PHY 103N: PHYSICS 2, (2007-2008, Semester -II)

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Assignment - 5 (2, 4, 6, 7, 10 will be discussed in the tutorials)

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1. Read section 4.4.3 *Energy in dielectric systems* from Griffiths' book. Discuss any doubts with your tutor.

2. Recall the video of the dancing balls between the plates of parallel plate capacitor shown in class (See http://www.youtube.com/watch?v=BiVoANaHWHI&feature=related). There are N dielectric balls of radii R and relative permittivity ε with a thin conducting surface (aluminum coating). A potential difference of V is applied between the plates of the capacitor where the balls are placed, the distance between the plates being d. Find the current in the system. Neglect the time involved in the collisions with the plates and effects of gravity in the problem.

3. Consider the motion of electrons in a region of space with perpendicularly oriented and spatially constant electric and magnetic fields ($E\hat{y}$ and $B\hat{z}$). If the electron were released at the origin with an initial velocity $v_0\hat{y}$, find the equation of motion for the electron.

4. (Problem 5.39 of Griffiths' Book) A current I flows along the $x-$ direction through a rectangular bar of a conductor with a magnetic field $B\hat{z}$. The dimensions of the bar are l along x, d along y and w along the z directions respectively. Find the potential that develops across the bar in the y direction. This is called the Hall Voltage and is critical to characterizing the number density and sign of the charge carriers in a semiconductor.

5. Find the magnetic field at the centre of a square loop of side a which carries a steady current I. Find the force on the square loop if an infinitely long current carrying thin wire is placed at a distance of $s > a$ from the centre of the wire.

6. (a) Using Ampère's law, compute the magnetic field everywhere for a very long solenoid (cylinder carrying an azimuthally oriented sheet current) with a surface current density of $\vec{K} = K\hat{\phi}$.
   (b) A thick slab extending between $z = \pm a$ carries a uniform volume current density $\vec{J} = j\hat{x}$. Find the magnetic field both inside and outside the slab.

7. Compute the magnetic vector potential everywhere for
   (a) A long, thick wire carrying a uniform current along it of radius R and a total current I.
   (b) A long Solenoid of radius R wound by a thin wire carrying a current I with n turns per unit length.

8. (Problem 6.1 of Griffths' book) Calculate the force and torque exerted on a square loop of side b that is placed a distance $r \gg a, b$ from a circular loop of radius a. Assume that both of them carry a current I.

9. (Problem 6.12 of Griffiths' book) An infinitely long cylinder of radius R carries a frozen-in magnetization parallel to the axis of $\vec{M} = Mr\hat{z}$ where r is the radial coordinate. Find the fields everywhere by using (a) the bound currents in the problem and (b) using Ampère's law for the H field.

10. Draw the field lines everywhere for $\vec{B}$, $\vec{H}$ and $\vec{M}$ for a uniformly magnetized sphere and a cylinder magnetized along its axis.