MATHEMATICAL METHODS IN PHYSICS -I

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PRE-REQUISITES : Basic calculus; Algebra; Basic complex numbers

INTENDED AUDIENCE : M.Sc Physics

COURSE OUTLINE :

Mathematical Methods in Physics- I is a basic course in physics for M.Sc (and/or B.Sc 3rd year) students which provides an overview of the essential mathematical methods used in different branches of physics. This course is mainly divided into two parts. In the first part we learn different aspects of the linear vector space which is the essential mathematical tool for quantum mechanics and can be applicable for many physical systems outside the domain of quantum mechanics. In the second part we cover complex analysis whose general application is vast. Students in 3rd year B. Sc or 1st year M. Sc are encouraged to take this course. All the assignments and the final examination will be of objective type.

ABOUT INSTRUCTOR :

Prof. Samudra Roy did his PhD from CGCRI (a CSIR Lab) in 2009 and carried out his post-doctoral research from Hokkaido University, Japan and Max Planck Institute, Germany during 2009-2013. In 2013, he joined in the Physics Department, IIT-Kharagpur as an assistant professor and also associated with the Center for Theoretical Studies-IIT Kharagpur. His research field is nonlinear photonics.

COURSE PLAN :

Week 1: Concept of Set, Binary composition, Group, Ring, Field, Vector Space, Examples of vector space in Euclidean space (R), Metric Space

Week 2: Linearly dependent & independent vectors, Dimensions, Basis, Span, Linear Functional, Dual space, Inner Product, Normed Space, Schwarz inequality, Gram-Schmidt orthonormalization, Completeness

Week 3: Linear Operator, Matrix representation, Transformation of axis, Change of Basis, Unitary transformation, Similarity transformation, Eigen value & Eigen vectors, Matrix decomposition

Week 4: Elementary Matrices,Rank, Subspace with examples. Diagonalization of matrix, The Cayley-Hamilton theorem, Function, mapping, Function space, Linearly dependent & independent function, Examples, Wronskian, Gram-determinant

Week 5: Inner product in function space, Orthogonal functions, Delta function, Completeness, Gram-Schmidt orthogonalization in function space, Legendre polynomials

Week 6: Fourier coefficients, Fourier Transform, Examples, Fourier Series, Parseval's relation, Convolution theorem, Polynomial Space

Week 7: Complex numbers, Roots of the complex numbers, Complex variable & Function, Limit and continuity, differentiability of a complex function, Branch Cut and branch point

Week 8: Cauchy-Riemann equation, Analytic function, Harmonic conjugate function, Examples, Singularities and their classifications

Week 9: Complex integration, Simply and multiply connected regions, Cauchy-Goursat theorem, Cauchy's integral formula, Examples

Week 10: Series & Sequence, Convergence test, Radius of convergence, Taylor's series, Maclaurin Series, Examples

Week 11: Laurent Series, Zeros and poles, Essential singularity, Examples, Residue, Classification of residue, Residue calculations for different orders of poles

Week 12: Cauchy's residue theorem, Application of residue theorem to calculate the definite integrals, Examples