

Physics — Quick Revision Sheet

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CONSTANTS & VALUES

$$g = 9.8 \text{ m s}^{-2} \quad G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \quad c = 3 \times 10^8 \text{ m s}^{-1} \quad h = 6.63 \times 10^{-34} \text{ J s} \quad e = 1.6 \times 10^{-19} \text{ C} \quad k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$$

$$N_A = 6.02 \times 10^{23} \text{ mol}^{-1} \quad R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1} \quad \epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1} \quad \mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1} \quad m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$m_p = 1.67 \times 10^{-27} \text{ kg} \quad \sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4} \quad 1 \text{ u} = 931.5 \text{ MeV}/c^2$$

Mechanics

Units, Dimensions & Errors

Dimensions of common quantities

$$[F] = MLT^{-2} \quad [E] = ML^2T^{-2} \quad [P] = ML^2T^{-3}$$

$$[\text{Pressure}] = ML^{-1}T^{-2}$$

More dimensions

$$[G] = M^{-1}L^3T^{-2} \quad [h] = ML^2T^{-1} \quad [\eta] = ML^{-1}T^{-1}$$

$$[S] = MT^{-2}$$

Electrical

$$[\epsilon_0] = M^{-1}L^{-3}T^4A^2 \quad [\mu_0] = MLT^{-2}A^{-2} \quad [B] = MT^{-2}A^{-1}$$

Error: sum / difference

$$\Delta x = \Delta a + \Delta b$$

Error: product / quotient

$$\frac{\Delta x}{x} = \frac{\Delta a}{a} + \frac{\Delta b}{b}$$

Error: power law

$$x = a^n b^m \Rightarrow \frac{\Delta x}{x} = n \frac{\Delta a}{a} + m \frac{\Delta b}{b}$$

Homogeneity principle: every term of a valid equation has the same dimensions; dimensional analysis cannot give dimensionless constants.

Least count: vernier = 1 MSD – 1 VSD; screw gauge = pitch / circular divisions. Count significant figures; leading zeros are not significant.

Vectors

Resultant

$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta} \quad \tan\alpha = \frac{B\sin\theta}{A + B\cos\theta}$$

Dot product

$$\vec{A} \cdot \vec{B} = AB\cos\theta = A_x B_x + A_y B_y + A_z B_z$$

Cross product

$$|\vec{A} \times \vec{B}| = AB\sin\theta \quad \vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

Projection of $\vec{A}$ on $\vec{B} = \vec{A} \cdot \hat{B}$; $\vec{A} \perp \vec{B} \Leftrightarrow \vec{A} \cdot \vec{B} = 0$; $\vec{A} \parallel \vec{B} \Leftrightarrow \vec{A} \times \vec{B} = 0$

Kinematics

Constant acceleration

$$v = u + at \quad s = ut + \frac{1}{2}at^2 \quad v^2 = u^2 + 2as$$

$$s_n = u + \frac{a}{2} (2n - 1)$$

Variable acceleration

$$v = \frac{dx}{dt} \quad a = \frac{dv}{dt} = v \frac{dv}{dx}$$

Projectile motion

$$T = \frac{2u\sin\theta}{g} \quad H = \frac{u^2\sin^2\theta}{2g} \quad R = \frac{u^2\sin 2\theta}{g}$$

Trajectory

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta} \quad R_{max} = \frac{u^2}{g} \quad (\theta = 45^\circ)$$

Relative velocity

$$\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$$

River-boat

$$t_{min} = \frac{d}{v_b} \quad (\text{heading } \perp \text{ bank}) \quad \sin\theta = \frac{v}{v_b} \quad (\text{zero drift})$$

$v-t$ area = displacement; $a-t$ area = change in velocity; $x-t$ slope = velocity.

★ Tip: Two angles θ and $90^\circ - \theta$ give the same range; $\tan\theta = 4H/R$.

Laws of Motion & Friction

Newton's second law

$$\vec{F} = \frac{d\vec{p}}{dt} = m\vec{a}$$

Friction

$$f_s \leq \mu_s N \quad f_k = \mu_k N \quad \tan\theta_{rep} = \mu_s$$

Block on incline

$$a = g (\sin\theta - \mu\cos\theta)$$

Atwood machine

$$a = \frac{(m_1 - m_2)g}{m_1 + m_2} \quad T = \frac{2m_1 m_2 g}{m_1 + m_2}$$

Circular motion

$$a_c = \frac{v^2}{r} = \omega^2 r \quad F_c = \frac{mv^2}{r}$$

Banked road

$$\tan\theta = \frac{v^2}{rg} \quad v_{max}^2 = rg \frac{\mu + \tan\theta}{1 - \mu\tan\theta}$$

Vertical circle

$$v_{top} \geq \sqrt{gr} \quad v_{bottom} \geq \sqrt{5gr} \quad T_b - T_t = 6mg$$

Lift: apparent weight $N = m(g \pm a)$. Pseudo force = $-m\vec{a}_{frame}$ in a non-inertial frame.

■ Work, Energy & Power

Work

$$W = \vec{F} \cdot \vec{s} = \int \vec{F} \cdot d\vec{r}$$

Energies

$$K = \frac{1}{2}mv^2 = \frac{p^2}{2m} \quad U_g = mgh \quad U_s = \frac{1}{2}kx^2$$

Work-energy theorem

$$W_{net} = \Delta K \quad F = -\frac{dU}{dx}$$

Power

$$P = \frac{dW}{dt} = \vec{F} \cdot \vec{v}$$

1-D elastic collision

$$v_1 = \frac{(m_1 - m_2)u_1 + 2m_2u_2}{m_1 + m_2}$$

Restitution

$$e = \frac{v_2 - v_1}{u_1 - u_2} \quad h_n = e^{2n}h_0$$

Perfectly inelastic

$$v = \frac{m_1u_1 + m_2u_2}{m_1 + m_2} \quad \Delta K = \frac{m_1m_2(u_1 - u_2)^2}{2(m_1 + m_2)}$$

Equal masses, elastic, head-on: velocities exchange. Conservative force: work independent of path.

■ Centre of Mass & Momentum

Centre of mass

$$\vec{r}_{cm} = \frac{\sum m_i \vec{r}_i}{\sum m_i}$$

Motion of COM

$$M\vec{a}_{cm} = \vec{F}_{ext} \quad \vec{J} = \int \vec{F} dt = \Delta \vec{p}$$

Hollow hemisphere: $R/2$; solid cone: $h/4$ from base; triangle: centroid (medians meet).

■ Rotational Motion

Rotational kinematics

$$\omega = \omega_0 + \alpha t \quad \theta = \omega_0 t + \frac{1}{2}\alpha t^2 \quad \omega^2 = \omega_0^2 + 2\alpha\theta$$

Torque & angular momentum

$$\vec{\tau} = \vec{r} \times \vec{F} = I\vec{\alpha} \quad \vec{L} = I\vec{\omega} = \vec{r} \times \vec{p}$$

Kinetic energy

$$K = \frac{1}{2}I\omega^2 \quad K_{roll} = \frac{1}{2}mv^2 \left(1 + \frac{k^2}{R^2}\right)$$

Rolling down incline

$$a = \frac{g \sin \theta}{1 + k^2/R^2}$$

Moment of inertia

$$\text{ring } MR^2 \quad \text{disc } \frac{1}{2}MR^2 \quad \text{solid sphere } \frac{2}{5}MR^2 \\ \text{hollow sphere } \frac{2}{3}MR^2$$

Rods

$$\text{centre } \frac{1}{12}ML^2 \quad \text{end } \frac{1}{3}ML^2$$

Axis theorems

$$I = I_{cm} + Md^2 \quad I_z = I_x + I_y \quad (\text{planar})$$

Pure rolling: $v = \omega R$, contact point at rest, friction does no work. L is conserved when $\tau_{ext} = 0$.

■ Gravitation

Newton's law

$$F = \frac{Gm_1m_2}{r^2}$$

Variation of g

$$g_h = g \left(1 - \frac{2h}{R}\right) \quad g_d = g \left(1 - \frac{d}{R}\right) \quad g_\lambda = g - \omega^2 R \cos^2 \lambda$$

Potential

$$V = -\frac{GM}{r} \quad U = -\frac{GMm}{r}$$

Escape & orbital speed

$$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{2gR} \quad v_o = \sqrt{\frac{GM}{r}}$$

Satellite energy

$$K = \frac{GMm}{2r} \quad E = -\frac{GMm}{2r} \quad T^2 = \frac{4\pi^2 r^3}{GM}$$

$v_e = \sqrt{2}$ $v_o = 11.2$ km/s on Earth. Kepler: $T^2 \propto a^3$; areal velocity constant. Geostationary: $T = 24$ h, $h \approx 36000$ km.

Properties of Matter & Thermal Physics

■ Elasticity, Surface Tension & Viscosity

Moduli

$$Y = \frac{F/A}{\Delta L/L} \quad B = -\frac{\Delta P}{\Delta V/V} \quad \eta = \frac{F/A}{\theta}$$

Wire

$$\Delta L = \frac{FL}{AY} \quad U = \frac{1}{2} \text{stress} \times \text{strain} \times V \quad \sigma = -\frac{\Delta d/d}{\Delta L/L}$$

Excess pressure

$$\frac{2S}{R} \text{ (drop)} \quad \frac{4S}{R} \text{ (soap bubble)}$$

Capillary rise

$$h = \frac{2S \cos \theta}{r \rho g}$$

Viscous force

$$F = \eta A \frac{dv}{dx} \quad F = 6\pi\eta r v \quad v_T = \frac{2r^2(\rho - \sigma)g}{9\eta}$$

Surface energy = $S \times \Delta A$; drops merging release energy; splitting needs energy.

■ Fluid Mechanics

Pressure

$$P = P_0 + \rho gh$$

Buoyancy

$$F_B = \rho_{fl} V_{sub} g$$

Continuity

$$A_1 v_1 = A_2 v_2$$

Bernoulli

$$P + \frac{1}{2}\rho v^2 + \rho gh = \text{const.}$$

Torricelli range is maximum at $h = H/2$ ($x_{max} = H$). A floating body displaces its own weight of fluid.

Thermal Properties & Heat Transfer

Thermal expansion

$$\Delta L = L\alpha\Delta T \quad \beta = 2\alpha \quad \gamma = 3\alpha$$

Heat

$$Q = ms\Delta T \quad Q = mL$$

Conduction

$$\frac{dQ}{dt} = \frac{KA\Delta T}{l} \quad R_{th} = \frac{l}{KA}$$

Newton's cooling

$$\frac{dT}{dt} = -k(T - T_0) \quad \frac{T_1 - T_2}{t} = k\left(\frac{T_1 + T_2}{2} - T_0\right)$$

Radiation

$$P = e\sigma AT^4 \quad \lambda_m T = b = 2.9 \times 10^{-3} \text{ m K}$$

Series: $R_{eq} = \sum R_i$; parallel: $1/R_{eq} = \sum 1/R$ (same as electrical).

Kinetic Theory of Gases

Ideal gas

$$PV = nRT = Nk_B T \quad P = \frac{1}{3}\rho v_{rms}^2$$

Speeds

$$v_{rms} = \sqrt{\frac{3RT}{M}} \quad v_{avg} = \sqrt{\frac{8RT}{\pi M}} \quad v_{mp} = \sqrt{\frac{2RT}{M}}$$

Energy & heat capacity

$$U = \frac{f}{2}nRT \quad C_V = \frac{f}{2}R \quad C_P = C_V + R \quad \gamma = 1 + \frac{2}{f}$$

Mean free path

$$\lambda = \frac{1}{\sqrt{2} \pi d^2 n}$$

Each degree of freedom: $\frac{1}{2}k_B T$ per molecule. Monatomic $f = 3, \gamma = \frac{5}{3}$; diatomic $f = 5, \gamma = \frac{7}{5}$; polyatomic $f = 6, \gamma = \frac{4}{3}$.
 $v_{mp} : v_{avg} : v_{rms} = \sqrt{2} : \sqrt{8/\pi} : \sqrt{3}$.

Thermodynamics

First law

$$\Delta U = Q - W \quad \Delta U = nC_V\Delta T \quad W = \int PdV$$

Isothermal

$$W = nRT \ln \frac{V_2}{V_1}$$

Adiabatic

$$PV^\gamma = \text{const.} \quad TV^{\gamma-1} = \text{const.} \quad W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

Other processes

isobaric: $W = P\Delta V$ isochoric: $W = 0$

Heat engine

$$\eta = 1 - \frac{T_2}{T_1} \quad \text{COP} = \frac{T_2}{T_1 - T_2}$$

Adiabatic curve is steeper than isothermal on a P - V diagram. Cyclic process: $\Delta U = 0, W = \text{area of loop}$.

Oscillations & Waves

Simple Harmonic Motion

Basics

$$a = -\omega^2 x \quad x = A \sin(\omega t + \phi) \quad v = \omega \sqrt{A^2 - x^2}$$

Energy

$$E = \frac{1}{2}m\omega^2 A^2 \quad K = \frac{1}{2}m\omega^2 (A^2 - x^2)$$

Spring-mass

$$T = 2\pi\sqrt{\frac{m}{k}} \quad k_{series} = \frac{k_1 k_2}{k_1 + k_2} \quad k_{par} = k_1 + k_2$$

Pendulum

$$T = 2\pi\sqrt{\frac{l}{g}} \quad T = 2\pi\sqrt{\frac{l}{mgd}} \quad (\text{physical})$$

$K = U$ at $x = \pm A/\sqrt{2}$. Time period of a seconds pendulum is 2 s.
Damped: $A = A_0 e^{-bt/2m}$.

Waves & Sound

Wave equation

$$y = A \sin(\omega t - kx) \quad v = f\lambda = \frac{\omega}{k}$$

Speed

$$v_{string} = \sqrt{\frac{T}{\mu}} \quad v_{gas} = \sqrt{\frac{\gamma P}{\rho}} \propto \sqrt{T}$$

Intensity

$$I = 2\pi^2 f^2 A^2 \rho v \quad L = 10 \log \frac{I}{I_0} \text{ dB}$$

Beats

$$f_{beat} = |f_1 - f_2|$$

Doppler effect

$$f' = f \frac{v + v_o}{v - v_s} \quad (\text{towards each other})$$

Organ pipes

$$\text{open: } f_n = \frac{nv}{2L} \quad \text{closed: } f_n = \frac{(2n-1)v}{4L}$$

Stationary wave

$$y = 2A \sin kx \cos \omega t \quad \text{string: } f_n = \frac{nv}{2L}$$

Closed pipe gives only odd harmonics. End correction $e = 0.6r$.
Doppler: approach raises the frequency, recession lowers it (use $-v_o$, $+v_s$ for recession).

Electricity & Magnetism

Electrostatics

Coulomb's law

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

Fields

$$E_{ring} = \frac{kQx}{(R^2 + x^2)^{3/2}} \quad E_{line} = \frac{\lambda}{2\pi\epsilon_0 r} \quad E_{sheet} = \frac{\sigma}{2\epsilon_0}$$

Gauss's law

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

Potential & energy

$$V = \frac{kq}{r} \quad E = -\frac{dV}{dr} \quad U = \frac{kq_1 q_2}{r}$$

Dipole

$$p = qd \quad \tau = pE \sin \theta \quad U = -\vec{p} \cdot \vec{E}$$

Dipole field

$$E_{axial} = \frac{2kp}{r^3} \quad E_{eq} = \frac{kp}{r^3}$$

Charged shell: $E = 0$ inside, $V = kQ/R$ (constant). Solid insulating sphere: $E_{in} = \frac{kQr}{R^3}$. Conductor surface: $E = \sigma/\epsilon_0$.

Capacitors

Capacitance

$$C = \frac{Q}{V} \quad C = \frac{K\epsilon_0 A}{d} \quad C_{sphere} = 4\pi\epsilon_0 R$$

Energy

$$U = \frac{1}{2} CV^2 = \frac{Q^2}{2C} \quad u = \frac{1}{2} \epsilon_0 E^2$$

Combination

$$\text{series: } \frac{1}{C_{eq}} = \sum \frac{1}{C} \quad \text{parallel: } C_{eq} = \sum C$$

RC circuit

$$q = CV(1 - e^{-t/RC}) \quad q = q_0 e^{-t/RC} \quad \tau = RC$$

Sharing charge

$$V = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2} \quad \Delta U = \frac{C_1 C_2 (V_1 - V_2)^2}{2(C_1 + C_2)}$$

Battery connected: V fixed; battery removed: Q fixed. Inserting dielectric (battery off): $C \uparrow, V \downarrow, U \downarrow$.

Current Electricity

Ohm's law & resistivity

$$V = IR \quad R = \frac{\rho l}{A} \quad R = R_0(1 + \alpha \Delta T)$$

Drift

$$I = nAev_d \quad v_d = \frac{eE\tau}{m} \quad \vec{J} = \sigma \vec{E}$$

Kirchhoff's laws

$$\sum I = 0 \text{ (junction)} \quad \sum V = 0 \text{ (loop)}$$

Power & heat

$$P = VI = I^2 R = \frac{V^2}{R} \quad H = I^2 R t$$

Cell

$$V = \epsilon - Ir \quad I = \frac{\epsilon}{R+r} \quad P_{max} = \frac{\epsilon^2}{4r} \quad (R = r)$$

Bridges

$$\frac{P}{Q} = \frac{R}{S} \quad r = R \left(\frac{l_1}{l_2} - 1 \right) \text{ (potentiometer)}$$

Meters

$$S = \frac{I_g G}{I - I_g} \text{ (shunt)} \quad R_s = \frac{V}{I_g} - G$$

n identical cells in series: $n\epsilon, nr$; m in parallel: $\epsilon, r/m$. Wheatstone balanced: no current in galvanometer.

Moving Charges & Magnetism

Lorentz force

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

Motion in B

$$r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB} \quad T = \frac{2\pi m}{qB}$$

Biot-Savart

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{Id\vec{l} \times \hat{r}}{r^2}$$

Wire

$$B = \frac{\mu_0 I}{2\pi r} \quad B = \frac{\mu_0 I}{4\pi r} (\sin \alpha + \sin \beta)$$

Loop

$$B_{centre} = \frac{\mu_0 I}{2R} \quad B_{axis} = \frac{\mu_0 IR^2}{2(R^2 + x^2)^{3/2}} \quad B_{arc} = \frac{\mu_0 I\theta}{4\pi R}$$

Solenoid, toroid

$$B = \mu_0 nI \quad B = \frac{\mu_0 NI}{2\pi r}$$

Force & torque

$$F = BIl \sin \theta \quad \frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d} \quad \vec{\tau} = \vec{M} \times \vec{B}, \quad M = NIA$$

Magnetic materials

$$\chi = \frac{C}{T} \text{ (para)} \quad \chi = \frac{C}{T - T_c} \text{ (ferro)}$$

Ampere's law: $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$. Cyclotron: $f = \frac{qB}{2\pi m}$, $K_{max} = \frac{q^2 B^2 R^2}{2m}$.
Dia: $\chi < 0$; para: small +; ferro: large +.

EMI & Alternating Current

Faraday-Lenz

$$\varepsilon = -\frac{d\Phi}{dt} \quad \Phi = BA \cos \theta$$

Motional emf

$$\varepsilon = Blv \quad \varepsilon = \frac{1}{2}B\omega l^2 \quad (\text{rotating rod})$$

Inductance

$$\varepsilon = -L \frac{dI}{dt} \quad U = \frac{1}{2}LI^2 \quad L = \mu_0 n^2 Al \quad M = \mu_0 n_1 n_2 Al$$

LR circuit

$$I = I_0 \left(1 - e^{-Rt/L}\right) \quad \tau = \frac{L}{R}$$

AC basics

$$I_{rms} = \frac{I_0}{\sqrt{2}} \quad X_L = \omega L \quad X_C = \frac{1}{\omega C}$$

Series LCR

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \quad \tan \phi = \frac{X_L - X_C}{R}$$

Resonance & power

$$\omega_0 = \frac{1}{\sqrt{LC}} \quad Q = \frac{\omega_0 L}{R} \quad P = V_{rms} I_{rms} \cos \phi$$

Transformer

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_p}{I_s}$$

In AC, current leads voltage in a capacitor and lags in an inductor by 90° . Power factor $\cos \phi = R/Z$.

Electromagnetic Waves

Speed

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \quad E_0 = cB_0$$

Intensity

$$I = \frac{1}{2} \varepsilon_0 c E_0^2 \quad u = \varepsilon_0 E_{rms}^2$$

Radiation pressure

$$P = \frac{I}{c} \quad (\text{absorbed}) \quad P = \frac{2I}{c} \quad (\text{reflected})$$

Spectrum (increasing frequency): radio, microwave, infrared, visible, UV, X-ray, γ . $\vec{E} \times \vec{B}$ gives direction of propagation.

Optics & Modern Physics

Ray Optics

Mirror

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \quad f = \frac{R}{2} \quad m = -\frac{v}{u}$$

Refraction at a surface

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

Lens

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

Power

$$P = \frac{1}{f} \quad (\text{D}) \quad P = P_1 + P_2 - dP_1 P_2$$

Snell & TIR

$$\mu_1 \sin i = \mu_2 \sin r \quad \sin C = \frac{1}{\mu}$$

Prism

$$\mu = \frac{\sin \frac{A + \delta_m}{2}}{\sin \frac{A}{2}} \quad \delta = (\mu - 1) A$$

Instruments

$$M_{micro} = \frac{L}{f_o} \left(1 + \frac{D}{f_e}\right) \quad M_{tele} = \frac{f_o}{f_e}$$

Real/apparent depth $= \mu$. Sign convention: Cartesian; $u < 0$ for real objects. Cauchy: $\mu = A + B/\lambda^2$.

Wave Optics

Young's double slit

$$\beta = \frac{\lambda D}{d} \quad \Delta x = \frac{yd}{D}$$

Interference

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \phi \quad \frac{I_{max}}{I_{min}} = \left(\frac{a_1 + a_2}{a_1 - a_2} \right)^2$$

Conditions

$$\Delta x = n\lambda \quad (\text{bright}) \quad \Delta x = \left(n + \frac{1}{2}\right)\lambda \quad (\text{dark})$$

Single-slit diffraction

$$a \sin \theta = n\lambda \quad (\text{minima}) \quad \text{width} = \frac{2\lambda D}{a}$$

Polarisation

$$I = I_0 \cos^2 \theta \quad \tan i_B = \mu$$

Thin film (reflected): $2\mu t \cos r = \left(n + \frac{1}{2}\right)\lambda$ is bright. Intensity $\propto$ (amplitude) $^2 \propto$ slit width.

Dual Nature of Matter & Radiation

Photon

$$E = hf = \frac{hc}{\lambda} = \frac{12400}{\lambda(\text{\AA})} \text{ eV} \quad p = \frac{h}{\lambda}$$

Photoelectric effect

$$K_{max} = hf - \phi_0 = eV_s \quad f_0 = \frac{\phi_0}{h}$$

de Broglie

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} \quad \lambda_e = \frac{12.27}{\sqrt{V}} \text{ \AA}$$

K_{max} and V_s depend on frequency, not intensity; saturation current $\propto$ intensity. Slope of V_s - f graph $= h/e$.

■ Atoms & Nuclei

Bohr model

$$r_n = 0.529 \frac{n^2}{Z} \text{ \AA} \quad v_n = 2.19 \times 10^6 \frac{Z}{n} \text{ m/s} \quad E_n = -13.6 \frac{Z^2}{n^2} \text{ eV}$$

Spectral lines

$$\frac{1}{\lambda} = RZ^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \quad R = 1.097 \times 10^7 \text{ m}^{-1}$$

Nucleus

$$R = R_0 A^{1/3}, \quad R_0 = 1.2 \text{ fm} \quad E = \Delta m c^2$$

Radioactivity

$$N = N_0 e^{-\lambda t} \quad T_{1/2} = \frac{0.693}{\lambda} \quad \text{Activity } A = \lambda N$$

X-rays

$$\lambda_{\min} = \frac{12400}{V(\text{volt})} \text{ \AA} \quad \sqrt{f} = a(Z - b)$$

α : $Z - 2, A - 4$; β^- : $Z + 1$; β^+ : $Z - 1$. After n half-lives, $N = N_0/2^n$.
BE/nucleon peaks near ^{56}Fe (≈ 8.8 MeV).

■ Semiconductors & Logic Gates

Carriers

$$n_e n_h = n_i^2 \quad E_g(\text{Si}) = 1.1 \text{ eV}, \quad E_g(\text{Ge}) = 0.7 \text{ eV}$$

Transistor

$$I_E = I_B + I_C \quad \alpha = \frac{I_C}{I_E} \quad \beta = \frac{I_C}{I_B} = \frac{\alpha}{1-\alpha}$$

Rectifier efficiency

$$\eta_{HW} = 40.6\% \quad \eta_{FW} = 81.2\%$$

Boolean laws

$$A + \bar{B} = \bar{A} \cdot B \quad \overline{A \cdot B} = \bar{A} + \bar{B}$$

n-type: pentavalent donor; p-type: trivalent acceptor. NAND and NOR are universal gates. Zener works in reverse breakdown (voltage regulator).

NEET Extras

■ Units, Conversions & Facts

Energy & pressure

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J} \quad 1 \text{ cal} = 4.18 \text{ J} \quad 1 \text{ kWh} = 3.6 \times 10^6 \text{ J} \\ 1 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 760 \text{ mm Hg}$$

Length & power

$$1 \text{ \AA} = 10^{-10} \text{ m} \quad 1 \text{ ly} = 9.46 \times 10^{15} \text{ m} \quad 1 \text{ HP} = 746 \text{ W}$$

Prefixes

$$n = 10^{-9} \quad \mu = 10^{-6} \quad m = 10^{-3} \quad k = 10^3 \quad M = 10^6 \quad G = 10^9$$

SI units: force N, pressure Pa, work/energy J, power W, charge C, potential V, capacitance F, resistance Ω , magnetic field T, flux Wb, inductance H, frequency Hz, activity Bq.

Fundamental SI quantities (7): length, mass, time, current, temperature, amount of substance, luminous intensity. Dimensionless: angle, strain, refractive index, μ_s .

★ **Tip:** NEET numericals are mostly direct-formula: check units and powers of 10 first; use $g = 10 \text{ m/s}^2$ only if the question says so.

■ Electricity & Magnetism Facts

Resistor colour code: black 0, brown 1, red 2, orange 3, yellow 4, green 5, blue 6, violet 7, grey 8, white 9; tolerance gold 5%, silver 10%, none 20%.

Earth's magnetism: dip $\delta = 0^\circ$ at equator, 90° at poles; $\tan \delta = V/H$; $B = \sqrt{H^2 + V^2}$. Neutral points, declination = angle between geographic and magnetic meridian.

Lenz's law is conservation of energy; eddy currents are used in induction furnaces, electromagnetic braking; reduced by laminating the core.

■ Modern Physics Facts

Hydrogen series: Lyman ($n \rightarrow 1$, UV), Balmer ($n \rightarrow 2$, visible), Paschen ($n \rightarrow 3$, IR), Brackett ($n \rightarrow 4$, IR), Pfund ($n \rightarrow 5$, IR).

Solids: conductor — bands overlap; semiconductor $E_g < 3 \text{ eV}$; insulator $E_g > 3 \text{ eV}$. Forward bias: LED, ordinary diode; reverse bias: Zener, photodiode; solar cell needs no bias.

Rectifier output frequency: half-wave f , full-wave $2f$. Logic gates: AND (1 only if both 1), OR (0 only if both 0), NOT, NAND/NOR (universal), XOR (1 for unlike inputs).