Illustrative examples are used to motivate mathematical topics including ordinary and partial differential equations, Fourier analysis, eigenvalue problems, and stability analysis. Analytical techniques that yield exact solutions to problems are developed when possible, but in many cases, numerical calculations are employed using programs such as Matlab and Maple. Students will learn the importance of mathematics in engineering.

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.

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L/R 427. (MEAM527) Finite Elements and Applications. (A) Prerequisite(s): MATH 241 or ENM 251 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. 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 combinatorics: the multiplication rule, the pigeonhole principle, permutations, combinations, binomial and multinomial coefficients, recurrence relations, methods of solving recurrence relations, permutations and combinations with repetitions, integer linear equation with unit coefficients, distributing balls into urns, inclusion-exclusion, an introduction to probability. Introduction to Probability: sets, sample setsevents, axioms of probability, simple results, equally likely outcomes, probability as a continuous set function and probability as a measure of belief, conditional probability, independent events, Bayes' formula, inverting probability trees. Random Variables: discrete and continuous, expected values, functions of random variables, variance. Some Special Discrete Random Variables: Bernoulli, Binomial, Poisson, Geometric, Pascal (Negative Binomial) Hypergeometric and Poisson.
   Some Special Continuous Random Variables: Uniform, Exponential, Gamma, Erlang, Normal, Beta and Triangular. Joint distribution functions, minimum and maximum of independent random variables, sums of independent random variables, reproduction properties. Properties of Expectation: sums of random variables, covariance, variance of sums and correlations, moment-generating function. Limit theorems: Chebyshev's inequality, law of large numbers and the central-limit theorem. Extra Topics: Generating random numbers and simulation, Monte-Carlo methods, The Poisson Process and Queueing Theory, Stochastic Processes and Regular Markov Chains, Absorbing Markov Chains and Random Walks.

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.

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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. Principles and Techniques of Applied Math I. (A) Prerequisite(s): Basic theory of ordinary and partial differential equations.

This course is targeted to engineering PhD students in all areas. It will focus on the stud of linear spaces (both finite and infinite dimensional) and of operators defined on such spaces. This course will also show students how powerful methods developed by the study of linear spaces can be used to systematically solve problems in engineering. The emphasis in this course will not be on abstract theory and proofs but on techniques that can be used to solve problems. Some examples of techniques that will be studied include, Fourier eries, Green's functions for ordinary and partial differential operators, eigenvalue problems for ordinary differential equations, singular value decomposition of matrices, etc.

L/R 521. Principles and Techniques of Applied Math II. (B)

This course is a continuatin of ENM 520 (or equivalent) and deals with classcial methods in applied mathematics. The topics to be covered include: Functions of a Complex Variable, Partial Differential Equations, Asymptotic and Perturbawtin Methods, and Convex Analysis and Variational Methods.

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

This course covers the essential mathematics behind continuous and discrete nonlinear dynamical systems with applications in Physics, Biology, Chemistry and Engineering. It covers one-dimensional, two-dimensional, three-dimensional and n-dimensional flows for continuous systems and one-dimensional flows for discrete systems. It also covers Cantor's set theory and Fractals.

540. Topics In Computational Science and Engineering. (M) 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.

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600. Functional Analysis. (C) 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.