Physics 212 Formula Sheet

Electrostatics:

$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}{}^2}\hat{r}$$

$$\vec{E} \equiv \frac{\vec{F}}{q_0}$$

$$\Phi_E = \int \vec{E}\cdot d\vec{S}$$

$$\oint \vec{E}\cdot d\vec{S} = \frac{Q_{encl}}{\varepsilon_0}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$

$$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{r}$$

$$\vec{E} = \pm\frac{\sigma}{2\varepsilon_0}\hat{x}$$

$$V_B - V_A \equiv \frac{W_{AB}}{q_0} = -\int_A^B \vec{E}\cdot d\vec{l}$$

$$\vec{E} = -\vec{\nabla}V$$

$$U = q_0 V$$

$$U_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$$

$$V(r) = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$\Delta V = \pm Ed$$

Capacitors and RC Circuits:

$$C \equiv \frac{Q}{V}$$

$$U = \tfrac{1}{2}CV^2 = \tfrac{1}{2}\frac{Q^2}{C}$$

$$C = C_1 + C_2$$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$C_0 = \frac{\varepsilon_0 A}{d}$$

$$C_0 = \frac{4\pi\varepsilon_0 ab}{(b-a)}$$

$$C_0 = \frac{2\pi\varepsilon_0 L}{\ln(b/a)}$$

$$C = \kappa C_0$$

$$Q(t) = Q(\infty)\left(1 - e^{-t/\tau}\right)$$

$$Q(t) = Q(0)e^{-t/\tau}$$

$$\tau = RC$$

$$u_E = \frac{1}{2}\varepsilon_0 E^2\kappa$$

Simple Circuits:

$$R = \frac{V}{I}$$

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

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R = R_1 + R_2$$

$$P = IV = I^2 R$$

Magnetostatics:

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

$$d\vec{F} = Id\vec{l}\times\vec{B}$$

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

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I$$

$$B = \frac{\mu_0}{2\pi}\frac{I}{r}$$

$$B_z = \frac{\mu_0 I R^2}{2(z^2+R^2)^{3/2}}$$

$$B = \mu_0 n I$$

$$\vec{\mu} = NI\vec{A}$$

$$\vec{\tau} = \vec{\mu}\times\vec{B}$$

$$U = -\vec{\mu}\cdot\vec{B}$$

Induction and RL Circuits:

$$EMF = -\frac{d\Phi_B}{dt}$$

$$\Phi_B = \int \vec{B}\cdot d\vec{S}$$

$$L \equiv \frac{\Phi_B}{I}$$

$$V = L\frac{dI}{dt}$$

$$U = \frac{1}{2}LI^2$$

$$L = L_1 + L_2$$

$$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}$$

$$I(t) = I(0)e^{-t/\tau}$$

$$I(t) = I(\infty)\left(1 - e^{-t/\tau}\right)$$

$$\tau = \frac{L}{R}$$

$$u_B = \frac{1}{2}\frac{B^2}{\mu_0}$$

LC, LCR, and AC Circuits:

$\omega_0 = \frac{1}{\sqrt{LC}}$ $\quad X_C \equiv \frac{1}{\omega C}$ $\quad X_L \equiv \omega L$ $\quad \tan\phi = \frac{X_L - X_C}{R}$

$Z \equiv \sqrt{R^2 + (X_L - X_C)^2}$ $\quad \varepsilon_{\max} = I_{\max} Z$ $\quad \varepsilon_{rms} = \frac{1}{\sqrt{2}}\varepsilon_{\max}$ $\quad V_2 = \frac{N_2}{N_1} V_1$

$< P >= \varepsilon_{rms} I_{rms} \cos\phi = \frac{1}{2}\varepsilon_{\max} I_{\max} \cos\phi = I_{rms}^2 R$ $\quad Q = \frac{\omega_0 L}{R} \approx \frac{\omega_0}{FWHM}$ $\quad I_1 V_1 = I_2 V_2$

EM Waves, Polarization, Reflection and Refraction:

$\oint \vec{B} \cdot d\vec{l} = \mu_0 I + \mu_0 I_D$ $\quad I_D = \varepsilon_0 \frac{d\phi_E}{dt}$ $\quad E = cB$ $\quad I = c\langle u \rangle = \frac{\langle E^2 \rangle}{Z_0} = \frac{1}{2}\frac{E_{\max}^2}{Z_0} = \frac{\langle P \rangle}{area}$

$\vec{S} \equiv \frac{\vec{E} \times \vec{B}}{\mu_0}$ $\quad \vec{B} = \hat{s} \times \frac{\vec{E}}{c}$ $\quad u = \varepsilon_0 E^2$ $\quad \frac{I}{c} = \frac{force}{area}$ $\quad E_{rms} = \frac{1}{\sqrt{2}} E_{\max}$

$\omega = 2\pi \mathrm{f}$ $\quad \mathrm{v} = \lambda f = \frac{\omega}{k}$ $\quad I_2 = I_1 \cos^2(\theta_1 - \theta_2)$ $\quad \mathrm{v} = c/n$ $\quad \frac{\lambda_1}{\lambda_2} = \frac{\mathrm{v}_1}{\mathrm{v}_2} = \frac{n_2}{n_1}$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$ $\quad \sin\theta_c = \frac{n_2}{n_1}$ $\quad f' = f\sqrt{\frac{1 \pm \mathrm{v/c}}{1 \mp \mathrm{v/c}}}$ $\quad f' \approx f(1 \pm \mathrm{v/c})$

Mirrors and lenses:

$f = \frac{R}{2}$ $\quad \frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$ $\quad \frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $\quad m = -\frac{s'}{s}$ $\quad power = \frac{1}{f}[Diopters]$

Energy:

$K = \frac{1}{2} m\mathrm{v}^2$ $\quad E = K + U = \text{const.}$

Centripetal Force:

$F_c = m\frac{\mathrm{v}^2}{r}$

Important Constants:

$k \equiv \frac{1}{4\pi\varepsilon_\circ} = 9 \times 10^9 \ \frac{\mathrm{Nm}^2}{\mathrm{C}^2}$ $\quad \varepsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$ $\quad \frac{\mu_0}{4\pi} \equiv 1 \times 10^{-7} \ \frac{\mathrm{N}}{\mathrm{A}^2} = 1 \times 10^{-7} \ T_m/A$

$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8 \mathrm{m/s}$ $\quad e = 1.60 \times 10^{-19}\ \mathrm{C}$ $\quad Z_0 = \mu_0 c = 377\ \Omega$

SI Prefixes

Power	Prefix	Symbol
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

Geometry

Circle
area $= \pi R^2$
circumf. $= 2\pi R$

Sphere
area $= 4\pi R^2$
volume $= \frac{4}{3}\pi R^3$

$\vec{\nabla} V = \hat{x}\frac{\partial V}{\partial x} + \hat{y}\frac{\partial V}{\partial y} + \hat{z}\frac{\partial V}{\partial z}$