Core IV

Mathematical Physics-II: Credit-3

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

Course Outcomes

- Conceptual understanding of Fourier series and its application in periodic function.
- Understanding the various special functions and its properties.
- Understanding various polynomials and special integrations.
- To learn the applications of partial differential equation.
- To apply the acquired knowledge to solve problems.

Unit I Fourier Series- I

Periodic functions, Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only), Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients, Complex representation of Fourier series, Expansion of functions with arbitrary period, Expansion of non-periodic functions over an interval, Even and odd functions and their Fourier expansions and Application, Summing of Infinite Series, Term-by-Term differentiation and integration of Fourier Series, Parseval Identity.

Unit II Frobenius Method and Special Functions

Singular Points of Second Order Linear Differential Equations and their importance, Singularities of Bessel's and Laguerre Equations, Frobenius method and its applications to differential equations: Bessel, Legendre and Hermite Differential Equations, Legendre and Hermite Polynomials: Rodrigues Formula, Generating Function, Orthogonality

Unit III

- **Polynomials:** Simple recurrence relations of Legendre and Hermite Polynomials, Expansion of function in a series of Legendre Polynomials, Associated Legendre Differential Equation, Associated Legendre polynomials, Spherical Harmonics. Spherical Bessel's Function (1^{st} and 2^{nd} kind).

- **Some Special Integrals:** Beta and Gamma Functions and relation between them, Expression of Integrals in terms of Gamma Functions, Error Function (Probability Integral).

Unit IV Partial Differential Equations

Solutions to partial differential equations using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Conducting and dielectric sphere in an external uniform electric field. Wave equation and its solution for vibrational modes of a stretched string.

Text Books:

- ✓ *Mathematical Methods for Physicists, G.B.Arfken, H.J.Weber, F.E.Harris.(2013, 7th Edn.,Elsevier)*
- ✓ *Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India*)

Reference Books:

- ✓ *Mathematical Physics and Special Relativity, M. Das, P.K. Jena and B.K. Dash (Srikrishna Prakashan)*
- ✓ *Mathematical Physics–H. K. Dass, Dr. Rama Verma (S. Chand Publishing)*
- ✓ *Mathematical Physics C. Harper (Prentice Hall India)*
- ✓ *Complex Variable: Schaum's Outlines Series M. Spiegel (2nd Edition, McGraw Hill Education)*
- ✓ *Complex variables and applications J.W.Brown and R.V.Churchill*
- ✓ *Mathematical Physics, Satya Prakash (Sultan Chand)*
- ✓ *Mathematical Physics B. D. Gupta (4th edition, Vikas Publication)*
- ✓ *Mathematical Physics, B.S.Rajput, Pragati Prakashan*

LAB: Credit 1

The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures(both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem.

Topics

Introduction to Numerical computation software Scilab: Introduction to Scilab, Advantages and disadvantages, Scilab computation software Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2),

Branching Statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program(2).

Curve fitting, Least square fit Goodness of fit, standard constant Deviation: Ohms law to calculate R, Hookes law to calculate spring constant

Solution of Linear system of equations by Gauss elimination Solution method and Gauss Seidal method. Diagonalization matrices, Inverse of a matrix, Eigen vectors, problems: Solution of mesh equations of electric circuits (3meshes), Solution of coupled spring mass systems (3meshes).

Solution of ODE First order Differential equation Euler, modiftedEuler Runge-Kutta second methods Second order differential equation. Fixed difference method:

First order diferential equation

- Radioactivedecay
- Current in RC, LC circuits with DCsource
- Newtons law ofcooling
- Classical equations of motion

Second order Differential Equation

- Harmonic oscillator (no friction)
- Damped Harmonic oscillator

- Overdamped
- Critical damped
- Oscillatory
- Forced Harmonic oscillator
- Transient and Steady state solution
- Apply above to LCR circuits also

Reference Books:

- ✓ *Mathematical Methods for Physics and Engineers, K.FRiley, M.P.Hobson and S. J.20 Bence, 3rd ed., 2006, Cambridge University Press.*
- ✓ *Complex Variables, A.S. Fokas and M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.*
- ✓ *Firstcourseincomplexanalysiswithapplications,D.G.ZillandP.D.Shana-han, 1940, Jones and Bartlett.*
- ✓ *Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fern- ndez. 2014 Springer.*
- ✓ *Scilab by example: M. Affouf2012, ISBN: 978-1479203444*
- ✓ *Scilab (Afreesoftwareto Matlab):H.Ramchandran,A.S.Nair.2011S.Chand andCompany*
- ✓ *Scilab Image Processing: Lambert M. Surhone. 2010 Beta script Publishing*