Physics 121 Equation Sheet

$$\vec{F} = k\frac{Q_1Q_2}{r^2}\hat{r};\ \ \hat{r} = \frac{\vec{r}_o - \vec{r}_s}{|\vec{r}_o - \vec{r}_s|}$$

$$\vec{E} = \frac{\vec{F}}{q} = \int d\vec{E} = \int dE\hat{r} = \int \frac{kdq}{r^2}\hat{r}$$

$$\vec{E}_Q = k\frac{Q}{r^2}\hat{r}$$

$$|\vec{E}_{\parallel}| = \frac{2kqs}{r^3};\ \text{dipole } r >> s$$

$$|\vec{E}_{\perp}| = \frac{kqs}{r^3};\ \text{dipole } r >> s$$

$$|\vec{E}_{rod}|_{\perp} = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{r\sqrt{r^2 + \left(L/2\right)^2}}\right]$$

$$|\vec{E}_{rod}|_{\parallel} = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{r(L+r)}\right];\ |\vec{E}_{rod}|_{\parallel} \sim \frac{1}{4\pi\varepsilon_0}\left(\frac{Q}{rL}\right)\ \ L >> r$$

$$|\vec{E}_{ring}| = \frac{1}{4\pi\varepsilon_0}\left[\frac{Qz}{\left(R^2+z^2\right)^{\frac{3}{2}}}\right]$$

$$|\vec{E}_{disk}| = \frac{Q}{2\pi\varepsilon_0 R^2}\left[1 - \frac{z}{\sqrt{R^2+z^2}}\right];\ \ |\vec{E}_{disk}| \sim \frac{Q}{2\varepsilon_0 A}\left[1 - \frac{z}{R}\right]\ \ z << R;\ \ |\vec{E}_{disk}| \sim \frac{Q}{2\varepsilon_0 A}\ \ z << R$$

$$|\vec{E}_{capacitor}| \sim \frac{Q}{\varepsilon_0 A};\ \ |\vec{E}_{fringe}| \sim \frac{Q}{2\varepsilon_0 A}\left(\frac{s}{R}\right)$$

$$W = -q\Delta V = -\Delta U = \Delta K;\ \ U = \sum_{i \neq j}\frac{kQ_iQ_j}{r_{ij}};$$

$$V_Q = \frac{kQ}{r};\ \ V_{Q's} = \sum_i \frac{kQ_i}{r_i}$$

$$\Delta V = -\int \vec{E}\cdot d\vec{r}$$

$$E_x = -\frac{\Delta V}{\Delta x};\ \ E_y = -\frac{\Delta V}{\Delta y};\ \ E_z = -\frac{\Delta V}{\Delta z};\ \ \vec{E} = -\left\langle \frac{dV}{dx}, \frac{dV}{dy}, \frac{dV}{dz}\right\rangle$$

$$Q = \left(\frac{\kappa\varepsilon_0 A}{s}\right)\Delta V$$

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

$$Q = Q_{\max}\left(1 - e^{-\frac{t}{RC}}\right);\ \ Q = Q_{\max}e^{-\frac{t}{RC}}$$

$$I = \frac{dQ}{dt} = n|e|Av_d = \int \vec{J}\cdot d\vec{A}$$

$$n = \frac{\rho}{M}N_A$$

$$\vec{J} = n|e|\vec{v}_d = \sigma\vec{E} = \tfrac{1}{\rho}\vec{E} \rightarrow V = IR;\ R = \frac{\rho L}{A}$$

$$P = IV = I^2R = \frac{V^2}{R} = \frac{dW}{dt}$$

$$\rho = \rho_0\left(1 + \alpha\Delta T\right)$$

$$\vec{F} = q\vec{v}\times\vec{B};\ \ |\vec{F}| = qvB\sin\theta$$

$$\vec{B} = \frac{\mu_o}{4\pi}\left(\frac{q\vec{v}\times\hat{r}}{r^2}\right)$$

$$d\vec{B} = \frac{\mu_o I}{4\pi}\left(\frac{d\vec{l}\times\hat{r}}{r^2}\right)$$

$$|\vec{B}_{wire}| = \frac{\mu_o LI}{4\pi r\sqrt{\left(\frac{L}{2}\right)^2 + r^2}};\ \ |\vec{B}_{wire}| \approx \frac{\mu_o I}{2\pi r}\ \ L >> r$$

$$|\vec{B}_{ring}| = \frac{\mu_o IR^2}{2\left(z^2+R^2\right)^{\frac{3}{2}}};\ |\vec{B}_{ring}| \approx \frac{\mu_o IR^2}{2z^3}\ \ z << R$$

$$g = 9.8\,\tfrac{m}{s^2}$$

$$1e = 1.6\times10^{-19}C$$

$$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^9\,\tfrac{Nm^2}{C^2}$$

$$\varepsilon_o = 8.85\times10^{-12}\,\tfrac{C^2}{Nm^2}$$

$$1eV = 1.6\times10^{-19}J$$

$$\mu_o = 4\pi\times10^{-7}\,\tfrac{Tm}{A}$$

$$c = 3\times10^8\,\tfrac{m}{s}$$

$$h = 6.63\times10^{-34}Js$$

$$m_e = 9.11\times10^{-31}kg = \frac{0.511MeV}{c^2}$$

$$m_p = 1.67\times10^{-27}kg = \frac{937.1MeV}{c^2}$$

$$m_n = 1.69\times10^{-27}kg = \frac{948.3MeV}{c^2}$$

$$1amu = 1.66\times10^{-27}kg = \frac{931.5MeV}{c^2}$$

$$N_A = 6.02\times10^{23}$$

$$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

$$\vec{v}_f = \left\langle v_{fx}, v_{fy}, v_{fz}\right\rangle = \left\langle v_{ix} + a_xt, v_{iy} + a_yt, v_{iz} + a_zt\right\rangle$$

$$\Delta\vec{r}_f = \left\langle x_f - x_i, y_f - y_i, z_f - z_i\right\rangle = \left\langle v_{ix}t + \tfrac{1}{2}a_xt^2, v_{iy}t + \tfrac{1}{2}a_yt^2, v_{iz}t + \tfrac{1}{2}a_zt^2\right\rangle$$

$$\vec{F} = m\vec{a}$$

$$|\vec{a}_c| = \frac{v_{\perp}^2}{r}$$

$$\vec{F} = I\vec{L}\times\vec{B};\ |\vec{F}| = ILB\sin\theta$$

$$V_{Hall} = wv_dB = \frac{IwB}{eAn}$$

$$\frac{1}{R_{eq}} = \sum_i \frac{1}{R_i}$$

$$R_{eq} = \sum_i R_i$$

$$C_{eq} = \sum_i C_i$$

$$\frac{1}{C_{eq}} = \sum_i \frac{1}{C_i}$$

$$\phi_B = \int \vec{B}\cdot d\vec{A}$$

$$\varepsilon = -N\frac{d\phi_B}{dt}$$

$$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$$

$$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$$

$$\vec{A}\times\vec{B} = \left\langle A_yB_z - A_zB_y, A_zB_x - A_xB_z, A_xB_y - A_yB_x\right\rangle$$

Cons. of Energy (Loop Rule): $\sum_i \Delta V_i = \sum_i E_i\Delta l_i = 0;\ \oint \vec{E}\cdot d\vec{l} = 0$

Cons. of Charge (Node Rule): $\sum I_{in} = \sum I_{out}$