PHY-807 Topics in Mathematical Physics

Credit Hours: 3-0
Prerequisite: None

Course Objectives: To learn special functions, solution of partial differential equations, integral transforms, introducing non-linear differential equations and tensor analysis.

Core Contents: This course focuses on special functions as solutions of ordinary differential equations, integral transforms, partial differential equations and their solutions, Introduction to nonlinear differential equation, tensor analysis

Detailed Course Contents: Ordinary Differential Equations, Frobenious method, Strum Liouville equation, Special functions: Legendre, associated Legendre, Bessel function, Orthogonality of Bessel's function, Green function, Transformation of differential equation into integral equation, Integral transform, generating functions, Introduction to non-linear methods and chaos, The logistic maps, Sensitivity to initial conditions and parameters, Nonlinear differential equations, Tensor Analysis, Tensor derivative operators.

Course Outcomes: Students will learn

1. Series solutions of ordinary differential equations
2. Fourier series Integral transforms
3. Special functions
4. Nonlinear differential equations,
5. Tensor Analysis.

Text Book:

George B. Arfken and Hans J. Weber, Mathematical Methods For Physicists, 6^{th} Edition, Elsevier Academic Press 2005. Refereed as (AW)

Reference Books:

1. Mary L. Boas, Mathematical Methods in the Physical Sciences, 3^{rd} ed. John Wiley and sons 2005.
2. Peter V. O'Neil, Advanced Engineering Mathematics, 7^{th} ed. Cengage Learning 2011.
3. Dennis G. Zill, Michael R. Cullen, Differential equations with boundary value problems, 7^{th}ed. Cengage Learning 2008.
4. Erwin Kreyszig, Advanced Engineering Mathematics, 10^{th} ed. John Wiley and Sons 2011.

Weekly Breakdown		
Week	***Section***	***Topics***
1.	AW 9.2-9.6	Review of partial differential equations, Separation of variables, Singularities in differential equation, Series solution of Differential equation (Frobenius method), Regular and irregular singularities, Linear independence of solutions.
2.	AW 9.6, 9.7	Second solution, Series form of second solutions, Non-homogeneous differential equations (Green's function), Symmetry of Green's function, Form of Green's functions,
3.	AW 9.7, 10.1	Examples of Green's functions (Quantum Mechanical scattering), Self adjoint ODE's,
4.	AW 10.4-10.5	Completeness of Eigen functions, Green's function eigen function expansion.
5.	AW 11.1	Bessel's function of first kind, Generating functions of integral order, Recurrence relation, Integral representation of Bessel's function.
6.	AW 11.2 - 11.3	Orthogonality relation of Bessel's functions, Bessel's function of second kind.
7.	AW 12.1-12.2	Introducing Legendre polynomials by means of generating functions, Recurrence relations and special properties of Legendre polynomials
8.	AW 12.3, 12.5	Orthogonality relation of Legendre functions, Associated Legendre functions.
9.	AW 15.1-15.3	Integral transform, Development of Fourier integral, Fourier transform-Inversion theorem.
10.	AW 15.4-15.5	Fourier transform of derivatives, Convolution theorem, Momentum representation.
11.	AW 16.1-16.2	Introduction to integral equation, Transformation of differential equation into integral equation, Integral transform, generating functions.
12.	AW 16.3-16.4	Newman series, separable(degenerate) Kernel, Hilbert Schmidt theory.
13.	AW 18.1-18.3	Introduction to non-linear methods and chaos, The logistic maps, Sensitivity to initial conditions and parameters.
14.	AW 18.4, 2.6-2.8	Nonlinear differential equations, Tensor Analysis, Contraction direct product, Quotient rule.
15.	AW 2.9-2.11	Pseudo tensors, Dual tensors, Tensor derivative operators.