EEC 130A: Homework 7

Due: 3:30 pm, Feb. 28th, 2012

Updated: Feb. 29th, 2012

1. (4 points) (FAE P4.48) With reference to Fig. 1, find $\mathbf{E}_1$ if $\epsilon_1 = 2\epsilon_0$, $\epsilon_2 = 18\epsilon_0$, $\mathbf{E_2} = \hat{\mathbf{x}}3 - \hat{\mathbf{y}}2 + \hat{\mathbf{z}}2$ (V/m), and the boundary has a surface charge density $\rho_s = 3.54 \times 10^{-11}$ (C/m^2). What angle does $\mathbf{E_2}$ make with the z-axis. (Hint: Read through Example 4-10 in the textbook.)

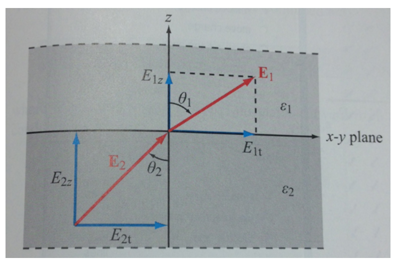

Figure 1: (FAE Fig. 4.19) Application of boundary conditions at the interface between two dielectric media (Example 4-10).

2. (4 points) (FAE P4.52) Determine the force of attraction in a parallel-plate capacitor with $A = 5$ cm^2, $d = 2$ cm, and $\epsilon_r = 4$ if the voltage across it is 50 V. (Hint: Read through Section 4-10 in the textbook.)

3. (4 points) (FAE P4.54) An electron with charge $Q_e = -1.6 \times 10^{-19}$ C and mass $m_e = 9.1 \times 10^{-31}$ kg is injected at a point adjacent to the negatively charged plate in the region between the plates of an air-filled parallel-plate capacitor with separation of 1 cm and rectangular plates each 10 cm^2 in area (Fig. 2). If the voltage across the capacitor is 10 V, find the following:

(a) The force acting on the electron.

(b) The acceleration of the electron.

(c) The time it takes the electron to reach the positively charged plate, assuming that it starts from rest.

4. (4 points) (FAE P4.56) Fig. 3-(a) depicts a capacitor consisting of two parallel, conducting plates separated by a distance d. The space between the plates contains two adjacent

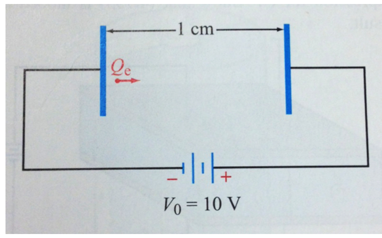

Figure 2: (FAE Fig. P4.54) Electron between charged plates of Problem 3.

dielectrics, one with permittivity ϵ_1 and surface area A_1 and another with ϵ_2 and A_2. The objective of this problem is to show that the capacitance C of the configuration shown in Fig. 3-(a) is equivalent to two capacitance in parallel, as illustrated in Fig. 3-(b), with

$$C = C_1 + C_2, \tag{1}$$

where

$$C_1 = \frac{\epsilon_1 A_1}{d},$$
$$C_2 = \frac{\epsilon_2 A_2}{d}.$$

To this end, proceed as follows:

(a) Find the electric field $\mathbf{E_1}$ and $\mathbf{E_2}$ in the two dielectric layers.

(b) Calculate the energy stored in each section and use the result to calculate C_1 and C_2.

(c) Use the total energy stored in the capacitor to obtain an expression for C. Show that (1) is indeed valid.

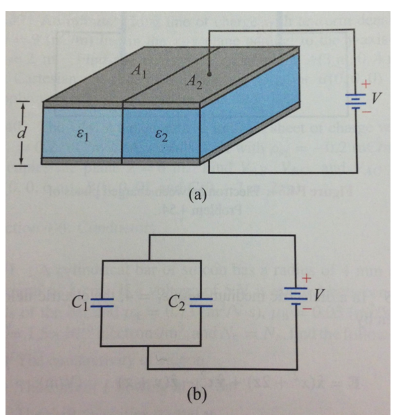

Figure 3: (FAE Fig. P4.56) (a) Capacitor with parallel dielectric section, and (b) equivalent circuit.

5. (4 points) (FAE P5.2) When a particle with charge q and mass m is introduced into a medium with a uniform field $\mathbf{B}$ such that the initial velocity of the particle $\mathbf{u}$ is perpendicular

to **B** (Fig. 4), the magnetic force exerted on the particle causes it to move in a circle of radius a. By equating $\mathbf{F_m}$ to the centripetal force on the particle, determine a in terms of q, m, u, and **B**.

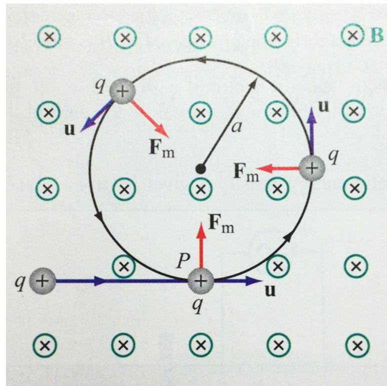

Figure 4: (FAE Fig. P5.2) Particle of charge q projected with velocity u into a medium with a uniform field **B** perpendicular to **u** (Problem 5).