Mock Semester Exam

Chapters 8 + 9

1. Conceptual type questions: multiple choice.

2. Consider a toroid with N windings and an inner diameter equal to a. The windings have a radius b that is much smaller than a. Assume an increasing current I(t) is put through the torroid:

   $I(t) = 2t \quad \text{for t} >= 0$
   $\text{I(t)} = 0 \quad \text{for t} < 0$

   Consider an off-axis point P within the windings of the torroid, close to the inner radius of the torroid.

   a. Find an expression for the magnetic field B(t) for point P.
   b. Find an expression for the electric field E(t) at point P.
   c. Find an expression for the Poynting vector at point P.
   d. Draw the direction of S in a sketch, make sure that the direction is unambiguous from your drawing. If necessary also describe in words.
   e. Is the total power flux going into the inductor or getting out of the inductor? Use two methods to determine the direction of the power: (1) consider the change in energy in the inductor, i.e. $0.5LI^2$; (2) Consider the direction of the Poynting vector at several points on the surface of the inductor.

3. A long coaxial cable, of length L, consists of an inner conductor (radius a) and an outer conductor (radius b). It is connected to a battery at one end and a resistor at the other (see figure below). The inner conductor carries a uniform charge per unit length of l, and a steady current I to the right; the outer conductor has the opposite charge and current.
   a. Derive and expression of the electric field in between the electrodes as a function of s (cylindrical coordinates).
   b. Derive an expression of the magnetic field in between the electrodes as a function of s (cylindrical coordinates).
   c. What is the electromagnetic momentum stored in the fields. Assume the cable has a length L.

4. Assume the following fields:
   $$\vec{E} = \vec{E}_o \cos\left(\vec{k} \bullet \vec{r} - \omega t + \delta_E\right)$$
   $$\vec{B} = \vec{B}_o \cos\left(\vec{k} \bullet \vec{r} - \omega t + \delta_B\right)$$
   a. Determine the time average of S by integrating over one period and dividing the result by T.

b. In the complex notation one can find the time average of a product of two functions f and g that have the same period and frequency using the following equation:

$$\langle fg \rangle = \frac{1}{2}\,\mathrm{Real}\left(\tilde{f}\ \tilde{g}^{*}\right)$$

Where g* is the complex conjugated of g. Calculate the time average of S for the waves using this technique for the waves provided above.

5. Using the exact amplitude coefficients of reflection and transmission (i.e. not assuming that $u_1=u_2=u_o$) determine expressions for the reflection and transmission coefficients (ratio of intensity!) at perpendicular incidence and proof that R+T=1.