

Columbia University  
Department of Physics  
Books and Topics List for the Qualifying Exam

**Books:**

Classical Mechanics:

J. R. Taylor, *Classical Mechanics*  
H. Goldstein, C. Poole, and J. Safko, *Classical Mechanics*  
L. D. Landau, E.M. Lifshitz, *Mechanics*

Electricity, Magnetism, and Electrodynamics:

D. J. Griffiths, *Introduction to Electrodynamics*  
E. M. Purcell, *Electricity and Magnetism*

Quantum Mechanics:

D. J. Griffiths, *Introduction to Quantum Mechanics*  
R. Shankar, *Principles of Quantum Mechanics*  
J. J. Sakurai, S. F. Tuan, *Modern Quantum Mechanics*

Thermodynamics:

D. V. Schroeder, *Thermal Physics*  
C. Kittel, H. Kroemer, *Thermal Physics*

Statistical Physics:

C. Kittel, *Elementary Statistical Physics*

Solid State/Condensed Matter:

C. Kittel, *Introduction to Solid State Physics*  
S. Simon, *The Oxford Solid State Physics Basics*

High-Energy Physics:

D. J. Griffiths, *Introduction to Elementary Particles*

Optics:

E. Hecht, *Optics*  
G. Fowles, *Introduction to Modern Optics*

Atomic Physics:

C. J. Foot, *Atomic Physics*

# Topics:

## Mechanics:

Newtonian Mechanics  
Lagrangian Mechanics  
Hamiltonian Mechanics  
Noether's Theorem  
Scattering  
Harmonic Oscillator  
Coupled Oscillators  
Kepler's Laws  
Non-inertial Frames  
Rigid Body Rotation  
Transverse Waves  
Acoustic Waves  
Normal Modes

## Special Relativity:

Time Dilation, Length Contraction  
Lorentz Transformation  
Four-vectors  
Relativistic Mechanics  
Compton Scattering

## Electricity, Magnetism and Electrodynamics:

### Electrostatics:

Electric Field, Coulomb's Law, Gauss's Law, Electric Potential, Conductors, Capacitors  
Laplace and Poisson Equation  
Image Charges  
Separation of Variables for Laplace's Equation  
Multipole Expansion  
Dielectrics, Polarization, Electric Displacement

### Magnetostatics:

Magnetic Field, Lorentz Force Law, Biot-Savart Law, Ampere's Law, Vector Potential  
Magnetization, Auxiliary Field  
Maxwell's Equations

Circuits: Resistors, Capacitors, Inductors

Conservation Laws

Electromagnetic Waves

Waveguides

### Radiation:

Electric and Magnetic Dipole radiation, Larmor formula, Radiation zone approximations,  
Bremsstrahlung

Lorentz Transformations of the Electric and Magnetic Fields

Gauge Transformation

Optics:

Dispersive Media (Phase Velocity vs. Group Velocity)

Lens Equation

Fresnel Equations

Refraction

Interference (e.g. Young's Experiment)

Diffraction

Images

Polarization

Quantum Mechanics:

Hilbert Space, Operators

Matter Waves

Uncertainty Principle

Commutation Relations

Angular Momentum, Rotational Invariance, Clebsch-Gordon Coefficients

Wave Function

Schrödinger Equation

Classical Limit

Quantum Harmonic Oscillator

Annihilation and Creation Operators

Spin

Hydrogen Atom

Time-Independent Perturbation Theory

Time-Dependent Perturbation Theory

WKB Approximation

Thermodynamics:

Ideal Gas

Heat and Work

Engines and Cycles

Enthalpy, Free Energy, Gibbs Free Energy

Maxwell Relations

Thermal Radiation

0th, 1st, 2nd, and 3rd Laws

Statistical Physics:

Entropy

Partition Function

Temperature

Kinetic Theory

Maxwell-Boltzmann Distribution

Maxwell Velocity Distribution

Planck Distribution

Fermi and Bose Statistics

Bose-Einstein Distribution  
Fermi-Dirac Distribution  
Density of States  
Quantum Gases  
Maxwell Relations  
System Parameters/Thermodynamic Potentials  
Phase Transitions  
Chemical Potential  
Equipartition Theorem of Energy  
Blackbody Radiation  
Interacting gases/Virial Coefficients/van der Waals  
Ising Model  
Microcanonical Ensemble, Canonical Ensemble, Grand Canonical Ensemble  
Connections between Statistical and Thermodynamic Properties