Physic 102 formula sheet (FA2016)

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: $R = \rho\frac{L}{A}$

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

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

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

Electromagnetic induction

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

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

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

Electromagnetic waves

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

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

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

Reflection and refraction

$\theta_r = \theta_i$ $\quad \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $\quad f = \pm\frac{R}{2}$ $\quad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$

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

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

Interference and diffraction

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

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

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

Quantum mechanics

$E = hf = \frac{hc}{\lambda}$ $\quad \lambda = \frac{h}{p}$ $\quad \Delta p_x \Delta x \geq \frac{\hbar}{2}$ $\quad \hbar = \frac{h}{2\pi}$

Bohr atom: $2\pi r_n = n\lambda$ $\quad n = 1, 2, 3, \cdots$ $\quad L_n = m_e v_n r_n = n\hbar$

$r_n = \left(\frac{\hbar^2}{m_e k e^2}\right)\frac{n^2}{Z} \approx (5.29 \times 10^{-11}\text{ m})\frac{n^2}{Z}$ $\quad E_n = -\left(\frac{m_e k^2 e^4}{2\hbar^2}\right)\frac{Z^2}{n^2} \approx -(13.6\text{ eV})\frac{Z^2}{n^2}$

$\frac{1}{\lambda} \approx (1.097 \times 10^7\text{ m}^{-1})Z^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

Quantum atom: $L = \sqrt{\ell(\ell+1)}\hbar$ $\quad L_z = m_\ell \hbar$ $\quad S_z = m_s \hbar$

Atomic magnetism: $\mu_{e,z} = -\frac{e}{2m_e}L_z$ $\quad \mu_{s,z} = -\frac{ge}{2m_e}S_z,\ g \approx 2$ $\quad \mu_B \equiv \frac{e\hbar}{2m_e} \approx 5.8 \times 10^{-5}\text{ eV/T}$

Nuclear physics and radioactive decay

$A = Z + N$ $\quad r \approx (1.2 \times 10^{-15}\text{ m})A^{1/3}$ $\quad E_0 = mc^2$

$m_{\text{nucleus}} = Zm_{\text{proton}} + Nm_{\text{neutron}} - \frac{|E_{\text{bind}}|}{c^2}$

$\frac{\Delta N}{\Delta t} = -\lambda N$ $\quad N(t) = N_0 e^{-\lambda t} = N_0 2^{-t/T_{1/2}}$ $\quad T_{1/2} = \frac{\ln 2}{\lambda} \approx \frac{0.693}{\lambda}$

Constants and unit conversion

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

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

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

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

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

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