

# Homework 6

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1. A point charge of charge  $q$  is located a distance  $d$  from a neutral atom with polarizability  $\alpha$ . The field from the point charge will induce a dipole moment in the atom, resulting in a force between the two objects. Find the magnitude of the force and indicate if it is attractive or repulsive.
2. A parallel plate capacitor has two metal plates and is filled with two different linear dielectrics. Each dielectric has thickness  $d/2$ . The lower dielectric (A) has a dielectric constant  $\epsilon_r = 3$  and the upper one (B) has dielectric constant  $\epsilon_r = 5$ . The upper plate has a charge density of  $+\sigma$  and the lower plate has a charge density of  $-\sigma$ 
  - (a) Find the electric displacement  $\vec{D}$  in the dielectrics
  - (b) Find the electric field  $\vec{E}$  in each dielectric
  - (c) Find the potential difference between the plates
  - (d) Find the location and value of all of the bound charge
3. Calculate the minimum possible volume for a 1[F] capacitor that can withstand 2.5[V] without breaking down. Assume that the geometry and plate separation can be optimized and that the thickness of the conducting plates is negligible.
  - (a) Assume the dielectric is air (dielectric strength = 3[MV/m], dielectric constant = 1)
  - (b) Assume the dielectric is strontium titanate (dielectric strength = 8[MV/m], dielectric constant = 233)Hint: Consider stored energy per unit volume
4. Two long coaxial cylindrical metal tubes (inner radius  $a$  and outer radius  $b$ ) stand vertically in a tank of dielectric oil (susceptibility  $\chi_e$ , mass density  $\rho_m$ ). The inner cylinder is maintained at a potential  $V$  and the outer one is grounded. To what height  $h$  does the oil rise, in the space between the tubes?
5. A point charge with charge  $q$  is fixed at the center of a sphere of radius  $R$  made of a linear dielectric material with susceptibility  $\chi_e$ . Find:

- (a) The electric field outside the sphere
- (b) The electric field in the sphere
- (c) The bound volume charge density  $\rho_b$
- (d) The bound surface charge density  $\sigma_b$  on the outer surface

Interesting question (not for credit): The dielectric sphere itself must be neutral, so where is the missing charge?