PHYS 703 Final Exam

December, 2013

As always, you may use any valid approach, but please *explain* each step **carefully and fully**. There are **five** problems below.

1. [10 points] Consider a hollow conducting sphere of radius a in which a segment subtending an angle α (azimuth) has been insulated from the rest. The segment is maintained at potential V while the remainder is grounded.

   Find:

   (a) The potential $\Phi(0)$ at the center of the sphere.

   (b) The total charge on the sphere (segment and remainder).

   [Hint: If you encounter integrals, do the easy ones and give the difficult ones a name / label and continue.]

2. [10 points] A sphere of radius a carries a uniform surface-charge distribution σ. The sphere is rotating about a diameter with constant angular velocity ω. Find the vector potential and magnetic field both inside and outside the sphere.

3. [10 points] Consider reflection and refraction from a boundary for the case of the electric field parallel to the plane of incidence as shown in Fig. 1b (Jackson's Figure 7.6b) below. Obtain the boundary conditions described in terms of the electric field amplitudes and use them to deduce the ratios of the reflected and refracted electric field amplitudes to the incident electric field amplitude.

4. [10 points] Consider a rectangular waveguide with sides a and b parallel to the x and y axes, respectively. For $a > b$ the lowest mode that propagates is the TE_{10} mode.

   (a) If the amplitude of the non-zero z-component of the fields is ψ_0, work out explicitly all three components of both fields as functions of x, y, z and t; the angular frequency is known to be ω.

   (b) What is the wavenumber k?

   (c) Calculate the time-averaged power transmitted down the waveguide by this TE wave.

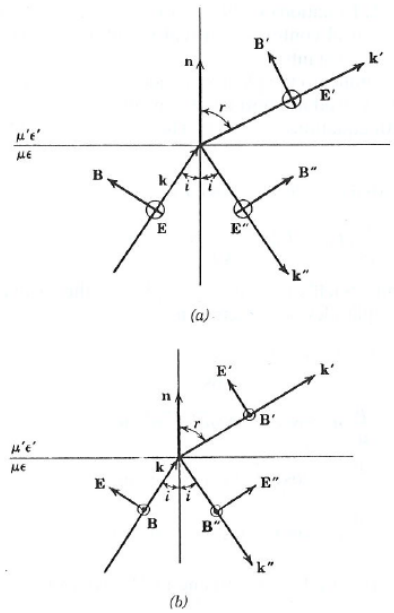

Figure 7.6 Reflection and refraction with polarization (*a*) perpendicular and (*b*) parallel to the plane of incidence.

Figure 1: Reflection and refraction with polarization (a) perpendicular and (b) parallel to the plane of incidence.

5. [10 points] In the Bohr model an electron revolves around the nucleus in a circular orbit. Consider the Bohr model of the hydrogen atom.

   (a) Assuming an orbital angular momentum of $\hbar$ for the electron, find the radius of the orbit (in meters, or Angstroms).

   (b) What is the acceleration of the electron and thus the power radiated at a given radius r if the orbital angular momentum remains fixed?

   (c) Find the time the electron should take, classically, to complete its death spiral from its orbit down to the nuclear radius (which you can take to be 1 fm) due to radiative power loss.