Physic 102 formula sheet

Kinematics and mechanics

$$x = x_0 + v_0 t + \frac{1}{2}at^2 \qquad\qquad v = v_0 + at \qquad\qquad v^2 = v_0^2 + 2a\Delta x$$

$$F = ma \qquad\qquad a_c = \frac{v^2}{r}$$

$$E_{\text{tot}} = K + U \qquad K = \frac{1}{2}mv^2 = \frac{p^2}{2m} \qquad p = mv \qquad W_F = Fd\cos\theta \qquad P = Fv\cos\theta$$

Electrostatics

$$F_{12} = k\frac{q_1 q_2}{r^2} \qquad E = \frac{F}{q_0} \qquad U_{12} = k\frac{q_1 q_2}{r} \qquad V \equiv \frac{U}{q_0} \qquad W_E = -\Delta U = -W_{\text{you}}$$

Point charge $\qquad E = k\frac{q}{r^2} \qquad V = k\frac{q}{r}$

Electric dipole $\qquad p = qd \qquad \tau_{\text{dip}} = pE\sin\theta \qquad U_{\text{dip}} = -pE\cos\theta$

Resistance

$$R = \frac{V}{I} \qquad\qquad I = \frac{\Delta q}{\Delta t} \qquad\qquad \text{Physical resistance: } R = \rho\frac{L}{A}$$

$$P = IV = I^2 R = \frac{V^2}{R} \qquad\qquad R_{\text{S}} = R_1 + R_2 + \cdots \qquad\qquad \frac{1}{R_{\text{P}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

Capacitance

$$C = \frac{Q}{V} \qquad \text{Parallel plate capacitor: } C = \frac{\kappa\epsilon_0 A}{d} \qquad E = \frac{Q}{\epsilon_0 A} \qquad V = Ed$$

$$U_C = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C} \qquad\qquad C_{\text{P}} = C_1 + C_2 + \cdots \qquad\qquad \frac{1}{C_{\text{S}}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$$

Circuits

$$\sum \Delta V = 0 \qquad\qquad \sum I_{\text{in}} = \sum I_{\text{out}}$$

$$q(t) = q_\infty(1 - e^{-t/\tau}) \qquad q(t) = q_0 e^{-t/\tau} \qquad I(t) = I_0 e^{-t/\tau} \qquad \tau = RC$$

Magnetism

$$F = qvB\sin\theta \qquad\qquad r = \frac{mv}{qB} \qquad F_{\text{wire}} = ILB\sin\theta \qquad \tau_{\text{loop}} = NIAB\sin\varphi$$

Magentic dipole: $\qquad \mu = NIA \qquad \tau_{\text{dip}} = \mu B\sin\varphi \qquad U_{\text{dip}} = -\mu B\cos\varphi$

$$B_{\text{wire}} = \frac{\mu_0 I}{2\pi r} \qquad\qquad B_{\text{sol}} = \mu_0 nI$$

Electromagnetic induction

$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t} \qquad\qquad \Phi = BA\cos\varphi$$

$$|\mathcal{E}_{\text{bar}}| = BLv \qquad\qquad \mathcal{E}_{\text{gen}} = \mathcal{E}_{\text{max}}\sin\omega t = \omega NAB\sin\omega t \qquad \omega = 2\pi f$$

$$V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}} \qquad\qquad I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}} \qquad\qquad \frac{V_{\text{p}}}{V_{\text{s}}} = \frac{I_{\text{s}}}{I_{\text{p}}} = \frac{N_{\text{p}}}{N_{\text{s}}}$$

Right-hand rule (RHR) reminders

Find the force on a moving positive charge:
1. Fingers point along the velocity direction
2. Curl fingers toward the magnetic field
3. Magnetic force points in the direction of your thumb

Find the direction of a magnetic field due to a current:
1. Thumb points along the (positive) current
2. The curl of your fingers shows the orientation of the magnetic field around the current

Electromagnetic waves

$$\lambda = \frac{c}{f} \qquad\qquad E = cB$$

$$u_E = \frac{1}{2}\epsilon_0 E^2 \qquad u_B = \frac{1}{2\mu_0}B^2 \qquad \overline{u} = \frac{1}{2}\epsilon_0 E_{\text{rms}}^2 + \frac{1}{2\mu_0}B_{\text{rms}}^2 = \epsilon_0 E_{\text{rms}}^2 = \frac{B_{\text{rms}}^2}{\mu_0} \qquad S = I = \overline{u}c = \frac{P}{A}$$

$$f_0 = f_e \sqrt{\frac{1 + v_{\text{rel}}/c}{1 - v_{\text{rel}}/c}} \approx f_e\left(1 + \frac{v_{\text{rel}}}{c}\right) \qquad\qquad I = I_0\cos^2\theta \qquad\qquad \text{E}_{\text{rms}}{}^2 = \text{E}_0{}^2/2$$

Reflection and refraction

$$\theta_{\text{r}} = \theta_{\text{i}} \qquad\qquad \frac{1}{d_{\text{o}}} + \frac{1}{d_{\text{i}}} = \frac{1}{f} \qquad\qquad f = \pm\frac{R}{2} \qquad\qquad m = \frac{h_{\text{i}}}{h_{\text{o}}} = -\frac{d_{\text{i}}}{d_{\text{o}}}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2 \qquad v = \frac{c}{n} \qquad\qquad \sin\theta_c = \frac{n_2}{n_1} \qquad\qquad M = \frac{\theta'}{\theta} \approx \frac{d_{\text{near}}}{f}$$

Compound microscope: $\quad m_{\text{obj}} = \dfrac{L_{\text{tube}}}{f_{\text{obj}}} \qquad\qquad M_{\text{eye}} = \dfrac{d_{\text{near}}}{f_{\text{eye}}} \qquad\qquad M_{\text{tot}} = M_{\text{eye}}m_{\text{obj}}$

Interference and diffraction

Double-slit interference: $\qquad d\sin\theta = m\lambda \qquad\qquad d\sin\theta = \left(m + \dfrac{1}{2}\right)\lambda \qquad m = 0, \pm 1, \pm 2, \cdots$

Single-slit diffraction: $\qquad\quad a\sin\theta = m\lambda \qquad\qquad m = 0, \pm 1, \pm 2, \cdots$

Circular aperture: $\qquad\qquad\; D\sin\theta \approx 1.22\lambda$

Constants and unit conversion

$g = 9.8 \text{ m/s}^2 \qquad\qquad\qquad\qquad e = 1.60 \times 10^{-19} \text{ C}$

$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2 \qquad\qquad k \equiv \dfrac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2 \qquad\qquad \mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m/A}$

$c = \dfrac{1}{\sqrt{\epsilon_0\mu_0}} = 3 \times 10^8 \text{ m/s} \qquad\quad h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s} \qquad\qquad hc = 1240 \text{ eV} \cdot \text{nm}$

$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J} \qquad\qquad\qquad\qquad\quad m_{\text{electron}} = 9.11 \times 10^{-31} \text{ kg} = 511 \text{ keV}/c^2$

$m_{\text{proton}} = 1.673 \times 10^{-27} \text{ kg} = 938 \text{ MeV}/c^2 \qquad\quad m_{\text{neutron}} = 1.675 \times 10^{-27} \text{ kg} = 939.5 \text{ MeV}/c^2$

SI Prefixes

Power	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^0	—	—
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p