NNSE 508/NENG452

Home assignment # 1   **Due: February 05, 2014**

1. Electric field is 2 V/cm everywhere on surface of a 10 cm diameter sphere and is centered on origin of the sphere. What is the net charge (sign and value) inside the sphere?

2. Calculate electric field in dielectric with $\varepsilon = 3.9$ over a charged surface with surface electron density 10^{12} cm^{-2}. [Typical MOSFET]

3. (RF plasma generator) Consider a single electron in an electric field between two parallel plates located 10 cm apart. The whole system is in vacuum. Assume the potential varies sinusoidally between 100 V and -100 V at a frequency of 13.5 MHz. The electron oscillates between these two plates without collision with the plates.
(a) Calculate the maximum kinetic energy of the electron.
(b) What is the minimum distance between the plates if electric field amplitude is kept constant?

4. Consider the electric field is measured much further that the distance between the charges in the dipole. Starting from Coulomb law (field or potential from a point charge) find the field (as a function of $\vec{p}$ and $\vec{r}$) of dipole:
a) in the plane normal to the dipole's axis as shown in the figure. Indicate the direction of the field.
b) along the axis of the dipole.

c) [bonus 20 points if solved] Show that the general expression for the electric field of dipole is

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\left[\frac{3\left(p\cdot r\right)\vec{r}}{r^5} - \frac{\vec{p}}{r^3}\right]$$

5. (Hall Effect) A strip of Cu 150 μm thick is placed in a perpendicular magnetic field B=0.65 T and current I=100 mA is set up in the strip. What potential difference V will appear across the width of the strip? Assume an electron density of 8.5×10^{22} cm^{-3} for Cu.

6. (Cyclotron resonance) An electromagnetic (EM) wave of free space wavelength 0.5 mm propagates through a piece of InSb that is placed in an axial magnetic field. There is a resonant absorption of the EM wave at a magnetic field B=0.323 T.
(a) What is the effective mass of the particle responsible for EM absorption?
(b) Assume that the collision time is 4ps (true for electrons around LN2 temperatures). Calculate the mobility (For this part, you need to understand the ideas of scattering and drift).