SEMESTER II

Paper: PHY801C (Core)
Electromagnetic Theory & Electrodynamics
Credits: 3+1+0=4

Theory: 48 Lecture

Electro and Magnetostatic [8 lectures]

Boundary valu problems of electro and magnetostatics , Green's function, Image problem. Green's reciprocity theorem. Scalar and vector potential for steady localized charge and current distributions, Multipole expansion.

Maxwell's Equations [6 lectures]

Maxwell's equations. Electromagnetic scalar and vector potentials and gauge transformations, Inhomogeneous wave equations and their solutions; Radiation from localised sources and multipole expansion in the radiation zone.

Conservation Laws [4 lectures]

Energy density of elctromagnetic field, Conservation law for energy and momentum, Poynting vector, Maxwell's Stress tensor, Energy-momentum tensor.

Electromagnetic Wave [6 lectures]

Propagation of em-waves in free space, non-conducting and conducting media; reflection and transmission at the boundary of two non-conducting media; reflection from a metal surface; propagation of em-waves in bounded media; idea of wave guides.

Relativistic Electrodynamics [6 lectures]

Recap of basic concepts of STR, introduction to 4-vectors, Lorentz transformations in terms of 4-vectors, Charge-Current density 4-vectors. Electromagnetic field tensor, Covariance of Maxwell's equations. Applications.

Radiation from moving charge [6 lectures]

Lienard Wiechert potential and fields for a point charge; total power radiated by an accelerated charge; angular distribution of radiation from charged particles in extremely relativistic motion: Cherenkov radiation, Synchrotron radiation.

Radiation reaction [3 lectures]

Radiation reaction from energy conservation; Problem with Abraham-Lorentz formula; Limitations of Classical Electrodynamics.

Scattering of electromagnetic waves [3 lectures]

Scattering of em-waves due to free electrons: Thompson scattering; scattering from bound electrons: Rayleigh scattering, resonance fluorescence; energy loss in radiation.

Plasma physics [6Lectures]

Definition of plasma; Its occurrence in nature; Dilute and dense plasma; Uniform but time-dependent magnetic field: Magnetic pumping; Static non-uniform magnetic field: Magnetic bottle and loss cone; MHD equations, Magnetic Reynold's number; Pinched plasma; Bennett's relation; Qualitative discus- sion on sausage and kink instability.

Recommended Books:

1. Introduction to Electrodynamics: D. Griffiths
2. Classical Electrodynamics: J. Jackson
3. Classical Electricity and Magnetism: W. K. H. Panofsky and M. Phillips.
4. Classical Electrodynamics: Julian Schwinger
5. The Classical Theory of Fields: L. Landau
6. The Feynman lectures on Physics: R. Feynman, R. Leighton and M. Sands.
7. Electromagnetic Field Theory and Wave Propagation: Uma Mukherjee
8. Engineering Electromagnetics: W. H. Hyat and J. A. Buck
9. Fundamentals of Electromagnetics: M. A. Wazed Miah
10. Electromagnetic Fields and Waves: P. Lorrain and D. Corson
11. 2000 Solved Problems in Electromagnetics: S. A. Nasar
12. Electromagnetics: B. B. Laud
13. Elementary Plasma Physics: C. L. Longmire
14. Introduction to Plasma Physics and Controlled Fusion: F. F. Chen

Paper: PHY802C (Core)
Quantum mechanics II
Credits: 3+1+0=4

Theory: 48 Lecture

AngularMomentum: (12 lectures)

Angular momentum as the generator of rotation. Commutation relations. Spin half system and Pauli matrices. Angular momentum algebra: Raising and lowering operators. Eigenfunctions and eigenvalue of angular momentum. Orbital angular momentum operator. Commutation relations. Spherical harmonics.

Addition of Angular Momentum: (8 Lectures)

Addition of angular momenta and Clebsch-Gordan coefficients. Tensor operator and Wigner-Eckart theorem (statement and elementary application only).

Indistinguishable and identical particles in quantum mechanics: (4 lectures)

Indistinguishable and identical particles in quantum mechanics. Combination of wave functions for a system of particles. Symmetric and anti-symmetric wave functions. Spin statistics connection. Exchange interaction and exchange energy.

Approximation Methods: (18 lectures)

Time-independent perturbation theory: first and second order non-degenerate degenerate cases. Stark and Zeeman effects. Variational methods and examples of hydrogen atom, Harmonic oscillator. Time-dependent perturbation theory: transition probability. Transition probability for constant perturbation. Transition to a continuum of final states. Fermi's golden rule. Harmonic perturbation. Adiabatic and sudden approximations.

Symmetry in Quantum Mechanics: (6 lectures)

Symmetries and conservation laws. Parity. Space inversion and time reversal symmetry.

Reading List:

1. Quantum Mechanics : C. Cohen-Tannoudji, B. Diu, and F. Laloe
2. The Principles of Quantum Mechanics: P. A. M. Dirac
3. Quantum Mechanics: N. Zettili
4. The Feynman Lectures on Physics: R. Feynman, R. Leighton and M. Sands

5. Quantum Mechanics: A. Ghatak and S. Lokanathan
6. Quantum Mechanics: A. Arhuldass
7. Quantum Mechanics: S N Biswas
8. Introduction to Quantum Mechanics: D. J. Griffiths
9. Modern Quantum Mechanics: J.J. Sakurai
10. Quantum Mechanics: Eugen Merzbacher

Paper: PHY803C (Core)
Mathematical Physics II
Credits: 3+1+0=4

Theory: 48 Lecture

Tensor Analysis: (12 lectures)
Co-ordinate transformations. Scalars, covariant and contravariant vectors and tensors. Vector algebra: addition, subtraction, outer product, inner product and contraction. Symmetric and anti-symmetric tensors. Quotient law. The metric tensor. Associate tensor. Raising and lowering of indices. The Christoffel symbols: transformation laws. Covariant derivatives of tensors.

Special Functions and Polynomials: (16 lectures)
Rodrigues' formula, generating functions, recurrence relations and orthogonality of Legendre, Hermite and Laguerre polynomials. Series expansion of a function in terms of a complete set of Legendre functions; Bessel functions: first and second kind. Generating function. Recurrence formula. Zeros of Bessel functions. Orthogonality.

Differential Equations: (8 lectures)
Sturm-Liouville theory. Hermitian operators. Completeness. Simple applications. Inhomogeneous equations. Green's functions and their applications.

Group Theory: (12 lectures)
Definition of group. Subgroups, cosets and classes. Factor group. Homomorphism. Isomorphism. Direct products, Group representation: reducible and irreducible representations. Symmetry group. Unitary group. Lie groups. SU(2) and SU(3). Simple applications.

References:

1. Mathematical Methods for Physicists, George B. Arfken, Hans J. Weber and Frank E. Harris, Academic Pres.s, 2013.

2. Mathematical Physics, A. K. Ghatak, I. C. Goyal and S. J. Chua, Macmillan, 1995.

3. Mathematics for Physicists, P. Dennery and A. Krzywicki, Dover, 1995.

4. Mathematical Physics (Advanced Topics), S. D. Joglekar, Universities Press, 2006.

5. Introduction to Mathematical Physics, Charlie Harper, Prentice-Hall, 1976.

Paper: PHY804C (Core)
Solid State Physics
Credits: 3+1+0=4

Theory: 48 Lecture

Crystal structure and binding: Diffraction of electromagnetic waves by crystals, Reciprocal Lattice, Powder and Rotating Crystal method, Neutron and electron diffraction. Types of crystal binding, London's theory of Van der Waals forces, Ionic bonding and Medelung constant. **(10 Lectures)**

Vibrations in solids: Classical treatment, Normal modes; Quantum treatment, Phonons, Anharmonic effects, Thermodynamic properties related to phonons, Continuum approximation; Measurement of phonon frequencies and inelastic scattering. Scattering mechanism- impurity and phonon scattering; Normal and Umklapp processes. Mobility of charge carriers and Seebeck coefficient.

(10 Lectures)

Electronic states in solids: Sommerfeld model, thermodynamic properties due to free electrons. Band structure: basic concepts, Bloch theorem, density of states, nearly free electron approach and pseudopotentials; tight binding method (linear combination of atomic orbital method); modern band structure method.

(10 Lectures)

Motion of electrons in solids: Semi classical model, band velocity, effective mass; Concept of electron, hole and open orbits. Effect of open orbits on electric and high magnetic fields; magnetoresistance. Experimental determination of Fermi surface, de Haas-van Alphen effect, anomalous skin effect and cyclotron resonance. **(14 Lectures)**

Defects and diffusion in solids: Point defects and dislocations, Fick's law, diffusion constant, self-diffusion, colour centres and exitons. **(4 lectures)**

Suggested Books:

1. Solid State Physics, Neil W Ashcroft and N Devid Mermin, McGraw-Hill Education, 1976).

2. Principles of the Theory of Solids, J M Jiman, Cambridge University Press, 2000.

3. Condensed Matter Physics, Michael P Marder, Wiley Interscience, 2000.

LIST OF EXPERIMENTS

Set the c-axis of the given crystal perpendicular to the incident x-ray beam.

1. Obtain an oscillation photograph of the given single crystal about c-axis, calculate the c-dimension of the unit cell, and index of reflection.

2. Obtain the Laue photograph of the given single crystal, draw gnomonic projection, and index of reflections.

3. Determine the cell dimensions and establish the face centring of copper by Debye-Scherrer method (Powder Method)

Paper: PHY805L (Lab)
Solid State Physics, Nuclear Phys & Laser Experiments
Credits: 0+0+4=4

List of Experiments:

1. Set the c-axis of the given crystal perpendicular to the incident x-ray beam.

2. Obtain an oscillation photograph of the given single crystal about c-axis, calculate the c-dimension of the unit cell, and index of reflection.

3. Obtain the Laue photograph of the given single crystal, draw gnomonic projection, and index of reflections.

4. Determine the cell dimensions and establish the face centring of copper by Debye-Scherrer method (Powder Method)

5. Measure the energy band-gap of a given semiconductor material of a PN junction and its junction capacity by reverse-biasing the junction.

6. Determine the conductivity type and Hall constant of a given semiconductor

7. Determine the constant of a Ballistic Galvanometer (BG) and study I-H and B-H curves

8. Determine e/m for electrons by magnetron method.

9. To study the statistical distribution law the govern nuclear decay using GM counter.

10. To study the variation of count rate with applied voltage and thereby determine the plateau, the operating voltage and the slope of plateau.

(**Department will add more experiments later**)