EMT 7201 Advanced Engineering Mathematics

Course objectives

The course gives the background for simple analytical derivation and numerical calculations for stochastic processes in discrete and continuous time as well as the application of Finite Element Methods to the solution of partial Differential Equations arising from Structural Engineering, Heat Conductions, Geomatic Engineering and Electrical Transmission Lines and using appropriate software tools e.g. MATLAB. Topics include Finite Element Discretization and the Direct Stiffness Method, Mathematical Formulation of Finite Elements, Computer Implementation of Finite Elements, Stochastic (Random) Processes and Estimation Theory.

AIM:

The objectives are to develop a fundamental understanding of state-of-the-art finite element formulations and procedures, to develop an appreciation for the strengths and limitations of modern finite element methods and related software, to reinforce knowledge in solid mechanics with particular emphasis on nonlinear and dynamic problems, and to learn to utilize finite element methods as a research tool. Topics include finite element fundamentals and Weighted residual and finite element methods for the solution of hyperbolic, parabolic and elliptical partial differential equations, with application to problems in science and engineering. Error estimates. Standard and discontinuous Galerkin methods

The course gives the background for simple analytical derivation and numerical calculations for stochastic processes in discrete and continuous time as well as Estimation Theory

Detailed Course Content:

1. Finite Element Methods (30 Hours)

1.1 Finite Element Discretization and the Direct Stiffness Method : The Direct Stiffness, Finite Element Modeling: Mesh, Loads, BCs, Multifreedom Constraints , Superelements and Global-Local Analysis

1.2 Mathematical Formulation of Finite Elements : Variational Formulation of Bar Element, Variational Formulation of Plane Beam Element, Advanced One-Dimensional Elements, The Plane Stress Problem, Three-Node Plane Stress Triangles, The Isoparametric Representation, Isoparametric Quadrilaterals, Shape Function Magic, FEM Convergence Requirements

1.3 Computer Implementation of Finite Elements: Implementation of One-Dimensional Elements, FEM Program for Space Trusses, FEM Programs for Trusses and Frames, Implementation of iso-P Quadrilateral Elements, Implementation of iso-P Triangular Elements, The Assembly Process, Solving FEM Equations, A Complete Plane Stress FEM Program, Stress Recovery, Fitting Fields Over, Thermomechanical Effects

2. Stochastic (Random) Processes (09 Hours)

Definition; Characterization: Probabilistic Description, Expected Values and Autocovariance Functions

Classification: Stationary, Wide-Sense Stationary, Ergodic, Markov, Normal and Poisson Processes

Analysis and Processing of Stochastic Processes: Spectral Density, and Response of Linear Systems to Random Input,

3. **Estimation Theory (06 Hours)**
   - Definitions: Estimators, Point and Interval Estimators Properties of Point Estimators
   - Types of Estimation: Estimation of a Distribution's Unknown Parameter; Estimating the value of an inaccessible variable in terms of an accessible variable
   - Estimators: Maximum Likelihood Estimator, Bayesian Estimator, Mean Square Linear Estimator: Univariate Linear Regression; Orthogonality; Basic extension to Multivariate Linear Regression

Learning Outcomes

Students should be proficient in basics of Finite Elements Methods, Properties and Classification of Stochastic Processes, associated mathematically rigorous proofs, and some programming language.

The Students should be able to articulate the Properties of classical Stochastic Processes and how these are applied in the classification of the same.

Teaching and Learning Pattern

The teaching of students will be conducted through lectures, tutorials, short classroom exercises, case studies, group discussions among the students and projects aimed at solving real life problems. The lecture material will be availed to the students in advance to enable them have prior reading. Solving real life problems in each theme or a number of topics will enhance the students' understanding of the problem based learning techniques.

Assessment method

Assessment will be done through coursework which will include assignments, class room and take home tests, project work and presentations and a written examination. Course work will carry a total of 40% and written examination carries 60%. Coursework marks will be divided into; Assignments 5%, Tests 10% and Practical/project Work 25%.

References:

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[**4**] Michel K. Ochi, 1990. Applied Probability and Stochastic Processes in Engineering and Physical Sciences. John Wiley & Sons, Inc. USA. ISBN 0-471-85742-4

[**5**] George R. Cooper, and Clare D. McGillem, 1999. Probobilistic Methods of Signal and Systems Analysis. 3rd Edition. Oxford University Press, Newyork, USA. ISBN 0-19-512354-9

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[8] Venkatarama Krishnan, 2006. Probability and Random Processes (Wiley Survival Guides in Engineering and Science), Wiley-Interscience; 1 Edition. ISBN-10: 0471703540, ISBN-13: 978-0471703549
[9] Donald G. Childers, 1997. Probability and Random Processes: Using Matlab with Applications to Continuous and Discrete Time Systems. Richard D Irwin. ISBN-10: 0256133611, ISBN-13: 978-0256133615
[10] Leon Garcia, 1993. Probability and Random Processes for Electrical Engineering. Addison Wesley Publishing Company; 2 Sol Edition. ISBN-10: 020155738X, ISBN-13: 978-0201557381
[11] Roy D. Yates, David J. Goodman, 2004. Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers. Wiley; 2nd Edition. ISBN-10: 0471272140, ISBN-13: 978-0471272144
[12] Paul M. Kurowski , 2004. Finite Element Analysis For Design Engineers. SAE International, ISBN-10: 9780768011401, ISBN-13: 978-0768011401, ASIN: 076801140X
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