Physics 251 Exam 1 Formula Sheet

Constants

$$k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \frac{N \cdot m^2}{C^2}$$
$$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N \cdot m^2}$$
$$N_A = 6.02 \times 10^{23}$$
$$q_e = e = -1.602 \times 10^{-19} C$$
$$m_e = 9.11 \times 10^{-31} kg$$
$$m_p = 1.67 \times 10^{-27} kg$$
$$c = 3.00 \times 10^8 m/s$$

Electric Fields

$$\vec{F} = q\vec{E}$$
$$\Delta U = q\Delta V$$
$$W_{a\to b} = U_a - U_b = -\Delta U$$
$$V_{ab} = \int_a^b \vec{E} \cdot d\vec{\ell}$$
$$\vec{E} = -\nabla V$$

Point Charges

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

Distributed Charges

$$\vec{E} = \int \frac{dq}{4\pi\epsilon_0 r^2}\hat{r}$$
$$V = \int \frac{dq}{4\pi\epsilon_0 r}$$

Collection of Charges

$$\vec{E}_T = \sum_i \vec{E}_i$$
$$U_T = \sum_{pairs} U_{ij}$$

Electric Dipoles

$$\vec{\tau} = \vec{p} \times \vec{E} = pE\sin\phi$$
$$U = -\vec{p} \cdot \vec{E} = -pE\cos\phi$$

Flux & Gauss's Law

$$\Phi_E = \oint_S \vec{E} \cdot d\vec{A} = \iint \vec{E} \cdot \hat{n} dA$$
$$\Phi_E = \frac{Q_{encl}}{\epsilon_0}$$

Capacitors and Dielectrics

$$C = \frac{Q}{V}$$
$$\text{parallel: } C_{eq} = \sum_i C_i$$
$$\text{serial: } \frac{1}{C_{eq}} = \sum_i \frac{1}{C_i}$$
$$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C} = \frac{1}{2}QV$$
$$u = \frac{1}{2}\epsilon_0 E^2$$
$$\text{dielectric: } C = KC_0 \ \epsilon = K\epsilon_0$$

Current & Current Density

$$I = \frac{dq}{dt}$$
$$I = \iint \vec{J} \cdot d\vec{A}$$
$$J = nqv_d$$

Ohm's Law & Electric Power

$$\vec{E} = \rho\vec{J}$$
$$V = IR$$
$$P = IV$$

Uniform currents

$$|E| = \frac{V}{L}$$
$$R = \rho\frac{L}{A}$$
$$|J| = \frac{I}{A}$$