

VE230 — Electromagnetics I

Homework 4

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Let x be the up direction.

$$D_1 = D_2,$$

$$\epsilon_0 E_1 = \epsilon_0 \epsilon_r E_2,$$

$$E_1 = 6E_2.$$

Let V_1 be the upper potential of the dielectric slab,

$$\begin{cases} V_0 = E_1 \cdot 0.2d + E_2 \cdot 0.8d \\ V_1 = E_2 \cdot 0.8d \end{cases} \Rightarrow V_1 = 0.4V_0.$$

Then

$$\begin{cases} V_0 = C_1 d + C_2 \\ V_1 = C_1 \cdot 0.8d + C_2 \\ V_1 = C_3 \cdot 0.8d + C_4 \\ 0 = C_3 \cdot 0 + C_4 \end{cases} \Rightarrow \begin{cases} C_1 = \frac{3V_0}{d} \\ C_2 = -2V_0 \\ C_3 = \frac{V_0}{2d} \\ C_4 = 0 \end{cases}.$$

a) In the dielectric slab, $0 \leq x \leq 0.8d$,

$$V = \frac{V_0}{2d}x, \quad \mathbf{E} = -\frac{V_0}{2d}\mathbf{a}_x.$$

b) In the air space between the dielectric slab and the upper plate, $0.8d \leq x \leq d$,

$$V = \frac{3V_0}{d}x - 2V_0, \quad \mathbf{E} = -\frac{3V_0}{d}\mathbf{a}_x.$$

c) On the upper plate,

$$\rho_s = \epsilon_0 |\mathbf{E}| = \frac{3V_0 \epsilon_0}{d}.$$

On the lower plate,

$$\rho_s = -\epsilon_0 \epsilon_r |\mathbf{E}| = -\frac{3V_0 \epsilon_0}{d}.$$

d) If there is no dielectric slab,

$$V = \frac{V_0}{d}x, \quad \mathbf{E} = -\frac{V_0}{d}\mathbf{a}_x.$$

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