Course Title

Engineering Mathematics for Advanced Studies

Credit Structure

L	T	P	C
3/4	0	0	6/8

Prerequisite

NA

Targeted Audience

Graduate students taking up research activity
Research oriented bachelor students interested to hone their skill in specific math modules that they have not worked on extensively in previous courses/research

Objective

To make the student recall the basics of each course module and show them how it will be applicable for research in engineering domain
Expected outcome is the understanding of the basic contents in the respective module in engineering context and with hands-on practice.

Credit allocation

At least 6 modules to obtain minimum 6 credits.
At least 8 modules to obtain 8 credits.
Relative grading for each module followed by absolute grading will be adopted for final course grade assessment.

Targeted Course Content

Module-1: Linear Algebra: Linear algebraic equations, Vector Spaces, Orthogonality, Determinants, Eigen-values and Eigen-vectors of matrices, Singular-value decomposition

Module-2: Ordinary Differential Equations: Terminology, Solution of Homogeneous and non-homogeneous 1st order linear ODE, Bernoulli, Riccatti and Logistic equations, Solution of Homogeneous and non-homogeneous 2nd order linear ODE, System of 1st order ODE

Module-3: Vector Calculus: Dot and Cross Product, Curves, Arc Length, Curvature, Torsion, Divergence and Curl of a Vector Field, Line Integrals, Green's Theorem, Stokes's Theorem, use of Vector Calculus in various engineering streams

Module-4: Laplace and Fourier transformation: First and Second Shifting Theorems, Transforms of Derivatives and Integrals, Fourier Cosine and Sine Transforms, Discrete and Fast Fourier Transforms, IVT and FVT significance

Module-5: Partial Differential Equations: Basic Concepts of PDEs, Laplace, Poisson, Heat, Wave Equations, Solution by Separating Variables, Solution by Fourier Series, Solution by Fourier Integrals and Transforms, Solution using similarity variable

Module-6: Numerical Methods: Methods for Linear Systems, Least Squares, Householder's Tridiagonalization and QR-Factorization, Numerical interpolation, Numerical integration, Methods for Elliptic, Parabolic, Hyperbolic PDEs,

Module-7: Optimization and Linear Programming: Introduction to convex sets and functions, and its properties, Important standard classes such as linear and quadratic programming, Lagrangian based method, Algorithms for unconstrained and constrained minimization (example gradient descent).

Module-8: **Probability Theory and Statistics:** Experiments, Outcomes, Events, Permutations and Combinations, Probability Distributions, Binomial, Poisson, and Normal Distributions, Distributions of Several Random Variables, Testing Hypotheses, Goodness of Fit, χ^2-Test

Module-9: Tensor Algebra: Index Notation and Summation Convection, Levi-

Module selection

A) PhD students: Module selection should be by mutual agreement between student and faculty advisor. Please ensure pre-requisite module completion requirement for each module

B) MS Students:

Modules mandatory for MS students-

EE: 1,3,4,6,7,8

ME: 1,2,3,4,5,6

C) B.Tech. Students:

Discussion with course instructor (SR) and faculty advisor with consideration to academic load and priorities is required

Civita symbol, Triple vector product, Tensor Product, Dyads, transpose, trace, contraction, projection, spherical and deviatoric tensors, tensorial transformation laws. Gradient of scalar valued tensor function, Gradient of tensor valued tensor function

Module-10: Complex Analysis and Potential Theory: The Cauchy-Riemann Equations, Use of Conformal Mapping, Electrostatic Fields, Heat and Fluid Flow Problems, <Poisson's Integral Formula for Potentials >

Texts/References

E. Kreyszig. Advanced Engineering Mathematics, John Wiley & Sons, 2011.
A. Schrijver, Theory of Linear and Integer Programming, 1998.
Gilbert Strang, Linear Algebra and Its Applications, 4th Edition, 2004.
Gilbert Strang Differential Equations and Linear Algebra, 2014
Additional references-
P.V. O'Neil. Advanced Engineering Mathematics, CENGAGE Learning, 2011.
D.G. Zill. Advanced Engineering Mathematics, Jones & Bartlett Learning 2016.
B. Dasgupta. Applied Mathematical Methods, Pearson Education, 2006.

Instructor (s)

Prof. SamarthR (SR) >> Module 1, 2, 3, 5, 6, 8, 9

Prof. ShrikanthV (SV) >> Module 4, 10

Prof. Naveen MB (NMB) >> Module 7

Departments to whom the course is relevant

CS/EE/ME

Justification

Engineering mathematics is a key-tool necessary for the research students to be good in mathematical methods in order to model and analyze the experimental/computational data. In this course, students learn mathematical techniques in linear algebra, Vector calculus, Laplace and Fourier transformations, ODEs and PDEs, elementary numerical methods, probability foundations. Special modules Tensor algebra and complex numbers are facilitated for those who are interested. Modular structure of this course offers flexibility to students to optimally use this course for their specific needs.

Summary

10 modules : SR (7) + SV(2) + NMB(1), modular structure, Course grading - average of grades received in all modules selected by student.

Time slots:

Classroom instruction – Room215, Slot 3, (Mon 10:35-11:30, Tue ~~11:35-12:30~~ 12:00-01:00 pm; Thu 8:30-9:25), some modules to run in different slots

Walk in hrs – Thu-2:00-3:00pm (tentative)

	Module Name	Instructor	Pre-requisite recommendation (not mandatory)	Mandatory modules for MS	
				EE	ME
1	Linear Algebra	SR		Y	Y
2	ODE	SR			Y
3	Vector Calculus	SR		Y	Y
4	Laplace/Fourier	SV	2	Y	Y
5	PDE	SR	2,4		Y
6	Num. Methods	SR	1,2	Y	Y
7	OptimizationLPP	NMB	1	Y	
8	Probability&Stats	SR		Y	
9	Tensor Algebra	SR	1,3		
10	Complex Analysis	SV	2,5		

Course webpage - https://homepages.iitdh.ac.in/~sraut/Au19_EnggMath/index.html