Physic 102 formula sheet

Kinematics and mechanics

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

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

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

Electrostatics

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

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

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

Resistance

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

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

Capacitance

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

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

Circuits

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

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

Magnetism

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

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

$B_{\text{wire}} = \frac{\mu_0 I}{2\pi r}$ $\quad B_{\text{sol}} = \mu_0 n I$

Electromagnetic induction

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

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

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

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

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

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

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

Reflection and refraction

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

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

Compound microscope: $m_{\rm obj} = \frac{L_{\rm tube}}{f_{\rm obj}}$ $\qquad M_{\rm eye} = \frac{d_{\rm near}}{f_{\rm eye}}$ $\qquad M_{\rm tot} = M_{\rm eye}m_{\rm obj}$

Interference and diffraction

Double-slit interference: $d\sin\theta = m\lambda$ $\qquad d\sin\theta = \left(m+\frac{1}{2}\right)\lambda$ $\qquad m = 0, \pm1, \pm2, \cdots$

Single-slit diffraction: $a\sin\theta = m\lambda$ $\qquad m = 0, \pm1, \pm2, \cdots$

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

Constants and unit conversion

$g = 9.8 \text{ m/s}^2$ $\qquad e = 1.60\times10^{-19}$ C

$\epsilon_0 = 8.85\times10^{-12}\ \text{C}^2/\text{Nm}^2$ $\qquad k \equiv \frac{1}{4\pi\epsilon_0} = 8.99\times10^9\ \text{Nm}^2/\text{C}^2$ $\qquad \mu_0 = 4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}$

$c = \frac{1}{\sqrt{\epsilon_0\mu_0}} = 3\times10^8$ m/s $\qquad h = 6.626\times10^{-34}\ \text{J}\cdot\text{s}$ $\qquad hc = 1240\ \text{eV}\cdot\text{nm}$

$1\text{ eV} = 1.60\times10^{-19}$ J $\qquad m_{\rm electron} = 9.11\times10^{-31}\text{ kg} = 511\text{ keV}/c^2$

$m_{\rm proton} = 1.673\times10^{-27}\text{ kg} = 938\text{ MeV}/c^2$ $\qquad m_{\rm neutron} = 1.675\times10^{-27}\text{ kg} = 939.5\text{ MeV}/c^2$

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