MPHC4101

Mathematical Physics I and Quantum Mechanics I

Group A: Mathematical Physics–I (Tensor and Complex Analysis)

Tensor Analysis

Tensors: Tensor equations as transformational invariants, mathematical operation with tensors (addition, subtraction & multiplication and contraction), metric tensors, raising and lowering of indices, covariant differentiation, Christoffel symbol, Geodesic Equation.

[12 lectures]

References:

(1) Vector analysis and an introduction to Tensor Analysis (Murray R. Spiegel);

(2) Introduction to Tensor Calculus and Continuum Mechanics (J.H. Heinbockel)

Complex Analysis: [Recapitulation of essential notions: Complex Plane, Analytic functions: elementary classification of singularities, Cauchy Riemann Equations, Cauchy Integral theorem and Integral formula] Complex Taylor Series. Laurent Series and the calculus of Residues: evaluation of integrals. **[10 Lectures]**

Application to the evaluation of Green's function for Inhomogeneous Differential Equations. **[8 Lectures]**

Analytic Continuation. Mittag-Leffler Expansions [Conformal Transformations].

[6 Lectures]

References:

1. Murray Spiegel et al, Schaum's Outline of Complex Variables, 2ed ; McGraw Hill Education
2. Churchill and Brown, Complex Variables and Applications; McGraw Hill Higher Education
3. Tristan Needham, Visual Complex Analysis; Oxford
4. Zill & Shanahan, A First Course in Complex Analysis with Applications
5. Harold Cohen, Complex Analysis with Applications in Science and Engineering; Springer

Group B: Quantum Mechanics–I

Vector space and inner product space: Axiomatic definition, completeness, linear independence, basis and dimension, inner product, norm, orthogonality, Gram-Schmidt orthogonalization. Dual space. Linear Operators, Eigenvalues and eigenvectors, Diagonalisation, Hermitian and Unitary operators. Tensor product space.

[12 lectures]

Formulation of quantum mechanics: Postulates and their interpretation, Quantisation scheme: Simple illustrative examples

[4 lectures]

Aspects of time evolution: Solution of the Schrodinger equation and the time evolution operator for conservative systems, time evolution of expectation values, Ehrenfest's theorem. Constants of motion. Heisenberg and interaction pictures of time evolution.

[6 lectures]

One dimensional harmonic oscillator by operator method. Three dimensional harmonic oscillator.

[3 lectures]

Symmetries: Momentum as translation generator, Angular momentum: Connection with rotational symmetry. Symmetry and invariance. **[3 lectures]**

Angular momentum algebra and generalised angular momentum. Solution of the eigenvalue problem using ladder operators. Spin angular momentum, matrix representations for s = ½ and s = 1.

[4 lectures]

Addition of angular momenta: Clebsch-Gordan coefficients.

[4 lectures]

References:

(1). Introduction to Quantum Mechanics; D. J. Griffiths; Pearson Education.

(2). Quantum Mechanics Vol 1 & 2; C. Cohen Tannoudji, B.Diu, F. Laloe; Wiley.

(3). Primer of Quantum Mechanics; Marvin Chester; John Wiley & Sons.

(4). Principles of Quantum Mechanics; R. Shankar; Springer

(5). Modern Quantum Mechanics: J. J. Sakurai (Addison-Wesley Publ. Co. Ltd.)

(6). Feynman Lectures Vol. III: R. P. Feynman, R. B. Leighton and M. Sands (Addison-Wesley)