Physics 435 Final Information and Endgame

1) You must turn in HW 11(last lecture) by Wed, May 1 < 5pm to receive credit.
   a) I will post all homework solutions by Wednesday evening
   b) "Homework "office hours on Tuesday, April 30 from 6:30 – 8:00 pm (144)
2) Be sure your grades are correctly recorded prior to the last day of class.
3) Our final exam is on Wednesday May 8 from 8 AM to 11 AM in class
   a) The final exam will be comprehensive covering all topics in the course up to and including the Electrodynamics chapter.
   b) Special "final" office hours on Reading Day, May 2 from 6:30 – 8:00 pm
   c) I will work the (attached) final review problems on the (last) May 1 lecture.
   d) If you arrive on time exam on you will have 3 hours
      i) There will be five problems on the final
      ii) You will need to turn in both your answers and the exam questions
      iii) The final exam is open book and open notes like the midterm.

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1. Be familiar the physics of conductors and know how to evaluate the surface charge and pressure on a conductor. Know how to compute the net force on a piece of a conductor by integrating the surface pressure.
2. Be familiar with the separation of variable solutions of Laplace's Equation in spherical, and cylindrical coordinates. Understand how to apply boundary conditions to eliminate unknowns in separation of variable solutions.
3. Be very expert with the use of Ampere's and Gauss's Law to compute electric and magnetic fields from charges and currents. Understand the use and calculation of the electric potential and the magnetic scalar and vector potential.
4. Be familiar with computing stored electrical and magnetic energy in terms of potentials and in terms of electrical and magnetic fields.
5. Be familiar with the various forms of currents, such as $I, \vec{K}$, and $\vec{J}$ and how to convert between them.
7. Be familiar electricity and magnetism in materials. Understand electrical and magnetic susceptibility and polarization and magnetization. Be familiar with bound surface and volume charge densities and bound $\vec{K}$ and $\vec{J}$ currents. Understand the use of the auxiliary fields $\vec{D}$ and $\vec{H}$ in computing fields and stored energy U'.
8. Understand Faraday's Law and the Maxwell-Ampere law in integral and differential form and how to use these laws to calculate induced magnetic and electric fields.
9. Be familiar with magnetic vector and scalar potentials , the magnetic dipole moment and how to compute them.

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1) Consider a spherical electret of radius R with a polarization density of $\vec{P} = P_0\ \hat{z}$.

a) Find $V(r < R)$ and $V(r > R)$. $V(r > R) = \dfrac{P_0 R^3 \cos\theta}{3\varepsilon_0 r^2}$

b) Find $\vec{E}(r < R)$ and $\vec{E}(r > R)$ in spherical coordinates.

c) Find $\vec{D}(r < R)$ and $\vec{D}(r > R)$ in spherical coordinates.

d) Which components of $\vec{D}$ are continuous across r = R according to part c)? Which components of $\vec{E}$ are continuous across r = R according to part b)? What should be the correct boundary conditions?

2) A perfect conductor filling the region $z < 0$, carries a surface current of the form $\vec{K} = \beta y\, \hat{y}$ and $\vec{E} = \vec{B} = \vec{J} = 0$ within the conductor. A vacuum with no currents or charge exist in the region $z > 0$. Recall the surface boundary conditions $\vec{E}_{>} - \vec{E}_{<} = \frac{\sigma \hat{\eta}}{\varepsilon_0}$ and $\vec{B}_{>} - \vec{B}_{<} = \mu_0 \vec{K} \times \hat{\eta}$ where in this problem $\hat{\eta} = \hat{z}$.

a) Find $\vec{B}$ just above the surface.

b) Find the most general form of the surface charge σ using $\vec{\nabla} \cdot \vec{K} + \partial\sigma/\partial t = 0$

$\boxed{\sigma = -\beta t + \sigma_0}$

c) Find the most general form for $\vec{E}$ just above the surface.

d) Show that your $\vec{B}$ expression of part a) and $\vec{E}$ expression of part c) satisfy each of the four Maxwell's equations.

3) A long solenoid of radius R produces a time dependent magnetic field given by $\vec{B}(s < R) = \beta\ t\ \hat{z}$.

a) Find $\vec{A}(s < R)$ and $\vec{A}(s > R)$ using $\oint \vec{A} \bullet d\ell = \int \vec{B} \bullet d\vec{a}$. $\boxed{\vec{A}(s > R) = \frac{\beta\ t\ R^2}{2s}\hat{\phi}}$

b) Verify $\left[\partial_s \vec{A}_{>} - \partial_s \vec{A}_{<}\right]_{s=R} = -\mu_0 \vec{K}$

c) Show that $\vec{E} = -\partial_t \vec{A}$ using Faraday's Law. This is easy since you just need to show that $\vec{E}$ and $-\partial_t \vec{A}$ have the same curl.

d) Find $\vec{E}(s < R)$ and $\vec{E}(s > R)$ using $\vec{E} = -\partial_t \vec{A}$

e) Check that your part d) answers satisfy $\vec{\nabla} \times \vec{E} = -\partial_t \vec{B}$

f) Verify that your $\vec{A}(s > R)$ gives $\vec{B}\ (s > R) = 0$