Syllabus

Interview Support Program for Postgraduate Students

A. Mathematical Physics (Reference: Mathematical Methods for Physics by Arfken, Erwin Kreyszig)

1. Curve Tracing of important functions: Exponential curve, Hyperbolic curve, Modulus, gaussian, etc. understanding the nature of the curve using maxima minima and functional values.

Practice following curve tracing:

(a) Algebraic

$f(r)=\frac{a}{r^2}-\frac{b}{r}$ for $r>0, f(x)=ax^2+\frac{b}{x^2}a,\ b>0,\ f(x)=\frac{x^2}{2}-\frac{x^3}{3}, f(x)=\frac{x^2}{2}-\frac{x^4}{4}$

$\log(x),\ x\log(x)$

(b) Trigonometric $\sin x, \cos x, \tan x, x\sin x, x\cos x, \frac{\sin x}{x}, \frac{\cos x}{x}$.

(c) Exponential and Modulus curve $\frac{e^x}{x}$ $|x|$, $e^{|x|}, e^{-|x|}, |\sin x|, |\cos x|$.

(d) Hyperbolic curve , $\sinh x, \cosh x, \tanh x, \sec hx$.

Suggested Tools for curve tracing:www.wolframalpha.com,www.desmos.com, www.geogebra.org

2. Fundamentals of Fourier Transformation, Laplace transform.
3. Matrices: Property of Hermitian and Unitary matrix, Pauli spin matrices.

Practice eigen values and eigen vectors of matrices $\begin{bmatrix}1&0&1\\0&1&0\\1&0&1\end{bmatrix}, \begin{bmatrix}0&1&0\\1&0&1\\0&1&0\end{bmatrix}$

$\begin{bmatrix}1&1&1\\1&1&1\\1&1&1\end{bmatrix}, \begin{bmatrix}1&0&0\\0&1&1\\0&1&1\end{bmatrix}, \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\end{bmatrix}$

Function of matrices

4. Differential Equation: solution of particle in gravitational field, Particle under damping, harmonic oscillator, charge particle under EM field, Damped and Forced Oscillator, LCR circuit
5. Dirac delta function properties.

6. Basics of Group Theory, Examples of SU(2), and SO(3).

B. Classical Mechanics (Reference: Goldstein and Klepner)

1. Phase Curve by Pravegaa Class Notes.
2. Lagrangian and Hamiltonian Formulation, Understanding of conservation principle by Poisson bracket.
3. Motion of simple Pendulum, moving pendulum, rotating pendulum double pendulum and Concept of Small Oscillation, Damped oscillation.
4. Central force problem, Two Body Problems, Sun Earth System Kepler's three laws.
5. Introduction of non-linear dynamics.

C. Quantum Mechanics (Reference: Arthur Beiser, Introduction of Quantum Mechanics by D. J. Griffith)

1. Notes by Pravegaa.
2. Particle properties of light, Wave Properties of particles, Atomic structure.
   Results and setup of different experiments.
   (a) Photo electric effect.
   (b) Compton effect.
   (c) Davisson Germer effect.
   (d) Stern-Gerlach experiment.
3. Schrödinger's Theory of Quantum Mechanics, solution of time-Independent Schrödinger Equation.
   Complete analysis of solution of Schrodinger wave equation
   (a) Particle in a box.
   (b) Harmonic Oscillator.
   (c) Dirac Delta Potential.
   (d) Hydrogen atom.
4. Space quantization (Angular momentum and spin).
5. Scattering with central potential.

D. Statistical Mechanics and thermodynamics (Reference: R.K. Pathria)

1. Laws of thermodynamic property, Maxwell relations and thermodynamical potential.
2. Identical particles.
   (a) Maxwell Boltzmann distribution.

(b) Fermi Dirac distribution.

(c) Bose Einstein distribution.

3. Ensemble Theory: Microcanonical, Canonical Ensemble and Grand Canonical.

Complete analysis of thermodynamic physical quantity at equilibrium temperature.

(a) Free particle.

(b) Harmonic oscillator.

(c) Paramagnetic substance.

(d) Basic property of first order and second order phase transition.

E. Optics and Waves (Reference: Ajoy Ghatak)

1. Ray optics -Format's principle, Snell's law, Total internal reflection, Properties of dispersion.
2. Interference: Young's double slits, Newton's Ring and Michelson Morle Experiment
3. Diffraction: Single slit, Double slit
4. Polarization: Malus law, Brewester Angle

F. Electromagnetic Theory Electrodynamics (Reference: David J. Griffiths)

1. Maxwell's Equations (differential and Integral form)
   (a) General Maxwell's Equations
   (b) Inside Matter
   (c) Applications of Gauss law.
   (d) Boundary Conditions
2. Propagation of Electromagnetic Waves in
   (a) In free space (b) Inside Dielectrics (c) Inside conductors
3. Reflection and Refraction at Interface
   (a) Brewester Angle (b) Critical Angle (c) Total Internal Reflection
4. Potential Formulation for time varying fields.
5. Concept of Vector potential and scalar potential.
6. Applications of Ampere circuital law.
7. Retarded potential
8. Lorentz gauge and coulomb gauge.
9. Green's function

G. Solid State and electronics Physics (References: C. Kittle and M.A. Wahab)

1. Fundamental of space Lattice, Symmetry Operation (Translational, Reflection & Inversion Symmetry Operator), Concept of Lattice in 2D and 3D.
2. Miller Indices, Planar Spacing, Packing Fraction, Diamond Cubic Structure, HCP Structure, *NaCL*, *ZnS* and *CsCl* Structure.
3. Reciprocal Lattice and X- ray Diffraction of Crystal (Structure Factor Calculation of SC, BCC, FCC, Hexagonal) and Braggs Law.
4. Heat capacity of solid.
5. Drude Model of Electrical Conductivity, Resistivity of Model, Semimetal, Insulator and Semiconductor, Concept of Phonons, Thermal Conductivity of Metal & Insulator, Hall Effect in Metal and Semiconductor.
6. Band Formation in Metal, Semimetal, Semiconductor & insulator Concept of Holes. Effective Mass of Electron and Holes.
7. Basic difference between normal conductor and superconductors.
8. Type-I and Type-II superconductors.
9. Semiconductor Physics.
10. Diode Application.
11. Basic Transistor.
12. Op-Amp.

H. Atomic (Reference: Bransden Joachain), Molecular (Reference: Banwell) and Nuclear Physics (Reference: S.N. Ghosal)

1. Atomic and Molecular Physics

(a) Interaction of orbital angular momentum with spin (Spin orbit coupling).

(b) Splitting of energy levels due to weak and strong magnetic fields (Zeeman, and Paschen Back effect).

(c) Splitting of energy levels due to electric field (Starc effect).

(d) Basic concept of Raleigh, Stokes and Anti-Stokes lines (Raman Effect).

2. Laser:

(a) Basic properties of laser.

(b) Concept of spatial and temporal coherence (properties of laser).

(c) Einstein coefficient's A and B coefficients.

(d) Basic working of He-Ne, Ruby, Nd-YAG, CO_2 lasers.

I. Nuclear Physics

(a) Basic properties nucleus.

(b) Binding energy Curve (Detail).

(c) Liquid drop model (Estimation of atomic number of most stable nuclei of a particular isobar).

(d) Shell model (Calculation of nuclear spin and parity).

(e) Nuclear Fusion and fission (Why it happens?).

(f) Alpha decay for higher atomic masses.

(g) Fundamental forces and their significance.

(h) Yukawa potential.