DURGESH PHYSICS

Complete Physics Study Notes for JEE, NEET & MHT-CET Preparation

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Mechanics

1. Kinematics

Key Concepts:

- Motion in one, two, and three dimensions
- Displacement, velocity, and acceleration
- Relative motion

Important Equations:

- $v = u + at$
- $s = ut + \frac{1}{2}at^2$
- $v^2 = u^2 + 2as$
- $s = (u + v)t/2$

Projectile Motion:

- Horizontal range: $R = u^2\sin(2\theta)/g$
- Maximum height: $H = u^2\sin^2\theta/2g$
- Time of flight: $T = 2u\sin\theta/g$

Key Points for Exams:

- Always draw proper free body diagrams
- Identify given and required quantities clearly
- Use appropriate kinematic equations
- Pay attention to signs and directions

2. Laws of Motion

Newton's Laws:

1. **First Law:** Object at rest stays at rest, object in motion stays in motion unless acted upon by external force
2. **Second Law:** F = ma
3. **Third Law:** Every action has equal and opposite reaction

Friction:

- Static friction: $f_s \leq \mu_s N$
- Kinetic friction: $f_k = \mu_k N$
- Always opposing relative motion

Circular Motion:

- Centripetal force: $F_c = mv^2/r = m\omega^2 r$
- Centripetal acceleration: $a_c = v^2/r = \omega^2 r$

3. Work, Energy, and Power

Work: $W = F \cdot s \cdot \cos\theta$ **Kinetic Energy:** $KE = \frac{1}{2}mv^2$ **Potential Energy:** $PE = mgh$ (gravitational) **Conservation of Energy:** $KE_1 + PE_1 = KE_2 + PE_2$ **Power:** $P = W/t = F \cdot v$

Work-Energy Theorem: Net work done = Change in kinetic energy

4. Rotational Motion

Angular displacement: θ (radians) **Angular velocity:** $\omega = d\theta/dt$ **Angular acceleration:** $\alpha = d\omega/dt$

Moment of Inertia:

- Point mass: $I = mr^2$
- Rod (center): $I = ML^2/12$
- Rod (end): $I = ML^2/3$
- Disk: $I = MR^2/2$
- Sphere: $I = 2MR^2/5$

Rotational Kinetic Energy: $KE_{rot} = \frac{1}{2}I\omega^2$ **Torque:** $\tau = rF \sin\theta = I\alpha$

Thermodynamics

1. Kinetic Theory of Gases

Ideal Gas Equation: PV = nRT = NkT **Kinetic Energy:** Average KE = (3/2)kT **RMS Speed:** vrms = √(3RT/M) = √(3kT/m)

Maxwell-Boltzmann Distribution:

- Most probable speed: vmp = √(2RT/M)
- Average speed: vavg = √(8RT/πM)

2. Laws of Thermodynamics

Zeroth Law: Thermal equilibrium is transitive **First Law:** ΔU = Q - W (Energy conservation) **Second Law:** Entropy of isolated system never decreases **Third Law:** Entropy approaches zero at absolute zero

Thermodynamic Processes:

- **Isothermal:** ΔT = 0, ΔU = 0, Q = W = nRT ln(Vf/Vi)
- **Adiabatic:** Q = 0, W = -ΔU = -nCvΔT
- **Isobaric:** ΔP = 0, W = PΔV
- **Isochoric:** ΔV = 0, W = 0, Q = ΔU

Heat Engines:

- Efficiency: η = W/Qh = 1 - Qc/Qh
- Carnot efficiency: ηc = 1 - Tc/Th

Waves and Oscillations

1. Simple Harmonic Motion (SHM)

Equation: x = A sin(ωt + φ) **Velocity:** v = Aω cos(ωt + φ) **Acceleration:** a = -Aω² sin(ωt + φ) = -ω²x

Energy in SHM:

- Total energy: E = ½mω²A²
- Kinetic energy: KE = ½mω²(A² - x²)
- Potential energy: PE = ½mω²x²

Common SHM Systems:

- Spring-mass: T = 2π√(m/k)
- Simple pendulum: T = 2π√(l/g)

- Physical pendulum: $T = 2\pi\sqrt{(I/mgd)}$

2. Wave Motion

Wave Equation: $y = A \sin(kx - \omega t + \varphi)$ **Wave speed:** $v = f\lambda = \omega/k$ **Wave number:** $k = 2\pi/\lambda$ **Angular frequency:** $\omega = 2\pi f$

Types of Waves:

- **Transverse:** Particle motion perpendicular to wave direction
- **Longitudinal:** Particle motion parallel to wave direction

Standing Waves:

- Nodes: Points of zero amplitude
- Antinodes: Points of maximum amplitude
- Distance between adjacent nodes = $\lambda/2$

Electromagnetism

1. Electrostatics

Coulomb's Law: $F = kq_1q_2/r^2 = q_1q_2/(4\pi\varepsilon_0 r^2)$ **Electric Field:** $E = F/q = kQ/r^2$ **Electric Potential:** $V = kQ/r$ **Relation:** $E = -dV/dr$

Gauss's Law: $\oint E \cdot dA = Q_{enc}/\varepsilon_0$

Capacitance:

- Parallel plate capacitor: $C = \varepsilon_0 A/d$
- Energy stored: $U = \frac{1}{2}CV^2 = \frac{1}{2}QV = Q^2/2C$
- Series: $1/C_{eq} = 1/C_1 + 1/C_2 + \ldots$
- Parallel: $C_{eq} = C_1 + C_2 + \ldots$

2. Current Electricity

Ohm's Law: $V = IR$ **Resistance:** $R = \rho l/A$ **Power:** $P = VI = I^2R = V^2/R$

Kirchhoff's Laws:

- **Current Law (KCL):** Sum of currents at a junction = 0
- **Voltage Law (KVL):** Sum of voltage drops in a loop = 0

Series Resistance: $Req = R_1 + R_2 + R_3 + ...$ **Parallel Resistance:** $1/Req = 1/R_1 + 1/R_2 + 1/R_3 + ...$

3. Magnetism

Magnetic Force:

- On moving charge: $F = qvB \sin\theta$
- On current-carrying conductor: $F = BIl \sin\theta$

Biot-Savart Law: $dB = (\mu_0/4\pi) \times (Idl \times r)/r^3$

Ampere's Law: $\oint B \cdot dl = \mu_0 I_{enc}$

Magnetic Field:

- Straight wire: $B = \mu_0 I/(2\pi r)$
- Center of circular loop: $B = \mu_0 I/(2R)$
- Solenoid: $B = \mu_0 nI$

4. Electromagnetic Induction

Faraday's Law: $\varepsilon = -d\Phi/dt$ **Lenz's Law:** Induced current opposes the change causing it
Motional EMF: $\varepsilon = Blv$

Self-Inductance: $\varepsilon = -L(dI/dt)$ **Energy in Inductor:** $U = \frac{1}{2}LI^2$

AC Circuits:

- RMS values: $V_{rms} = V_0/\sqrt{2}$, $I_{rms} = I_0/\sqrt{2}$
- Power: $P = V_{rms} I_{rms} \cos\varphi$
- Reactances: $X_L = \omega L$, $X_C = 1/(\omega C)$
- Impedance: $Z = \sqrt{(R^2 + (X_L - X_C)^2)}$

Optics

1. Geometric Optics

Reflection:

- Law: Angle of incidence = Angle of reflection
- Mirror equation: $1/f = 1/u + 1/v$
- Magnification: $m = -v/u = h'/h$

Refraction:

- Snell's Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$
- Critical angle: $\sin\theta c = n_2/n_1$ ($n_1 > n_2$)
- Lens equation: $1/f = 1/u + 1/v$
- Lens maker's formula: $1/f = (n-1)(1/R_1 - 1/R_2)$

2. Wave Optics

Interference:

- Constructive: Path difference = $n\lambda$
- Destructive: Path difference = $(n + ½)\lambda$
- Young's double slit: $\beta = \lambda D/d$

Diffraction:

- Single slit: $a \sin\theta = n\lambda$ (minima)
- Rayleigh criterion: $\theta = 1.22\lambda/D$

Polarization:

- Malus's Law: $I = I_0 \cos^2\theta$
- Brewster's angle: $\tan\theta B = n$

Modern Physics

1. Photoelectric Effect

Einstein's Equation: $hf = \varphi + KEmax$ **Stopping potential:** $eV_0 = KEmax = hf - \varphi$ **Threshold frequency:** $f_0 = \varphi/h$

2. Atomic Structure

Bohr's Model:

- Angular momentum: $mvr = nh/2\pi$
- Energy levels: $En = -13.6/n^2$ eV (for hydrogen)
- Rydberg formula: $1/\lambda = R(1/n_1^2 - 1/n_2^2)$

3. Nuclear Physics

Mass-Energy Relation: $E = mc^2$ **Radioactive decay:** $N = N_0e^{(-\lambda t)}$ **Half-life:** $t_{1/2} = \ln 2/\lambda = 0.693/\lambda$

Important Formulas Summary

Mechanics

- $v^2 = u^2 + 2as$
- $F = ma$
- $W = F \cdot s \cdot \cos\theta$
- $KE = \frac{1}{2}mv^2$
- $PE = mgh$
- $\tau = I\alpha$

Thermodynamics

- $PV = nRT$
- $\Delta U = Q - W$
- $\eta = 1 - Tc/Th$ (Carnot)

Waves

- $v = f\lambda$
- $T = 2\pi\sqrt{(m/k)}$
- $T = 2\pi\sqrt{(l/g)}$

Electricity

- $V = IR$
- $P = VI = I^2R$
- $C = Q/V$
- $F = kq_1q_2/r^2$

Magnetism

- $F = qvB \sin\theta$
- $B = \mu_0 I/(2\pi r)$
- $\varepsilon = -d\Phi/dt$

Optics

- $1/f = 1/u + 1/v$

- $n_1 \sin\theta_1 = n_2 \sin\theta_2$
- $\beta = \lambda D/d$

Modern Physics

- $E = hf$
- $E = mc^2$
- $En = -13.6/n^2$ eV

Problem-Solving Strategies

General Approach:

1. **Read carefully** - Understand what's given and what's asked
2. **Draw diagrams** - Visual representation helps
3. **Identify concepts** - Which physics principles apply?
4. **List known values** - Organize given information
5. **Choose appropriate formula** - Select relevant equations
6. **Solve systematically** - Step-by-step calculation
7. **Check units** - Ensure dimensional consistency
8. **Verify answer** - Does it make physical sense?

Common Mistakes to Avoid:

- Not drawing free body diagrams
- Mixing up signs and directions
- Using wrong formulas
- Calculation errors
- Not checking units
- Rushing through problems

Time Management Tips:

- Attempt easy questions first
- Don't spend too much time on one problem
- Practice speed with accuracy
- Review and revise regularly
- Solve previous year papers

Important Topics by Weightage:

NEET High Priority:

- Mechanics (25-30%)
- Thermodynamics (10-12%)
- Waves and Sound (8-10%)
- Electricity (15-18%)
- Optics (10-12%)
- Modern Physics (12-15%)

JEE Main High Priority:

- Mechanics (30-35%)
- Electricity and Magnetism (20-25%)
- Thermodynamics (8-10%)
- Waves (8-10%)
- Modern Physics (10-12%)
- Optics (8-10%)

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*Prepared by **DURGESH PHYSICS** for additional practice problems and detailed solutions, consult standard physics textbooks and previous year question papers.*