ALL 14 CHAPTERS · NCERT (CBSE)

Class 12 Physics Formula Sheet

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Class 12 · Physics
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1 Electric Charges and Fields

Quantisation	$q = ne,\ e = 1.6 \times 10^{-19}$ C
Coulomb's law	$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$; in a medium $F = \frac{q_1 q_2}{4\pi\varepsilon_0 K r^2}$
Electric field	$\vec{E} = \frac{\vec{F}}{q_0}$; point charge $E = \frac{kq}{r^2}\left(k = \frac{1}{4\pi\varepsilon_0}\right)$
Dipole moment	$p = q\,(2a)$, directed from $-q$ to $+q$
Dipole field ($r \gg a$)	Axial $E = \frac{2kp}{r^3}$ (along $\vec{p}$); equatorial $E = \frac{kp}{r^3}$ (opposite $\vec{p}$)
Dipole in $\vec{E}$	$\vec{\tau} = \vec{p} \times \vec{E},\ \tau = pE\sin\theta$; net force $= 0$
Flux, Gauss's law	$\Phi = \oint \vec{E} \cdot d\vec{S} = \frac{q_{\text{enc}}}{\varepsilon_0}$
Infinite line (λ)	$E = \frac{\lambda}{2\pi\varepsilon_0 r}$
Infinite sheet (σ)	$E = \frac{\sigma}{2\varepsilon_0}$ (independent of distance)
Thin shell (q, R)	$E = \frac{kq}{r^2}$ for $r \geq R$; $E = 0$ inside ($r < R$)

2 Electrostatic Potential and Capacitance

Potential	Point charge $V = \frac{kq}{r}$; dipole $V = \frac{kp\cos\theta}{r^2}$
Field, work	$E = -\frac{dV}{dr};\ W^{\text{ext}}_{A\to B} = q\,(V_B - V_A)$
Potential energy	Two charges $U = \frac{kq_1 q_2}{r}$ Dipole in $\vec{E}$: $U = -\vec{p}\cdot\vec{E} = -pE\cos\theta$
Capacitance	$C = \frac{Q}{V}$; parallel plate $C = \frac{\varepsilon_0 A}{d},\ E = \frac{\sigma}{\varepsilon_0}$
With dielectric	Filled $C = \frac{K\varepsilon_0 A}{d}$ Slab of thickness t: $C = \frac{\varepsilon_0 A}{d - t + t/K}$
Combinations	Series $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$; parallel $C = C_1 + C_2$
Stored energy	$U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$
Energy density	$u = \frac{1}{2}\varepsilon_0 E^2$

3 Current Electricity

Current, Ohm's law	$I = \frac{dq}{dt};\ V = IR,\ R = \frac{\rho l}{A}$
Drift velocity	$v_d = \frac{eE\tau}{m},\ I = neAv_d,\ j = \frac{I}{A} = \sigma E$
Resistivity	$\rho = \frac{m}{ne^2\tau},\ \sigma = \frac{1}{\rho}$
Mobility	$\mu = \frac{v_d}{E} = \frac{e\tau}{m}$
Temperature	$\rho_T = \rho_0\,[1 + \alpha\,(T - T_0)]$
Power	$P = VI = I^2R = \frac{V^2}{R}$
Cell (emf ε, r)	$I = \frac{\varepsilon}{R + r};\ V = \varepsilon - Ir$ (discharging)
Cells in series	$\varepsilon_{\text{eq}} = \varepsilon_1 + \varepsilon_2,\ r_{\text{eq}} = r_1 + r_2$
Cells in parallel	$\varepsilon_{\text{eq}} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2},\ r_{\text{eq}} = \frac{r_1 r_2}{r_1 + r_2}$
Kirchhoff's rules	Junction: $\sum I = 0$; loop: $\sum \Delta V = 0$
Wheatstone bridge	Balanced ($I_g = 0$): $\frac{P}{Q} = \frac{R}{S}$

4 Moving Charges and Magnetism

Lorentz force	$\vec{F} = q\,(\vec{E} + \vec{v} \times \vec{B});\ F_m = qvB\sin\theta$
Force on wire	$\vec{F} = I\vec{l} \times \vec{B}$
Circular path ($\vec{v} \perp \vec{B}$)	$r = \frac{mv}{qB},\ \omega = \frac{qB}{m},\ T = \frac{2\pi m}{qB}$
Biot–Savart law	$dB = \frac{\mu_0}{4\pi}\frac{I\,dl\sin\theta}{r^2}$
Circular loop	Centre $B = \frac{\mu_0 NI}{2R}$; axis $B = \frac{\mu_0 NIR^2}{2\,(x^2 + R^2)^{3/2}}$
Ampère's law	$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{\text{enc}}$
Long straight wire	$B = \frac{\mu_0 I}{2\pi r}$
Long solenoid	$B = \mu_0 nI$ inside (n: turns per unit length)
Parallel wires	$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$; same direction attract
Torque on loop	$\vec{\tau} = \vec{m} \times \vec{B},\ m = NIA,\ \tau = NIAB\sin\theta$
Galvanometer (G, I_g)	Ammeter: shunt $S = \frac{I_g G}{I - I_g}$ Voltmeter: series $R = \frac{V}{I_g} - G$

5 Magnetism and Matter

Bar magnet ($r \gg l$)	Axial $B = \frac{\mu_0}{4\pi}\frac{2m}{r^3}$; equatorial $B = \frac{\mu_0}{4\pi}\frac{m}{r^3}$
Magnet in $\vec{B}$	$\vec{\tau} = \vec{m} \times \vec{B},\ U = -\vec{m}\cdot\vec{B}$
Gauss's law	$\oint \vec{B}\cdot d\vec{S} = 0$ (no isolated poles)
Magnetisation	$M = \frac{m_{\text{net}}}{V},\ B = \mu_0(H + M)$
Susceptibility	$M = \chi H,\ \mu_r = 1 + \chi,\ \mu = \mu_0\mu_r,\ B = \mu H$
Special cases	Superconductor: $\chi = -1$, $\mu_r = 0$ (Meissner effect); ferro → para when heated

Dia: $-1 \leq \chi < 0$, $\mu_r < 1$ · **Para:** χ small, positive, μ_r slightly > 1 · **Ferro:** $\chi \gg 1$, $\mu_r \gg 1$

6 Electromagnetic Induction

Magnetic flux	$\Phi_B = \vec{B}\cdot\vec{A} = BA\cos\theta$ (Wb)
Faraday + Lenz	$\varepsilon = -N\frac{d\Phi_B}{dt}$ (Lenz: opposes the change)
Motional emf	$\varepsilon = Blv$; rod rotating about an end $\varepsilon = \frac{1}{2}B\omega R^2$
Self-inductance	$N\Phi = LI,\ \varepsilon = -L\frac{dI}{dt}$; solenoid $L = \mu_0 n^2 Al$
Mutual inductance	$\varepsilon_1 = -M\frac{dI_2}{dt}$; solenoids $M = \mu_0 n_1 n_2 \pi r_1^2 l$
Energy in inductor	$U = \frac{1}{2}LI^2,\ u_B = \frac{B^2}{2\mu_0}$
AC generator	$\varepsilon = NBA\omega\sin\omega t,\ \varepsilon_0 = NBA\omega$

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7 Alternating Current

rms values	$I_{\text{rms}} = \dfrac{I_m}{\sqrt{2}} = 0.707\, I_m,\ V_{\text{rms}} = \dfrac{V_m}{\sqrt{2}}$
Reactances	$X_L = \omega L$ (i lags v by $\frac{\pi}{2}$) $X_C = \dfrac{1}{\omega C}$ (i leads v by $\frac{\pi}{2}$)
Series LCR	$Z = \sqrt{R^2 + (X_C - X_L)^2},\ \tan\phi = \dfrac{X_C - X_L}{R}$ $(v = v_m \sin\omega t,\ i = i_m \sin(\omega t + \phi))$
Resonance	$X_L = X_C$: $\omega_0 = \dfrac{1}{\sqrt{LC}},\ Z = R,\ I$ maximum
Quality factor	$Q = \dfrac{\omega_0 L}{R} = \dfrac{1}{\omega_0 C R}$
Average power	$P = V_{\text{rms}} I_{\text{rms}} \cos\phi$; power factor $\cos\phi = \dfrac{R}{Z}$
Ideal transformer	$\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p} = \dfrac{I_p}{I_s}$

8 Electromagnetic Waves

Displacement current	$i_d = \varepsilon_0 \dfrac{d\Phi_E}{dt};\ \oint \vec{B} \cdot d\vec{l} = \mu_0(i_c + i_d)$
Speed	$c = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$; in a medium $v = \dfrac{1}{\sqrt{\mu\varepsilon}}$
Fields	$\dfrac{E_0}{B_0} = c;\ \vec{E} \perp \vec{B} \perp$ direction of travel; $c = \nu\lambda$

Spectrum (increasing λ): γ-rays · X-rays · UV · visible (400–700 nm) · infrared · microwaves · radio waves

9 Ray Optics and Optical Instruments

Mirror	$\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f},\ f = \dfrac{R}{2},\ m = -\dfrac{v}{u}$
Thin lens	$\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f},\ m = \dfrac{v}{u}$
Snell's law	$n_1 \sin i = n_2 \sin r,\ n_{21} = \dfrac{n_2}{n_1} = \dfrac{v_1}{v_2}$
Apparent depth	$n = \text{real depth} / \text{apparent depth}$
Critical angle	$\sin i_c = \dfrac{n_{\text{rarer}}}{n_{\text{denser}}}$; glass–air: $\sin i_c = \dfrac{1}{n}$
Spherical surface	$\dfrac{n_2}{v} - \dfrac{n_1}{u} = \dfrac{n_2 - n_1}{R}$
Lensmaker	$\dfrac{1}{f} = (n_{21} - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$
Power, combination	$P = \dfrac{1}{f}$ (f in m, unit dioptre D) $P = P_1 + P_2,\ m = m_1 m_2$
Prism	$A + \delta = i + e,\ r_1 + r_2 = A$
Minimum deviation	$n = \dfrac{\sin[(A + D_m)/2]}{\sin(A/2)}$; thin prism $\delta = (n-1)A$
Simple microscope	$m = 1 + \dfrac{D}{f}$ (image at D = 25 cm); $\dfrac{D}{f}$ (at ∞)
Compound microscope	$m = m_o m_e$; image at ∞: $m = \dfrac{L}{f_o} \cdot \dfrac{D}{f_e}$
Telescope (normal)	$m = \dfrac{f_o}{f_e},$ length $= f_o + f_e$

10 Wave Optics

Interference	Bright $\Delta = n\lambda$; dark $\Delta = \left(n + \frac{1}{2}\right)\lambda$; $\phi = \frac{2\pi}{\lambda}\Delta$
YDSE	$\Delta = \dfrac{xd}{D}$; bright $x_n = \dfrac{n\lambda D}{d}$; width $\beta = \dfrac{\lambda D}{d}$
Intensity	$I = 4I_0 \cos^2\dfrac{\phi}{2}$
Single slit	Minima $a \sin\theta = n\lambda$ ($n = \pm1, \pm2, \ldots$) Central maximum angular width $= 2\lambda/a$
Malus's law	$I = I_0 \cos^2\theta$; unpolarised light → $I_0/2$

11 Dual Nature of Radiation and Matter

Photon	$E = h\nu = \dfrac{hc}{\lambda},\ p = \dfrac{h}{\lambda}$
Photoelectric	$K_{\max} = h\nu - \phi_0 = eV_0$ (V_0: stopping potential)
Threshold	$\nu_0 = \phi_0/h,\ \lambda_0 = hc/\phi_0$
de Broglie	$\lambda = \dfrac{h}{p} = \dfrac{h}{mv} = \dfrac{h}{\sqrt{2mK}}$
Electron, p.d. V	$\lambda = \dfrac{h}{\sqrt{2meV}} = \dfrac{1.227}{\sqrt{V}}$ nm

12 Atoms

Closest approach	$d = \dfrac{1}{4\pi\varepsilon_0}\dfrac{2Ze^2}{K}$ (α-particle, KE K)
Bohr's postulate	$mvr = \dfrac{nh}{2\pi};\ h\nu = E_i - E_f$
Orbit radius (H)	$r_n = \dfrac{n^2 h^2 \varepsilon_0}{\pi m e^2} = n^2 a_0,\ a_0 = 0.529$ Å
Energy (H)	$E_n = -\dfrac{13.6}{n^2}$ eV; $K = -E,\ U = 2E$
Emitted photon	$h\nu = E_{n_i} - E_{n_f} = 13.6\left(\dfrac{1}{n_f^2} - \dfrac{1}{n_i^2}\right)$ eV

Series (n_f): Lyman 1 (UV) · Balmer 2 (visible) · Paschen 3, Brackett 4, Pfund 5 (IR)

13 Nuclei

Nuclear radius	$R = R_0 A^{1/3},\ R_0 = 1.2$ fm; density same for all A
Mass defect	$\Delta M = [Zm_p + (A - Z)m_n] - M$
Binding energy	$E_b = \Delta M c^2$; E_b/A peaks ≈ 8.75 MeV ($A \approx 56$)
Mass–energy	$E = mc^2$; $1\text{ u} = 931.5\text{ MeV}/c^2$

14 Semiconductor Electronics: Materials, Devices and Simple Circuits

Carriers	$n_e n_h = n_i^2$; intrinsic $n_e = n_h = n_i$
n-type	Pentavalent donor (As, Sb, P): $n_e \gg n_h$
p-type	Trivalent acceptor (In, B, Al): $n_h \gg n_e$
Band gap	Metal: overlap · semiconductor $E_g < 3$ eV · insulator > 3 eV
Rectifier output	Half-wave: frequency f; full-wave: $2f$

CONSTANTS

$e = 1.6 \times 10^{-19}$ C	$\varepsilon_0 = 8.854 \times 10^{-12}$ C² N⁻¹ m⁻²
$\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m² C⁻²	$\mu_0 = 4\pi \times 10^{-7}$ T m A⁻¹
$c = 3 \times 10^8$ m s⁻¹	$h = 6.63 \times 10^{-34}$ J s
$m_e = 9.11 \times 10^{-31}$ kg	$1\text{ u} = 1.66 \times 10^{-27}$ kg
$hc \approx 1240$ eV nm	$m_p = 1.67 \times 10^{-27}$ kg
$a_0 = 0.529$ Å	$1\text{ eV} = 1.6 \times 10^{-19}$ J

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