Physics 121 Formula Sheet

Electrostatics & Electricity

$\vec{F} = \frac{kQ_1Q_2}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}\hat{r}; \quad \hat{r} = \frac{\vec{r}_o - \vec{r}_s}{|\vec{r}_o - \vec{r}_s|}$

$\vec{E} = \frac{\vec{F}}{q} = \int d\vec{E} = \int \frac{kdq}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r^2}\hat{r}$

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

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

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

Rod: $|\vec{E}_\perp| = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{r\sqrt{r^2 + \left(\frac{L}{2}\right)^2}}\right]; \quad |\vec{E}_\parallel| = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{r(L+r)}\right]; \quad |\vec{E}_\parallel| \sim \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{rL}\right]$ for $L \gg r$;

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

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

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

$W = -q\Delta V = -\Delta U_e = \Delta K$

$\Delta V = \int \vec{E}\cdot d\vec{r} \rightarrow \vec{E} = -\langle\frac{dV}{dx}, \frac{dV}{dy}, \frac{dV}{dz}\rangle$

$V_{point\ charge} = \frac{kQ}{r} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

$Q = CV; \quad C_{plates} = \frac{\kappa\varepsilon_0 A}{d}; \quad C_{cylindrical} = \frac{2\pi\varepsilon_0 L}{\ln\left(\frac{r_{outer}}{r_{inner}}\right)}; \quad C_{spherical} = 4\pi\varepsilon_0\left(\frac{r_{outer} \times r_{inner}}{r_{outer} - r_{inner}}\right)$

Capacitors: $C_{parallel} = \sum_{i=1}^{N} C_i\,; \quad \frac{1}{C_{series}} = \sum_{i=1}^{N}\frac{1}{C_i}$

$U_e = \frac{1}{2}qV = \frac{1}{2}CV^2 = \frac{q^2}{2C}$

$I = \frac{dQ}{dt} = neAv_d; \quad n = \frac{\rho}{M}N_A$

Charging: $Q(t) = Q_{max}\left(1 - e^{-\frac{t}{RC}}\right); \quad I(t) = \frac{dQ(t)}{dt} = \frac{Q_{max}}{RC}e^{-\frac{t}{RC}} = I_{max}e^{-\frac{t}{RC}}$

Discharging: $Q(t) = Q_{max}e^{-\frac{t}{RC}}; \quad I(t) = \frac{dQ(t)}{dt} = \frac{Q_{max}}{RC}e^{-\frac{t}{RC}} = I_{max}e^{-\frac{t}{RC}}$

$\vec{J} = \sigma\vec{E} = \frac{1}{\rho}\vec{E} \rightarrow V = IR; \quad R = \frac{\rho L}{A}; \quad \rho = \rho_0(1 + \alpha\Delta T)$

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

Resistors: $R_{series} = \sum_{i=1}^{N} R_i\,; \quad \frac{1}{R_{parallel}} = \sum_{i=1}^{N}\frac{1}{R_i}$

Magnetism

$\vec{F}_B = q\vec{v} \times \vec{B} \rightarrow |\vec{F}_B| = qvB\sin\theta$; $\quad \vec{F}_B = I\vec{L} \times \vec{B} \rightarrow ILB\sin\theta$

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

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

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

$|\vec{B}_{ring}| = \frac{\mu_0 IR^2}{2(z^2 + R^2)^{\frac{3}{2}}}$; $\quad |\vec{B}_{ring}| \sim \frac{\mu_0 IR^2}{2z^3}$ for $z \ll R$

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

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

$V_{Hall} = wv_d B = \frac{IwB}{neA}$

Vectors

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

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

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

Constants

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

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

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

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

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

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

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

$h = 6.63 \times 10^{-34}Js = 4.14 \times 10^{-15}eVs$

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

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

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

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

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

Common Metric Prefixes

$nano\ (n) = 10^{-9}$

$micro\ (\mu) = 10^{-6}$

$milli\ (m) = 10^{-3}$

$centi\ (c) = 10^{-2}$

$kilo\ (k) = 10^3$

$mega\ (M) = 10^6$

Geometry/Algebra

Circles:	$A = \pi r^2$	$C = 2\pi r$
Cylinders:	$A = 2\pi rL + 2\pi r^2$	$V = \pi r^2 L$
Spheres:	$A = 4\pi r^2$	$V = \frac{4}{3}\pi r^3$
Triangles:	$A = \frac{1}{2}bh$	
Quadratics:	$ax^2 + bx + c = 0 \rightarrow x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$	

Useful Physics 120 Formulas

$\vec{F} = m\vec{a}$; $\quad \vec{F}_G = \frac{GM_1m_2}{r^2}\hat{r}$; $\quad F_s = -ky$; $\quad a_c = \frac{v^2}{r}$

$W = -\Delta U_g - \Delta U_s = \Delta K$

$U_g = mgy$

$U_s = \frac{1}{2}ky^2$

$K = \frac{1}{2}mv^2$

$\vec{r}_f = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$; $\quad \vec{v}_f = \vec{v}_i + \vec{a}t$; $\quad v_f^2 = v_i^2 + 2a_r\Delta r$