
PHYSICS

TRANSLATIONAL MOTION

1. Dimensions (length or distance, time)
2. Vectors, components
3. Vector addition
4. Speed, velocity (average and instantaneous)
5. Acceleration
6. Freely falling bodies

FORCE AND MOTION, GRAVITATION

1. Center of mass
2. Newton's first law (inertia)
3. Newton's second law ($F = ma$)
4. Newton's third law (forces equal and opposite)
5. Concept of a field
6. Law of gravitation ($F = -Gm_1m_2/r^2$)
7. Uniform circular motion
8. Centripetal force ($F = -mv^2/r$)
9. Weight
10. Friction (static and kinetic)
11. Motion on an inclined plane
12. Analysis of pulley systems
13. Force

EQUILIBRIUM AND MOMENTUM

A. Equilibrium

1. Concept of force, units
2. Translational equilibrium ($\sum F_i = 0$)
3. Rotational equilibrium ($\sum \tau_i = 0$)
4. Analysis of forces acting on an object
5. Newton's first law (inertia)
6. Torques, lever arms
7. Weightlessness

B. Momentum

1. Momentum = mv
2. Impulse = Ft
3. Conservation of linear momentum
4. Elastic collisions
5. Inelastic collisions

WORK AND ENERGY

A. Work

1. Derived units, sign conventions
2. Path independence of work done in gravitational field
3. Mechanical advantage
4. Work–energy theorem
5. Power

B. Energy

1. Kinetic energy ($KE = mv^2/2$, units)
2. Potential energy
 - a. gravitational, local ($PE = mgh$)
 - b. spring ($PE = kx^2/2$)
 - c. gravitational, general ($PE = -GmM/r$)
3. Conservation of energy
4. Conservative forces
5. Power, units

WAVES AND PERIODIC MOTION

A. Periodic Motion

1. Amplitude, period, frequency
2. Phase
3. Hooke's law ($F = -kx$)
4. Simple harmonic motion, displacement as a sinusoidal function of time
5. Motion of a pendulum
6. General periodic motion (velocity, amplitude)

B. Wave Characteristics

1. Transverse and longitudinal waves
2. Wavelength, frequency, wave speed
3. Amplitude and intensity
4. Superposition of waves, interference, wave addition
5. Resonance
6. Standing waves (nodes, antinodes)
7. Beat frequencies
8. Refraction and general nature of diffraction

SOUND

1. Production of sound
2. Relative speed of sound in solids, liquids, and gases
3. Intensity of sound (decibel units, log scale)
4. Attenuation

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5. Doppler effect (moving sound source or observer, reflection of sound from a moving object)
 6. Pitch
 7. Resonance in pipes and strings
 8. Harmonics
 9. Ultrasound

FLUIDS AND SOLIDS

A. Fluids

1. Density, specific gravity
2. Archimedes' principle (buoyancy)
3. Hydrostatic pressure
 - a. Pascal's law
 - b. pressure versus depth ($P = \rho gh$)
4. Poiseuille flow (viscosity)
5. Continuity equation ($Av = \text{constant}$)
6. Concept of turbulence at high velocities
7. Surface tension
8. Bernoulli's equation

B. Solids

1. Density
2. Elastic properties (elementary properties)
3. Elastic limit
4. Thermal expansion coefficient
5. Shear
6. Compression

ELECTROSTATICS AND ELECTROMAGNETISM

A. Electrostatics

1. Charges, conductors, charge conservation
2. Insulators
3. Coulomb's law ($F = kq_1q_2/r^2$, sign conventions)
4. Electric field
 - a. field lines
 - b. field due to charge distribution
5. Potential difference, absolute potential at point in space
6. Equipotential lines
7. Electric dipole
 - a. definition of dipole
 - b. behavior in electric field
 - c. potential due to dipole

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8. Electrostatic induction
 9. Gauss's law

B. Magnetism

1. Definition of the magnetic field **B**
2. Existence and direction of force on charge moving in magnetic field

C. Electromagnetic Radiation (Light)

1. Properties of electromagnetic radiation (general properties only)
 - a. radiation velocity equals constant c in vacuo
 - b. radiation consists of oscillating electric and magnetic fields that are mutually perpendicular to each other and to the propagation direction
2. Classification of electromagnetic spectrum (radio, infrared, UV, X-rays, etc.)

ELECTRONIC CIRCUIT ELEMENTS

A. Circuit Elements

1. Current ($I = \Delta Q / \Delta t$, sign conventions, units)
2. Battery, electromotive force, voltage
3. Terminal potential, internal resistance of battery
4. Resistance
 - a. Ohm's law ($I = V/R$)
 - b. resistors in series
 - c. resistors in parallel
 - d. resistivity ($\rho = RA/L$)
5. Capacitance
 - a. concept of parallel-plate capacitor
 - b. energy of charged capacitor
 - c. capacitors in series
 - d. capacitors in parallel
 - e. dielectrics
6. Discharge of a capacitor through a resistor
7. Conductivity theory

B. Circuits

1. Power in circuits ($P = VI$, $P = I^2R$)

C. Alternating Currents and Reactive Circuits

1. Root-mean-square current
2. Root-mean-square voltage

LIGHT AND GEOMETRICAL OPTICS

A. Light (Electromagnetic Radiation)

1. Concept of interference, Young's double-slit experiment

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2. Thin films, diffraction grating, single-slit diffraction
 3. Other diffraction phenomena, X-ray diffraction
 4. Polarization of light
 5. Doppler effect (moving light source or observer)
 6. Visual spectrum, color
 - a. energy
 - b. lasers

B. Geometrical Optics

1. Reflection from plane surface (angle of incidence equals angle of reflection)
2. Refraction, refractive index n , Snell's law ($n_1 \sin \theta_1 = n_2 \sin \theta_2$)
3. Dispersion (change of index of refraction with wavelength)
4. Conditions for total internal reflection
5. Spherical mirrors
 - a. mirror curvature, radius, focal length
 - b. use of formula $(1/p) + (1/q) = 1/f$ with sign conventions
 - c. real and virtual images
6. Thin lenses
 - a. converging and diverging lenses, focal length
 - b. use of formula $(1/p) + (1/q) = 1/f$ with sign conventions
 - c. real and virtual images
 - d. lens strength, diopters
 - e. lens aberration
7. Combination of lenses
8. Ray tracing
9. Optical instruments

ATOMIC AND NUCLEAR STRUCTURE

A. Atomic Structure and Spectra

1. Emission spectrum of hydrogen (Bohr model)
2. Atomic energy levels
 - a. quantized energy levels for electrons
 - b. calculation of energy emitted or absorbed when an electron changes energy levels

B. Atomic Nucleus

1. Atomic number, atomic weight
2. Neutrons, protons, isotopes
3. Nuclear forces
4. Radioactive decay (α , β , γ , half-life, stability, exponential decay, semilog plots)
5. General nature of fission
6. General nature of fusion
7. Mass deficit, energy liberated, binding energy