Please write your name on your exam.

Use Letter size paper only.

Do not staple your test.

PHYS 703 Final Exam

December, 2010

1. [10 points] The time-averaged potential of a hydrogen atom is given by $\Phi = \frac{q}{4\pi\epsilon_0}\frac{e^{-\alpha r}}{r}\left(1+\frac{\alpha r}{2}\right)$

where q is the magnitude of the electronic charge, and $\alpha^{-1} = a_0/2$, a_0 being the Bohr radius. Find the distribution of charge (both continuous and discrete) that will give this potential and interpret your result physically.

2. [10 points] A dielectric sphere of radius a and dielectric constant ϵ is immersed in an initially uniform electric field $\vec{E} = E_0\hat{k}$. Find the electric potential inside and outside the sphere. Specify the multipoles that arise in each region and explain any "normally forbidden" behavior in the r-dependence.

3. [10 points]

(a) An electron is precessing in the xy-plane around a uniform magnetic field $\vec{B} = B_0\hat{k}$. When the momentum vector rotates by an angle θ, by how much does the spin rotate? Assume that the spin and momentum are initially aligned. Use classical physics with the assumption that the g-factor of the electron is 2. [Hint: compare the differential equation for the rate of change of momentum with that for the rate of change of spin.]

(b) Consider the toroidal magnet in Fig. 1. The average radius of the torus (distance from center of the hole to toroidal matter) is R, the magnetic permeability is μ, there are n turns per unit length and a current I is flowing in the coils. What are the boundary conditions for magnetic fields at the sliced face of the material? What are the B-fields in the torus and in the thin gap of width w?

4. [10 points] Find the potentials and fields due to a current I in a long straight wire which is turned on at time $t = 0$.

5. [10 points]

(a) Write down the electric field for an electromagnetic plane wave of angular frequency ω, polarized in the direction $\hat{\epsilon}$ and propagating with wave-vector $\vec{k}$ in vacuum.

(b) Use the Maxwell equations to find the magnetic field in terms of the electric field.

(c) Obtain conditions between the quantities mentioned in part (a) using the Maxwell equations.

(d) Use the Maxwell equations to obtain the wave equation for the fields and show that this is satisfied by your fields of part (a).

(e) Write down an expression for the electric field of a right-circularly polarized wave.

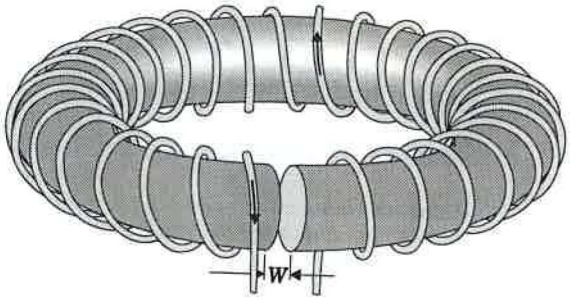

Figure 1: