Outline for qualifying exams

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1 Classical Mechanics

1. Newtonian Mechanics
   (a) Newton's Laws/Kinematics
   (b) Energy
   (c) Momentum/Angular Momentum
2. Lagrangian Mechanics
   (a) Calculous of Variations
   (b) Principle of Least Action/Lagranges Equation
   (c) Generalized Coordinates
   (d) Holonomic/Non-Holonomic Constraints
   (e) Noether's Theorem
   (f) Rigid Body Motion
      i. Inertia Tensor
      ii. Euler's Equations
3. Hamiltonian Formalism
   (a) Legendre Transformation/Hamilton's Equations
   (b) Generalized Momenta/Cyclic Coordinates/Conserved Quantities
   (c) Liouville's Theorem
   (d) Poisson Brackets
   (e) Canonical Transformations

2 Statistical Mechanics

1. Thermodynamics Review
    (a) Laws of Thermodynamics
    (b) Intensive vs Extensive Variables
    (c) Thermodynamic Potentials and Ensembles
    (d) Maxwell's Relations
    (e) Various Definitions
        i. Compressibility
        ii. Heat Capacity etc.
2. Statistical Mechanics
    (a) Statistical Review
    (b) Partition Function/Trace
    (c) Thermodynamic Limit
    (d) Density Matrix
    (e) Ideal Gas
    (f) Ideal Bose Gas
    (g) Ideal Fermi Gas
    (h) Photons (BB)
    (i) Phonons
    (j) Bose-Einstein Condensates
    (k) Cluster Expansion

3 Quantum Mechanics

1. Shankar Math Review
2. Postulates
3. Free Particle
4. Particle in a Box
5. Harmonic Oscillator
6. Angular Momentum
7. Hydrogen Atom
8. Spin

9. Angular Momentum Addition
10. Time-Independent Perturbation Theory
11. Time-Dependent Perturbation Theory
    (a) Einstein A and B Coefficients
12. Scattering
13. WKB Formula
14. Dirac Equation

4 Electricity and Magnetism

1. Electrostatics
    (a) Coulomb's Law
    (b) Electrostatic Potentials
        i. Poisson/Laplace's Equations
    (c) Boundary Conditions
    (d) Method of Images
    (e) Multipole Expansion
    (f) Work and Energy
    (g) Electric Fields in Matter
2. Magnetostatics
    (a) Lorentz Force Law
    (b) Biot-Savart Law
    (c) Vector Potential
    (d) Magnetic Fields in Matter
3. Electrodynamics
    (a) Faraday's Law
    (b) Ampere's Law
    (c) Ohm's Law
    (d) Maxwell's Equations
    (e) Boundary Conditions to Maxwell's Equations
    (f) Continuity Equation

   (g) Poynting's Theorem
   (h) Maxwell Stress Tensor
   (i) Electromagnetic Waves
      i. The Wave Equation from Maxwell's Eq.
      ii. EM Waves in Matter
      iii. Wave Guides
4. Scalar and Vector Potentials
5. Coulomb and Lorentz Gauge
6. Retarted Potentials
7. Lienard-Wiechert Potentials
8. Radiation
   (a) Electric/Magnetic Dipole Radiation
9. Helmholtz Theorem
10. Special Relativity
   (a) Einstein's Postulates
   (b) Lorentz Transformation
   (c) 4-Vectors
   (d) Field Tensor and Transformation
   (e) Relativistic Potentials