Course Title: Methods of Mathematical Physics

Course Code: MATH-310

Course Type: Major Math

Prerequisites: Partial Differential Equations

Course Objectives: After the completion of the course, students will be able to:

- Understand and apply Fourier and Laplace transforms.
- Utilize advanced techniques for solving partial differential equations (PDEs).
- Understand and apply Green's functions and transform methods.
- Apply perturbation techniques for algebraic and differential equations.
- Understand variational methods and their applications.
- Enhance analytical and problem-solving skills in applied mathematics.

Course Contents:

Sturm Liouville Systems: Regular, periodic, and singular Sturm-Liouville systems and their solutions.

Laplace Transforms: Introduction and properties of Laplace transform, transforms of elementary functions, periodic functions, error function and Dirac delta function, inverse Laplace transform, convolution theorem, Hankel transforms for the solution of PDEs and their application to boundary value problems.

Fourier Transforms: Fourier integral representation, Fourier sine and cosine representation, Fourier transform pair, transform of elementary functions and Dirac delta function, finite Fourier transforms, Solutions of heat, wave and Laplace equations by Fourier transforms.

Green's Functions and Transform Methods: Expansion for Green's functions, transform methods, closed form Green's functions.

Perturbation Techniques: Perturbation methods for algebraic equations, perturbation methods for differential equations.

Variational Methods: Euler-Lagrange equations, integrand involving one, two, three and n variables, special cases of Euler-Lagrange equations, Necessary conditions for the existence of an extremum of a functional, constrained maxima and minima.

Recommended Books:

1. Boyce, W. E., *Elementary Differential Equations*, John Wiley & Sons Inc., 9th edition, 2008.
2. Bender, C. M. and Orszag, S. A., *Advanced Mathematical Methods for Scientists and Engineers*, Springer, Ist Edition, 1999.

3. Brown, J. W. and Churchill, R. V., *Fourier Series and Boundary Value Problems*, McGraw Hill, 8th edition, 2011.

4. Powers, D. L., *Boundary Value Problems and Partial Differential Equations*, Academic Press, 6th edition, 2009.

5. Krasnov, M. L., Makarenko, G. I. and Kiselev, A. I., *Problems and Exercises in the Calculus of Variations*, Imported Publications, Inc., 1985.

6. Snider, A. D., *Partial Differential Equations: Sources and Solutions*, Dover Publications, 2006.

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