Physics 3300A December ??, 2012

Final Examination

Name: ____

Time allowed: 3 hours
The use of simple calculators (with no stored information) is permitted. A **formula sheet** (using the same notations as during the classes) is attached; no other aids are permitted.

There are ***two sections***:
Section A consists of longer questions and is worth 64% of the total marks; you should answer **any four** (out of the five) questions in this section.
Section B consists of shorter questions and is worth 36% of the total marks; you should answer **all** of the questions in this section.

Use the space on this exam paper to provide your answers. The marking scheme (out of 100) is indicated.

SECTION A

Answer **any four** of these questions

A.1 *[16 marks]*

A.2 *[16 marks]*

A.3 *[16 marks]*

A.4 *[16 marks]*

A.5 *[16 marks]*

SECTION B

Answer **all** of these questions

B.1 *[9 marks]*

B.2 *[9 marks]*

B.3 *[9 marks]*

B.4 *[9 marks]*

Formula Sheet (for Final)

Sections 2 and 3

$\mathbf{F} = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{r_e^2}\hat{\boldsymbol{r}}_e$ $\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\int_{\text{volume}}\frac{\rho(\mathbf{r}')}{r_e^2}\hat{\boldsymbol{r}}_e d\tau'$ $\oint_{\text{surface}}\mathbf{E}\cdot d\boldsymbol{a} = \frac{1}{\varepsilon_0}Q_{\text{enc}}$

$\nabla\cdot\mathbf{E} = \frac{1}{\varepsilon_0}\rho$ $\mathbf{E} = -\nabla V$ $\nabla^2 V = -\frac{\rho}{\varepsilon_0}$ $V(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\int\frac{\rho(\mathbf{r}')}{r_e}d\tau'$ $C = \frac{Q}{V}$

$\mathbf{E}_{above} - \mathbf{E}_{below} = \frac{1}{\varepsilon_0}\sigma\hat{\mathbf{n}}$ $W = \frac{1}{2}\frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\sum_{j=1(i\neq j)}^{n}\frac{q_i q_j}{r_{eij}}$ $W = \frac{1}{2}\sum_{i=1}^{n}q_i V(\mathbf{r}_i)$ $\nabla\times\mathbf{E} = 0$ $\mathbf{p} = q\mathbf{d}$

$W = \frac{\varepsilon_0}{2}\int_{\text{allspace}}E^2\,d\tau$ $\mathbf{f} = \frac{1}{2\varepsilon_0}\sigma^2\hat{\mathbf{n}}$ $P = \frac{\varepsilon_0}{2}E^2$ $W = \frac{1}{2}CV^2$ $W = \frac{1}{2}\int\rho V\,d\tau$

$V(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\left[\frac{1}{r}\int\rho(\mathbf{r}')d\tau' + \frac{1}{r^2}\int r'\cos\theta'\,\rho(\mathbf{r}')d\tau' + \frac{1}{r^3}\int(r')^2\left(\frac{3}{2}\cos^2\theta' - \frac{1}{2}\right)\rho(\mathbf{r}')d\tau' + \cdots\right]$ $V_{\text{dip}}(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\frac{\mathbf{p}\cdot\hat{\mathbf{r}}}{r^2}$

Sections 4 and 5

$\mathbf{p} = \alpha\mathbf{E}$ $\mathbf{N} = \mathbf{p}\times\mathbf{E}$ $\mathbf{F} = \mathbf{p}\cdot\nabla\mathbf{E}$ $\sigma_b = \mathbf{P}\cdot\hat{\mathbf{n}}$ $\rho_b = -\nabla\cdot\mathbf{P}$ $\mathbf{D} = \varepsilon_0\mathbf{E} + \mathbf{P}$

$\nabla\cdot\mathbf{D} = \rho_f$ $\oint\mathbf{D}\cdot d\boldsymbol{a} = Q_{f-\text{enc}}$ $\mathbf{P} = \varepsilon_0\chi_e\mathbf{E}$ $\mathbf{D} = \varepsilon\mathbf{E}$ $\varepsilon = \varepsilon_r\varepsilon_0$ $\varepsilon_r = 1 + \chi_e$

$V(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\int_V\frac{\hat{\mathbf{r}}_c\cdot\mathbf{P}(\mathbf{r}')}{r_c^2}d\tau'$ $\mathbf{F} = Q[\mathbf{E} + (\mathbf{v}\times\mathbf{B})]$ $\mathbf{F}_{\text{mag}} = \int I(d\mathbf{l}\times\mathbf{B})$ $\nabla\cdot\mathbf{J} = -\frac{\partial\rho}{\partial t}$

$\nabla\cdot\mathbf{B} = 0$ $\nabla\times\mathbf{B} = \mu_0\mathbf{J}$ $\oint\mathbf{B}\cdot d\mathbf{l} = \mu_0 I_{\text{enc}}$ $\mathbf{B}(\mathbf{r}) = \frac{\mu_0}{4\pi}\int\frac{I\,d\mathbf{l}'\times\hat{\mathbf{r}}_c}{r_c^2}$ $\mathbf{B} = \nabla\times\mathbf{A}$

$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi}\int\frac{\mathbf{J}(\mathbf{r}')}{r_c}d\tau'$ $\nabla\cdot\mathbf{A} = 0$ $\nabla^2\mathbf{A} = -\mu_0\mathbf{J}$ $\mathbf{B}_{\text{above}} - \mathbf{B}_{\text{below}} = \mu_0(\mathbf{K}\times\hat{\mathbf{n}})$ $\mathbf{A}_{\text{dip}}(\mathbf{r}) = \frac{\mu_0}{4\pi}\frac{\mathbf{m}\times\hat{\mathbf{r}}}{r^2}$

$\mathbf{A}(\mathbf{r}) = \frac{\mu_0 I}{4\pi}\left[\frac{1}{r^2}\oint r'\cos\theta'\,d\mathbf{l}' + \frac{1}{r^3}\oint(r')^2\left(\frac{3}{2}\cos^2\theta' - \frac{1}{2}\right)d\mathbf{l}' + \cdots\right]$ $\mathbf{m} = I\int d\boldsymbol{a} = I\boldsymbol{a}$

Sections 6 and 7

$\mathbf{N} = \mathbf{m}\times\mathbf{B}$ $\mathbf{F} = \nabla(\mathbf{m}\cdot\mathbf{B})$ $\mathbf{J}_b = \nabla\times\mathbf{M}$ $\mathbf{K}_b = \mathbf{M}\times\hat{\mathbf{n}}$ $\mathbf{B} = \mu_0(\mathbf{H} + \mathbf{M})$ $\nabla\times\mathbf{H} = \mathbf{J}_f$

$\mathbf{M} = \chi_m\mathbf{H}$ $\mathbf{B} = \mu\mathbf{H}$ $\mu = \mu_0(1 + \chi_m)$ $\mathbf{J} = \sigma(\mathbf{E} + \mathbf{v}\times\mathbf{B})$ $R = \frac{L}{\sigma A}$ $\sigma = \frac{nfq^2\lambda}{2mv_{\text{thermal}}}$

$P = IV = I^2 R$ $\Phi = \int\mathbf{B}\cdot d\mathbf{a}$ $\mathcal{E} = -\frac{d\Phi}{dt}$ $\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}$ $\Phi_2 = M_{21}I_1$

$M_{21} = \frac{\mu_0}{4\pi}\oint\oint\frac{d\mathbf{l}_1\cdot d\mathbf{l}_2}{r_c}$ $\Phi = LI$ $W = \frac{1}{2}LI^2$ $W_{\text{mag}} = \frac{1}{2}\int(\mathbf{A}\cdot\mathbf{J})d\tau = \frac{1}{2\mu_0}\int B^2\,d\tau$

$\nabla\times\mathbf{B} = \mu_0\mathbf{J} + \mu_0\varepsilon_0\frac{\partial\mathbf{E}}{\partial t}$ $\mathbf{J}_{\text{d}} = \varepsilon_0\frac{\partial\mathbf{E}}{\partial t}$ $\mathbf{J}_p = \frac{\partial\mathbf{P}}{\partial t}$

Maxwell's equations: $\nabla\cdot\mathbf{D} = \rho_f$ $\nabla\cdot\mathbf{B} = 0$ $\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}$ $\nabla\times\mathbf{H} = \mathbf{J}_f + \frac{\partial\mathbf{D}}{\partial t}$