

What should a Physics Major Know?

An incomplete list based on quick analysis of two old GRE exams

Atomic - Bohr model (energies)
Atomic - Bohr Model - Definition of K transition
Atomic - Bohr model, $1/n^2$ dependence for energy
Atomic - emission lines in a magnetic field, general properties
Atomic - filling the levels (order, total number)
Atomic - first order Stark effect for H in the ground state
Atomic - ground state spin of helium atom
Atomic - hydrogen atom - energy levels
Atomic - life-time broadening
Atomic - notation ("³S ground state")
Atomic - notation ($1s^2 2s^2 2p^6$, etc)
Atomic - positronium (Bohr model for)
Atomic - scattering - cross section, differential (order of magnitude from data)
Atomic - selection rules (electric dipole)
Atomic - typical K series transition energies

Circuits - RC time constant
Circuits - RLC circuit with damping - natural frequency of
Circuits - current divider
Circuits - finding currents in branches
Circuits - impedance matching
Circuits - LR time constant
Circuits - Ohm's law
Circuits - $P = I^2 R$
Circuits - parallel and series resistors, equivalents
Circuits - voltage divider, voltages in simple circuits

Constants - speed of light $c \approx 3 \times 10^8$ m/s
Constants - $hc \approx 1240$ eV·nm (or equivalent)
Constants - mass of electron in energy units ≈ 0.511 MeV/ c^2
Constants - 1 eV $\approx 1.6 \times 10^{-19}$ J $\approx 11,000$ K
Constants - Planck's constant $h \approx 1 \times 10^{-34}$ J·s

E&M (waves) - reflection of plane waves from a conductor
E&M - accelerating charge through a potential ($U = qV$)
E&M - boundary conditions at a conductor
E&M - capacitor - energy stored
E&M - charged particle in E and M fields, general properties of motion
E&M - Coulomb's law (in MKS)
E&M - current in wire, drift velocity
E&M - current loop is magnetic dipole (far away)
E&M - cyclotron frequency

E&M - definition of capacitance
E&M - direction of M field from current carrying wire
E&M - effect of dielectric on capacitance
E&M - $\mathbf{F} = q[\mathbf{v} \times \mathbf{B}]$
E&M - fall off of fields from dipole
E&M - field from finite charged rod, along axis
E&M - Gauss's Law - indicator of charge present
E&M - Gauss's law, field inside sphere
E&M - general knowledge - experiment to determine exponent in Coulomb's law accurately
E&M - image charges (for infinite conducting plane)
E&M - internal resistance of a battery
E&M - magnetism - Ampere's law (simple path)
E&M - magnetism - Faraday's law of induction
E&M - magnetism - force between two (parallel) wires
E&M - magnetism - Lenz's law
E&M - Maxwell's equations
E&M - Maxwell's equations - meaning of terms
E&M - polarization of dielectric, surface charge density
E&M - potential difference - from electric field and distance (simple cases)
E&M - radiation from accelerating charge (general properties)
E&M - radiation from oscillating charge, general properties
E&M - superposition principle
E&M - surface charge density on a conductor with charges nearby

General - angular frequencies (ω)
General - circumference of a circle
General - complex exponentials
General - exponentials and natural logarithms - time constants
General - field lines, interpreting
General - Fourier series - simple cases (odd/even fcn, odd/even harmonics)
General - matrices - moving rows and columns
General - matrices - recognizing eigenvalues
General - meaning of "divergence is zero"
General - Right Hand Rule for cross products
General - units (checking)
General - vectors - $\mathbf{i}, \mathbf{j}, \mathbf{k}$ notation
General - vectors - resolving components and their manipulations
General - volume of sphere

Mechanics - acceleration near earth = g?
Mechanics - circular motion - separating components
Mechanics - circular motion - uniform, description in x, y coordinates.
Mechanics - circular motion, uniform, $\mathbf{F} = m\mathbf{a}$ for
Mechanics - collisions, simple
Mechanics - conservation of energy

Mechanics - conservation of angular momentum
 Mechanics - conservation of momentum
 Mechanics - constant acceleration
 Mechanics - eigenfrequencies (of normal modes)
 Mechanics - elastic collisions (conservation of momentum)
 Mechanics - extremum (variational methods)
 Mechanics - $F=dp/dt$, with mass not constant (rocket problem)
 Mechanics - falling body (constant acceleration)- with initial conditions
 Mechanics - falling body with air resistance - general properties
 Mechanics - forces - resolving components
 Mechanics - forces - resolving components - tension in a string
 Mechanics - frequency of harmonic oscillator (mass on a spring)
 Mechanics - friction - simple model, maximum static
 Mechanics - friction, dynamic
 Mechanics - getting F from U
 Mechanics - gravitation - force inside a spherical shell is zero
 Mechanics - gravitation - universal law ($1/r^2$ dependence)
 Mechanics - Hamiltonian, writing down for simple case
 Mechanics - impulse - change of speed by
 Mechanics - inelastic collision
 Mechanics - kinetic energy ($1/2 mv^2$)
 Mechanics - Lagrangians - definition of generalized momentum
 Mechanics - Lagrangians - what is for simple cases (including simple constraint)
 Mechanics - Lagrangians - when is generalized momentum conserved
 Mechanics - mass - computed from volume and density
 Mechanics - moment of inertia - simple systems
 Mechanics - moments of inertia - rod about its end
 Mechanics - normal modes
 Mechanics - orbits, relating periods for different radii
 Mechanics - oscillations, velocity from A and f
 Mechanics - pendulums
 Mechanics - potential energy from $F(r)$
 Mechanics - reduced mass (positronium)
 Mechanics - rigid pendulum - frequency for small oscillations (changing inertia I)
 Mechanics - rolling bodies (down incline)
 Mechanics - rolling bodies - contact point acceleration
 Mechanics - rotating bodies - kinetic energy ($K = I\omega^2$)
 Mechanics - rotation bodies - $\tau = I\alpha$ (for constant α)
 Mechanics - satellite orbits, perturbing circular
 Mechanics - simple pendulum, $\omega = (g/l)^{1/2}$
 Mechanics - small angle approximation (pendulums)
 Mechanics - small oscillation approximation - getting frequencies of
 Mechanics - speed = distance/time
 Mechanics - symmetry - use of
 Mechanics - torques - as vectors
 Mechanics - torques - balancing

Mechanics – torques, $\tau = r \times F$

Mechanics - work, simple computations

Mechanics - work-energy theorem

Mechanics - zero of arbitrary potential

Nuclear - basic nuclear decay equations

Nuclear - binding energies, general trends in the Periodic Table

Nuclear - Cherenkov radiation - conditions for

Nuclear - pair production, general

Nuclear - radioactive decay - half life from counts per minute

Nuclear - scattering cross section

Nuclear - types of decay

Optics - diffraction gratings

Optics - diffraction limit

Optics - group vs. phase velocity in materials

Optics - how do holograms work?

Optics - lens coating thickness, understanding non-reflective

Optics - lens formula (a simple telescope)

Optics - Michelson interferometer (basic idea, conditions for fringes)

Optics - multiple polarizers in optical path

Optics - phase velocity in a dielectric

Optics - polarizers, behavior of

Optics - refractive index (speed of light)

Particles - muon, general properties

Particles - what is a "decay due to the weak interaction"

Practical - amplifier gain fall-off from log-log plot

Practical - count rate errors ($N^{1/2}$), nuclear counting

Practical - errors, combining two uncorrelated errors for total error

Practical - ideal diode behavior

Practical - Lissajous figures - interpreting

Practical - mass of Earth - estimate within 3 orders of magnitude given radius

Practical - nuclear radiation - typical penetration depths for various types

Practical - OR gate, what is

Practical - oscilloscope (what it shows)

Quantum - adding angular momenta (max and min possible)

Quantum – Bohr's magneton (mass dependence)

Quantum - common particles, fermions vs. or bosons

Quantum - commutation - simultaneous eigenvalues

Quantum - Compton scattering - basics of

Quantum - computing probabilities

Quantum – de Broglie's wavelength

Quantum - $E_{\text{photon}} = hc/\lambda$ (need to know value for hc or equivalent!)

Quantum - finite square well - general form of wavefunctions

Quantum - form of wavefunctions for H.O. (Odd/Even parity)
 Quantum - Franck-Hertz experiment, what does it show?
 Quantum - ground state energy (infinite square well)
 Quantum - ground state wavefunction of H.O., recognizing
 Quantum - Hamiltonian from classical Hamiltonian
 Quantum - harmonics oscillator - ground state energy of
 Quantum - how operators used to get expectation values
 Quantum - hydrogen atom - spherical harmonics and orbital quantum numbers
 Quantum - impact of (electron) spin on properties (of materials)
 Quantum - infinite square well - energy eigenvalues
 Quantum - infinite square well - momentum of eigenstate = 0
 Quantum - infinite wall boundary conditions
 Quantum - infinite well, n dependence of E
 Quantum - infinite well, perturbation theory, general (odd/even)
 Quantum - infinite well, recognize n from graph of wavefunction
 Quantum - normalizing a wavefunction, rigid rotator
 Quantum - orthogonality (definition off).
 Quantum - Pauli Exclusion Principle
 Quantum - photoelectric effect
 Quantum - spacing of rotational levels (free rotor)
 Quantum - two particle wavefunctions, fermions vs. bosons
 Quantum - uncertainty principle
 Quantum - wavefunction of free particle

Solid State - Bragg reflection
 Solid State - conductivities for semiconductors vs. metals, general trends and magnitudes
 Solid State - Debye and Einstein theory, specific heat from
 Solid State - effective mass from $E(k)$
 Solid State - Fermi temperature - kinetic energy of conduction electron
 Solid State - Hall effect, general
 Solid State - types of binding in solids
 Solid State - why energy of conduction electrons is $\gg kT$?

Special Relativity - conditions to move at c (on mass, spin)
 Special relativity - $E^2 = (pc)^2 + (mc^2)^2$
 Special Relativity - length contraction
 Special relativity - Lorentz transformation (invariants)
 Special relativity - $x^2 + y^2 + z^2 - t^2 = \text{frame-independent}$
 Special relativity - space-time interval - computing from coordinates
 Special relativity - speed of light $c = \text{constant}$
 Special relativity - time dilation (half-lives)
 Special relativity - transformation of EM field, general properties

Thermo - (differential) relations between thermo quantities
 Thermo - average energy of particles with three states of freedom
 Thermo - average energies in equilibrium

Thermo - blackbody radiation - T^4 -law
Thermo - Boltzmann to quantum transition, fermions vs. bosons, general
Thermo - Carnot cycle, general properties
Thermo - diatomic gas, specific heat for dumbbell vs. masses on spring
Thermo - entropy of ensemble of two-state particles - high and low T
Thermo - entropy related to laws of thermo
Thermo - heat capacitance from internal energy vs. T
Thermo - heat engine - Carnot cycle (work done during)
Thermo - ideal gas, specific heats (why different at constant V or constant p?)
Thermo - isotherms, definition
Thermo - phase transitions (qualitative), critical temperatures, phase co-existence
Thermo - probability of occupation of states
Thermo - probability related to entropy
Thermo - specific heat - diatomic molecule (masses on a spring model)
Thermo - work done by expanding gas (reversible, isothermal)

Waves - Doppler effect (sound), general properties
Waves - group velocity and phase velocity (from dispersion curves)
Waves - group velocity from dispersion relation
Waves - interference - from soap film (explain)
Waves - interference - two slits, finite width slit
Waves - interference from two coherent sources, different phases
Waves - reflection of
Waves - single slit diffraction (circular hole)
Waves - transmission lines - characteristic impedance, terminating in
Waves - traveling waves - plane waves
Waves - wavenumbers ($k = 2\pi/\lambda$)