Physics 333 **Electromagnetic Theory I** **Fall 2006**

Equations for Exam #1

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\int_{\mathcal{V}} \frac{\rho(\mathbf{r}')}{\mathscr{r}^2}\hat{\mathscr{r}}\, d\tau' \qquad \oint_{\mathcal{S}} \mathbf{E}\cdot d\mathbf{a} = \frac{1}{\epsilon_0}Q_{\text{enc}} \qquad \nabla\cdot\mathbf{E} = \frac{1}{\epsilon_0}\rho$$

$$\mathbf{E} = \frac{\sigma}{2\epsilon_0}\hat{\mathbf{n}} \qquad \nabla\times\mathbf{E} = 0 \qquad V(\mathbf{r}) = -\int_{\mathcal{O}}^{\mathbf{r}} \mathbf{E}\cdot d\mathbf{l} \qquad \mathbf{E} = -\nabla V$$

$$\nabla^2 V = -\frac{\rho}{\epsilon_0} \qquad V(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\int \frac{\rho(\mathbf{r}')}{\mathscr{r}}\, d\tau' \qquad \mathbf{E}_{\text{above}} - \mathbf{E}_{\text{below}} = \frac{\sigma}{\epsilon_0}\hat{\mathbf{n}}$$

$$W = \frac{1}{2}\int_{\mathcal{V}} \rho V\, d\tau = \frac{\epsilon_0}{2}\int_{\text{all space}} E^2\, d\tau$$

$$d\tau = dx\, dy\, dz = s\, ds\, d\phi\, dz = r^2\sin\theta\, dr\, d\theta\, d\phi$$

Equations for Exam #2

$$C \equiv Q/V \qquad \sigma = -\epsilon_0\left(\frac{\partial V^{above}}{\partial n} - \frac{\partial V^{below}}{\partial n}\right)$$

You will be given any Fourier integrals, such as $\int_0^a \sin(n\pi x/a)\sin(m\pi x/a)dx$ as well as specific Legendre polynomials, i.e. $P_2(\cos\theta) = \frac{3}{2}\cos^2\theta - \frac{1}{2}$.

$$V(r,\theta) = \sum_{\ell=0}^{\infty}\left(A_\ell r^\ell + \frac{B_\ell}{r^{\ell+1}}\right)P_\ell(\cos\theta) \qquad V_{mono} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$$

$$\mathbf{p} = \int \mathbf{r}'\rho(\mathbf{r}')\, d\tau' \qquad V_{dip} = \frac{1}{4\pi\epsilon_0}\frac{\mathbf{p}\cdot\hat{\mathbf{r}}}{r^2} \qquad \mathbf{E}_{dip} = \frac{p}{4\pi\epsilon_0 r^3}(2\cos\theta\,\hat{\mathbf{r}} + \sin\theta\,\hat{\theta})$$

$$\mathbf{N} = \mathbf{p}\times\mathbf{E} \qquad U = -\mathbf{p}\cdot\mathbf{E} \qquad \sigma_b = \mathbf{P}\cdot\hat{\mathbf{n}} \qquad \rho_b = -\nabla\cdot\mathbf{P}$$

$$V(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\int_{\mathcal{V}}\frac{\hat{\mathscr{r}}\cdot\mathbf{P}(\mathbf{r}')}{\mathscr{r}^2}d\tau' = \frac{1}{4\pi\epsilon_0}\left[\oint_{\mathcal{S}}\frac{\sigma_b}{\mathscr{r}}da' + \int_{\mathcal{V}}\frac{\rho_b}{\mathscr{r}}d\tau'\right]$$

$$\rho = \rho_b + \rho_f \qquad \mathbf{D} = \epsilon_0\mathbf{E} + \mathbf{P} \qquad \nabla\cdot\mathbf{D} = \rho_f \qquad \oint_{\mathcal{S}}\mathbf{D}\cdot d\mathbf{a} = Q_{f,enc}$$

Equations for Exam #3

Equations repeated from Exam #2 are not listed here.

$$\mathbf{P} = \epsilon_0 \chi_e \mathbf{E} \qquad \mathbf{D} = \epsilon \mathbf{E} \qquad \epsilon_r = 1 + \chi_e \qquad \mathbf{F} = q(\mathbf{v} \times \mathbf{B})$$

$$\mathbf{F} = \int I \, d\mathbf{l} \times \mathbf{B} \qquad \nabla \times \mathbf{B} = \mu_0 \mathbf{J} \qquad \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_{enc} \qquad \nabla \cdot \mathbf{B} = 0$$

$$\mathbf{B} = \frac{\mu_0}{4\pi} \int \frac{I \, d\mathbf{l}' \times \hat{\boldsymbol{\mathscr{r}}}}{\mathscr{r}^2} \qquad \mathbf{B} = \nabla \times \mathbf{A} \qquad \nabla^2 \mathbf{A} = -\mu_0 \mathbf{J} \qquad \mathbf{A} = \frac{\mu_0}{4\pi} \int \frac{\mathbf{J}(\mathbf{r}')}{\mathscr{r}} d\tau'$$

$$\mathbf{B}_{above} - \mathbf{B}_{below} = \mu_0 \mathbf{K} \times \hat{\mathbf{n}} \qquad \mathbf{m} = I\mathbf{a} \qquad \mathbf{J}_b = \nabla \times \mathbf{M} \qquad \mathbf{K}_b = \mathbf{M} \times \hat{\mathbf{n}}$$

Equations from Chapter 7

$$\mathcal{E} = IR \qquad \mathbf{J} = \sigma \mathbf{E} \qquad P = IV = I^2 R \qquad \mathcal{E} = \oint \mathbf{f} \cdot d\mathbf{l} \qquad \mathcal{E} = -\frac{d\Phi}{dt}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \qquad \Phi_2 = M I_1 \qquad \Phi = LI \qquad W_{mag} = \tfrac{1}{2} L I^2 = \frac{1}{2\mu_0} \int B^2 \, d\tau$$

$$\frac{\partial \rho}{\partial t} = -\nabla \cdot \mathbf{J} \qquad \nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$