MA602 – Applied Vector Calculus and Differential Equations
(2023 Spring Semester)

Instructor: Projesh Nath Choudhury **Office:** AB-5/344
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Course website: http://people.iitgn.ac.in/ ∼projesh/Teaching/MA602_2023/MA609_2023.html

Course goals: This course is to help Masters and PhD level Engineering students develop and sharpen their mathematical skills to tackle problems arising in their respective research fields. The course will focus on the following three modules: (i) Vector Calculus, (ii) Integral Transforms, and (iii) Differential Equations.

COURSE CONTENTS

(1) **Vector Calculus.** (i) Vectors, Vectors in 3−d, scalar product, triple product, Einstein summation convention for manipulation of vectors. (ii) Gradient, divergence, and curl operators and their interpretation. (iii) Vector integration: Line integrals, surface integrals, and volume integrals. (iv) Gauss' theorem, Green's theorem, and Stokes' theorem. (v) Numerical integration: Newton-Coates, Extrapolation and Romberg integration, adaptive integration, Gaussian quadrature, and multiple integrals.

(2) **Integral Transforms.** (i) Basics of Fourier series: Expressing periodic functions as a Fourier series, operations (computing and manipulating Fourier series. Use of shifts, differentiation and integration, examples and applications). (ii)Impulse or delta function as inputs to DEs, convolution and its use in Green's formula. (iii) Discrete Fourier transform and fast Fourier Transforms. (iv) Laplace and inverse Laplace transforms, partial fractions, transfer functions, applications.

(3) **Differential Equations.** (i) Linear ODEs with constant coefficients: Geometric meaning and direction fields, solution techniques for linear ODEs with constant coefficients. (ii) Linear ODEs with variable coefficients: Power series method, Legendre's equation and the Legendre polynomials, Frobenius' method, the Bessel's functions, solutions using Laplace transforms. (iii) Systems of ODEs: Phase plane method, criteria for critical points. Stability, qualitative Methods for nonlinear systems, nonhomogeneous linear systems of ODEs. (iv) Numerical solution of ODEs: Euler method, Runge-Kutta method, shooting method, and finite difference method. (v) Sturm-Liouville problems: Eigenvalues and eigenfunctions with properties. (vi) Partial differential equations: Solution of elliptic, parabolic, and hyperbolic PDEs, Green's functions for nonhomogeneous PDEs. (vi) Numerical solution of PDEs.

Textbooks

(1) L. Andrews and B. Shivamoggi, *Integral Transforms for Engineers.* PHI Press, 2003.
(2) M. Braun, *Differential equations and their applications.* Springer Press, 1993.
(3) J.D. Hoffman, M. Dekker, *Numerical Methods for Engineers and Scientists.* CRC Press, 2001.
(4) G.B. Arfken, H.J. Weber and F.E. Harris, *Mathematical Methods for Physicists: A Comprehensive Guide.* Elsevier, 2012.

LECTURES AND TUTORIALS

- **Lectures:** Tue Thu 10.00–11.20 am (Room AB 7/208)
- **Tutorials:** Wed 8.30–9.50 am (Room AB 7/104)

Tutorial and Assignments

Two types of problem sets will be posted in regular intervals: Tutorials and Assignments.

- **Tutorial problems:** At least some fraction of them—will be discussed in tutorial session.
- **Assignment problems:** Assignment problems will not be discussed in class. Students are expected to work out these problems and submit them by the appropriate deadline. Solutions to assignments will be provided after deadline.

Discussing in a group is allowed and encouraged; however, each student should hand in their independently written solutions, written in their own words. Mere copying of others' work is strictly prohibited.

POLICY FOR EVALUATION

- **Examination 1:** 20%
- **Quiz:** 10%
- **Examination 2:** 20%
- **Assignment:** 10%
- **Project:** 10%
- **Attendance:** 10%
- **Examination 3:** 20%

GRADING POLICY

Relative grading policy will be followed.