

Physics 212 Formula Sheet

Electrostatics:

$$\vec{F} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r_{12}^2} \hat{r}$$

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

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

$$\oint \vec{E} \cdot d\vec{S} = \frac{Q_{encl}}{\epsilon_0}$$

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \hat{r}$$

$$\vec{E} = \frac{\lambda}{2\pi\epsilon_0 r} \hat{r}$$

$$\vec{E} = \pm \frac{\sigma}{2\epsilon_0} \hat{x}$$

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

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

$$U = q_0 V$$

$$U_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r_{12}}$$

$$V(r) = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$$

$$\Delta V = \pm Ed$$

Capacitors and RC Circuits:

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

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

$$C = C_1 + C_2$$

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

$$C_0 = \frac{\epsilon_0 A}{d}$$

$$C_0 = \frac{4\pi\epsilon_0 ab}{(b-a)}$$

$$C_0 = \frac{2\pi\epsilon_0 L}{\ln(b/a)}$$

$$C = \kappa C_0$$

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

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

$$\tau = RC$$

$$u_E = \frac{1}{2} \epsilon_0 E^2 \kappa$$

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:

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

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

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

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

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

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

$$B = \mu_0 nI$$

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

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

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

Induction and RL Circuits:

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

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

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

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

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

$$L = L_1 + L_2$$

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

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

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

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

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

LC, LCR, and AC Circuits:

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

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

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

EM Waves, Polarization, Reflection and Refraction:

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

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

$$\omega = 2\pi f \quad v = \lambda f = \frac{\omega}{k} \quad I_2 = I_1 \cos^2(\theta_1 - \theta_2) \quad v = c/n \quad \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1}$$

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

Mirrors and lenses:

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

Energy:

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

Centripetal Force:

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

Important Constants:

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

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

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

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