

Physics 121 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k \frac{Q_1 Q_2}{r^2} \hat{r}; \quad \hat{r} = \frac{\vec{r}_o - \vec{r}_s}{|\vec{r}_o - \vec{r}_s|}$$

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

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

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

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

$$|\vec{E}_{rod \perp}| = \frac{1}{4\pi\epsilon_0} \left[\frac{Q}{r\sqrt{r^2 + (L/2)^2}} \right]$$

$$|\vec{E}_{rod ||}| = \frac{1}{4\pi\epsilon_0} \left[\frac{Q}{r(L+r)} \right]; |\vec{E}_{rod ||}| \sim \frac{1}{4\pi\epsilon_0} \left(\frac{Q}{rL} \right) \quad L \gg r$$

$$|\vec{E}_{ring}| = \frac{1}{4\pi\epsilon_0} \left[\frac{Qz}{(R^2 + z^2)^{3/2}} \right]$$

$$|\vec{E}_{disk}| = \frac{Q}{2\pi\epsilon_0 R^2} \left[1 - \frac{z}{\sqrt{R^2 + z^2}} \right]; |\vec{E}_{disk}| \sim \frac{Q}{2\epsilon_0 A} \left[1 - \frac{z}{R} \right] \quad z \ll R; \quad |\vec{E}_{disk}| \sim \frac{Q}{2\epsilon_0 A} \quad z \ll R$$

$$|\vec{E}_{capacitor}| \sim \frac{Q}{\epsilon_0 A}; \quad |\vec{E}_{fringe}| \sim \frac{Q}{2\epsilon_0 A} \left(\frac{s}{R} \right)$$

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

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

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

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

$$Q = \left(\frac{\kappa\epsilon_0 A}{s} \right) \Delta V$$

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

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

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

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

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

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

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

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

$$\vec{B} = \frac{\mu_0}{4\pi} \left(\frac{q\vec{v} \times \hat{r}}{r^2} \right)$$

$$d\vec{B} = \frac{\mu_0 I}{4\pi} \left(\frac{d\vec{l} \times \hat{r}}{r^2} \right)$$

$$|\vec{B}_{wire}| = \frac{\mu_0 I L}{4\pi r \sqrt{(\frac{L}{2})^2 + r^2}}; \quad |\vec{B}_{wire}| \approx \frac{\mu_0 I}{2\pi r} \quad L \gg r$$

$$|\vec{B}_{ring}| = \frac{\mu_0 I R^2}{2(z^2 + R^2)^{3/2}}; \quad |\vec{B}_{ring}| \approx \frac{\mu_0 I R^2}{2z^3} \quad z \ll R$$

Constants

$$g = 9.8 \frac{m}{s^2}$$

$$1e = 1.6 \times 10^{-19} C$$

$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{Nm^2}{C^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$$

$$1eV = 1.6 \times 10^{-19} J$$

$$\mu_0 = 4\pi \times 10^{-7} \frac{Tm}{A}$$

$$c = 3 \times 10^8 \frac{m}{s}$$

$$h = 6.63 \times 10^{-34} Js$$

$$m_e = 9.11 \times 10^{-31} kg = \frac{0.511 MeV}{c^2}$$

$$m_p = 1.67 \times 10^{-27} kg = \frac{937.1 MeV}{c^2}$$

$$m_n = 1.69 \times 10^{-27} kg = \frac{948.3 MeV}{c^2}$$

$$1amu = 1.66 \times 10^{-27} kg = \frac{931.5 MeV}{c^2}$$

$$N_A = 6.02 \times 10^{23}$$

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

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

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

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

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

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

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

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

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

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

$$\vec{A} \times \vec{B} = \langle A_y B_z - A_z B_y, A_z B_x - A_x B_z, A_x B_y - A_y B_x \rangle$$