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.