

**PHYSICS 7B – Fall 2010**  
**Midterm 2, R. Ramesh**  
**Monday, November 1, 2010**

**Problem 1 (25 points)**

A parallel plate capacitor has area  $A=20\text{cm}^2$  and plate separation of 4mm.

- a) If the breakdown field in air is  $3\cdot 10^6\text{V/m}$ , calculate the maximum voltage and charge the capacitor can hold.
- b) A Teflon sheet (dielectric constant  $\kappa=2.1$ ) is slid between the plates, filling the volume. Find the new capacitance and maximum charge if the breakdown field is 25 times larger than air.
- c) Before insertion of the Teflon plate, the plates are set to a voltage of 24V and then the battery is disconnected. What are the energies in the capacitor BEFORE and AFTER the Teflon is inserted?
- d) If in part c the Teflon sheet was instead only 2mm thick and placed halfway between the plates, find the electric field everywhere inside and the new capacitance.

**Problem 2 (20 points)**

The ionization field in air is  $3\times 10^6\text{ N/C}$ . For a cylindrical capacitor structure in with an outer radius of 10cm and inner radius 1mm, find the necessary potential difference such that the ionization field is attained at five times the inner radius. Find the capacitance of this arrangement (do NOT just write down the answer).

**Problem 3 (15 points)**

An extremely long insulating cylinder has a radius  $R_0$ . The charge density within the cylinder is given by  $\rho_E(R) = \rho_0(R/R_0)^2$ . Calculate the electric field everywhere within the cylinder and outside.

**Problem 4 (20 points)**

A small insulating sphere is hung from an ideal spring (spring constant  $k=126\text{N/m}$ ). The total mass of the sphere is 0.65kg and its center lies 15 cm above a tabletop in equilibrium. The sphere is then pulled down 5cm below this equilibrium, an electric charge  $Q= -3\mu\text{C}$  is deposited on it and then it is released. Using what you know from harmonic oscillations, write an expression for the electric field at a point on the table right below the sphere, as a function of time. You may assume that the field can be found using techniques from electrostatics and that no energy is dissipated.

**Problem 5 (20 points)**

- a) Calculate the energy density everywhere and total potential energy stored in a spherical conductor of radius  $R$  with net charge  $Q$ .
- b) Compare the potential energy to the work done to charge the sphere.
- c) What is the electric field and potential inside and outside the sphere?
- d) If  $R=32\text{cm}$  and the sphere is charged to a potential of 680V what is the surface charge density? Also, at what distance will the potential be 25V?