

Study guide for qualifying exams

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1 Classical Mechanics Equations

Newtonian Mechanics

Newton's Laws:

Second Law:

Angular Position/Velocity/Acceleration:

Angular Momentum:

Torque:

Centripital Acceleration:

Centrifugal/Coriolis Forces:

Work to go from positions \vec{a} to \vec{b} :

Conservative Force Field (2 eq):

Lagrangian Formalism

Functional Derivative:

Principle of Least Action:

Lagranges Equation:

Holonomic Constraints:

Noether's Theorem:

Moment of Inertia Tensor:

Euler's Equations:

Hamiltonian Formalism

Generalized Momenta:

Hamiltonian:

Hamilton's Equations:

Cyclic/Ignorable Coordinates:

Liousille's Theorem:

Poisson Bracket:

Constant of Motion from Poisson Bracket:
Canonical Transformation:

2 Statistical Mechanics Equations

2.1 Thermodynamics

Laws of Thermodynamics:
Intensive vs Extensive Variables:
Thermodynamic Potentials:
Thermodynamic Ensembles:
Maxwell's Relations (4 main):
Engine Efficiency:
Isobaric Thermal Expansion Coefficient:
Isothermal Compressibility:
Isentropic(Adiabatic) Compressibility:
Specific Heat at Constant V:
Specific Heat at Constant p:
Fermi Energy/Temperature:

2.2 Statistical Mechanics

Number of microstates in a macrostate (ways to get n heads):
Stirling's Approximation:
How many order important ways to order n things:
How many order important ways to order n things r at a time:
How many NOT order important ways to order n things r at a time:
Microcanonical(Classical) Partition Function:
Canonical Partition Function:
Grand Canonical Partition Function:
Geometric Series:
Classical limit of the trace of an operator:
Thermodynamic Limit:
Expectation value for pure/mixed:
Density Matrix (ex. Canonical Ensemble):
Expectation value with Density Matrix:
Trace of Density matrix:
Time evolution of density matrix:
 Z_{gc} for an ideal gas:
 Z_{gc} for ideal fermi gas:
 Z_{gc} for ideal bose gas:
Explain Bose-Condensates with Bose statistics:

What is cluster expansion used for?:

3 Quantum Mechanics Equations

Properties of a vector space:

Hilbert space:

Expand in orthonormal basis:

Hermitian operator:

Anti-Hermitian operator:

Unitary operator:

Orthogonality:

Completeness:

Postulates of QM:

Schrödinger equation:

Free particle ψ_p and E_p :

Particle in a box ψ_n and E_n :

Harmonic Oscillator \hat{H} , ψ_n and E_n :

Raising and lowering operators and how to affect $|n\rangle$ (3-2):

\hat{H} in terms of a and a^\dagger :

Commutation relations for \hat{H} , a , a^\dagger :

J^2 and J_z on the angular momentum state $|jm_j\rangle$:

Commutation relations for J_i and J_j and for J^2 and J_i :

J_z and J^2 in position basis:

Raising and Lowering Angular Momentum Operators on $|j, m\rangle$:

J_x and J_y in terms of J_+ and J_- :

Momentum eigenstate, $\langle x|p\rangle$:

Hydrogen Atom $V(r)$, ψ_n , E_n (x4):

Pauli matrices and commutation relations:

Non-Deg Time-Ind Perturbation, $E_n^{(1)}$, $|n^{(1)}\rangle$, $E_n^{(2)}$:

Deg Time-Ind Perturbation, $E_n^{(1)}$:

Time-Dep Perturbation, $P_{i \rightarrow f}(t)$:

Fermi's golden rule, and $g(E_f) \rho(E_f)$:

Einstein's Stimulated/Spontaneous emission coefficients:

Total $\psi(\mathbf{r})$ in scattering problem:

Differential Cross Section:

Born Approximation:

Dirac Equation:

4 Electricity and Magnetism Equations

Maxwell's Equations in Vacuum (SI):

Maxwell's Equations in Matter (SI), and D and H:

Continuity Equation:

Lorentz Force:

Coulomb's Law (x2):

Gauss' Law:

Electrostatic Potential (x2):

Laplace's Equation & General Solution(Spherical Coordinates, no ϕ):

Poisson's Equation:

Explain the Method of Images:

Method of Images (plane, sphere, hem boss):

Multipole Expansion of $\Phi(\mathbf{r})$:

Work and Energy in Electrostatics:

Atomic Polarizability (α):

Polarization:

Magnetization:

Bound Charge:

Bound Current:

Linear Media x2:

Biot-Savart Law:

Ohm's Law:

Resistivity:

Boundary Conditions:

Poynting's Theorem, units of S:

Maxwell Stress Tensor and Static Force:

Index of Refraction:

What is a Waveguide:

Transverse electric/magnetic and TEM

E and B in terms of A and Φ :

Coulomb/Lorentz Gauge:

Retarded Scalar and Vector Potentials:

What are the Liénard-Wiechert Potentials?:

Radiation Estimate $|\mathbf{r} - \mathbf{r}'|$ and $\frac{1}{|\mathbf{r} - \mathbf{r}'|}$:

Radiation Dipole Approximation

Electric Dipole Moment:

Larmor Formula:

Helmholtz Theorem:

Einstein's Postulates of Special Relativity:

Boost in the x-direction in terms of x_i , γ and β :

Boost in the x-direction in matrix form:

Covariant vs. Contravariant:

Minkowski metric:

Four-(v, p, J, A):

Relativistic Energy x2:
Field Tensor and Transformation:
Maxwell's Equations with d'Alembertian:

5 Miscellaneous Physics

Taylor Expansion:
Gaussian Integral:
3 types of Boundary Conditions:
Value of fine structure constant:
Mass of electron in eV:
Value of the Bohr radius:
Wave Equation:
Diffusion Equation: