Mathematical Physics-II

Programme: M.Sc. (Physics)	Year: 1st year	Semester : 2nd semester
Course : Core Course	Credits : 4	Hours (LTP): 40+12+0

Course Context and Overview:

Importance of mathematics in the formulation of physics is well known. This course introduces the students to some of the more advanced concepts used mathematical tools in physics. These tools find applications in almost all areas of physics like classical mechanics and quantum mechanics as well as in statistical mechanics and condensed matter physics.

Prerequisite Courses:

Mathematical Physics-I

Course outcomes(COs):

On completion of this course
CO1: Students would have a basic understanding of complex analysis as required in physics and should be able to use this knowledge to understand more advanced topics in quantum mechanics etc.
CO2: Students will be able to use integral transforms as a basic tool of analysis in almost all branches of physics.
CO3: Students would have an appreciation for the most commonly occurring partial differential equations in physics and the methods for solving them.
CO4: Students would acquire a basic understanding of the concepts of probability and statistics as used in physics and applied sciences. This should enable them to develop an appreciation for the analysis of experimental data.
CO5: Students would acquire a basic knowledge of elementary ideas of group theory. This will help them understand the language of more advanced topics in physics like gauge theories and crystallography.

Course Topics:

Topics	Lectures+Tutorials
Complex Analysis: Basic notions of set theory, neighborhood of a point, isolated point, accumulation point, interior point of a set, open set, closed set, region. Complex numbers and complex plane, Functions of complex argument, derivative of functions of complex variable, Cauchy-Riemann conditions, single valued and multivalued functions, analytic functions and domain of analyticity, entire function, regular	12+4

point, singular point isolated singular point, Examples of analytic functions, integration of functions of complex variables (contour integral), Darboux inequality, Cauchy's integral theorem, Cauchy's integral formula, derivatives of analytic functions, local behavior of analytic functions, Cauchy-Liouville theorem, Morera's theorem, Taylor series, Laurent series, zeros and isolated singular points of analytic functions – simple pole, meromorphic functions, isolated essential singularity, removable singularity, calculus of residues, application of residue theorem to evaluation of integrals, multivalued functions and Riemann surfaces, branch point and branch cut, evaluation of integrals involving multivalued functions.	
Integral Transforms: Definition, from Fourier series to Fourier transform, inverse Fourier transform, Properties of Fourier transform – linearity, transform of derivatives, integrals etc., convolution theorem, Parseval's relation, Transfer function, Laplace transform and its properties.	8+2
Partial differential equations: Classification of partial differential equations, characterstics, boundary conditions, Solution of partial differetial equations using separation of variables (examples of separation in Cartesian, spherical and cylindrical coordinates), solution using integral transform, solution by Green's function method.	8+2
Probability and statistics: Data representation, average, spread, experiments and outcome, Probability, random variables, probability distributions, mean and variance of a distribution, binomial, Poisson and normal distributions	6+2
Group Theory: Definition and general properties of groups, continuous groups, generators of continuous groups. Examples of SO(3) and SU(2).	6+2

Textbooks:

1. G.B. Arfken and H.J. Weber, *Mathematical Methods for Physicists* (Elsevier; 7th Ed. 2012).
2. E. Kreyszig, *Advanced Engineering Mathematics* (Wiley; 10th edition, 2015).

Additional References:

1. P. Dennery and A. Krzywicki, *Mathematics for Physicists*, (Dover Publications Inc.; New edition, 1996). (Especially for Complex Analysis).
2. J. Mathews and R.L. Walker, *Mathematical Methods of Physics*, (Pearson Addison-Wesley; 2nd edition, 1971).

Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):

1. Video lectures on Selected topics in Mathematical Physics by Prof. V. Balakrishnan (IIT Madras) available at http://nptel.ac.in/courses/115106086/