**Some (possibly useful) relations for 8.02 Hour Test 3, April 27, 2001**

You may use these freely unless the problem specifically prescribes a different approach.

$$\mathbf{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\,\hat{\mathbf{r}} \quad ; \quad \mathbf{F} = q\mathbf{E}$$

$$\oint\!\!\oint \mathbf{E}\cdot d\mathbf{A} = \frac{q_{in}}{\varepsilon_0}$$

$$V(b) - V(a) \equiv -\int_a^b \mathbf{E}\cdot d\mathbf{s}$$

$$\varepsilon_0 \cong 9\times 10^{-12}\ \mathrm{C^2\,N^{-1}\,m^{-2}}$$

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

$$\mathbf{E} = -\left(\frac{\partial V}{\partial x}\hat{\mathbf{x}} + \frac{\partial V}{\partial y}\hat{\mathbf{y}} + \frac{\partial V}{\partial z}\hat{\mathbf{z}}\right)$$

$$\frac{1}{4\pi\varepsilon_0} \cong 9 \times 10^9\ \mathrm{N\,m^2\,C^{-2}}$$

$$U_E = \frac{C(\Delta V)^2}{2} = \frac{Q^2}{2C}$$

$$u_E = \frac{1}{2}\varepsilon_0\,\mathbf{E}\cdot\mathbf{E} = \frac{1}{2}\varepsilon_0\,|\mathbf{E}|^2$$

$$\mathbf{E} = \rho\,\mathbf{j}\ ; \quad R = \rho\, l/A \quad ; \quad V = iR$$

$$P = iV = i^2 R = V^2/R$$

$$i = \iint \mathbf{j}\cdot d\mathbf{A}$$

$$\Phi_E = \iint \mathbf{E}\cdot d\mathbf{A}$$

$$\mathbf{F} = q\,(\mathbf{v}\times\mathbf{B})$$

$$i = dq/dt \quad ; \quad d\mathbf{F} = i\,(d\mathbf{s}\times\mathbf{B})$$

$$\boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B} \quad ; \quad |\boldsymbol{\mu}| = N\,i\,A$$

$$\oint \mathbf{B}\cdot d\mathbf{s} = \mu_0\, i_{\mathrm{encl}}$$

$$\mu_0 = 4\pi\times 10^{-7}\ \frac{\mathrm{T\cdot m}}{\mathrm{A}}$$

$$d\mathbf{B} = \frac{\mu_0\, i}{4\pi}\frac{d\mathbf{s}\times\mathbf{r}}{r^3}$$

$$|\mathrm{B}| = \mu_0\, n\, i$$

$$\mathcal{E} = -N\frac{d\phi_B}{dt}$$

$$L = \frac{N\,\phi}{i} \quad ; \quad M_{2,1} = \frac{N_2\,\phi_{2,1}}{i_1}$$

$$\mathcal{E} = -L\frac{di}{dt}$$

$$U_L = \frac{1}{2}L\,i^2$$

$$u_B = \frac{\mathbf{B}\cdot\mathbf{B}}{2\mu_0} = \frac{|\mathbf{B}|^2}{2\mu_0}$$

$$\tau = RC \quad ; \quad \tau = L/R$$

$$X_L = \omega L \quad ; \quad X_C = \frac{1}{\omega C}$$

$$\omega_0 = (LC)^{-1/2}$$

$$i_m = \frac{\mathcal{E}_m}{Z} = \frac{\mathcal{E}_m}{\left[R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2\right]^{1/2}}$$

$$\tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R}$$