EE3140 Quiz 4, Spring 2003

Show your work for full credit.

1. Given an interface with unit normal $\hat{z}$ and $\vec{D}_2 = \hat{x} + \hat{z}$ [Coul/m$^2$] for $z < 0$ and $\vec{D}_1 = 2\hat{x} + \hat{z}$ [Coul/m$^2$] for $z > 0$, circle the answer below that best describes this situation: (3 points)

(a) medium 1 and medium 2 are dielectrics with $\epsilon_1 > \epsilon_2$
(b) medium 1 and medium 2 are dielectrics with $\epsilon_1 < \epsilon_2$
(c) there is positive surface charge on the boundary between two dielectrics
(d) medium 2 is a perfect conductor
(e) impossible

\[ \vec{D}_n = \vec{D}_{n2} \Rightarrow \text{no surface charge} \]

\[ \vec{D}_n > \vec{D}_{n2} \Rightarrow \epsilon_1 E_{n1} > \epsilon_2 E_{n2} \]

\[ \therefore \epsilon_1 > \epsilon_2 \]

2. A perpendicularly-polarized uniform plane wave at 300MHz in air is incident at a 45° angle on a lossless dielectric, with relative permittivity of 2. Find:

(a) $k_z$ (3 points)

\[ k_z = k_0 \sin 45° = \frac{k_0}{\sqrt{2}} = \frac{2 \pi f}{\sqrt{2} c} = 4.44 \text{[m}^{-1}] \]

(b) $k_{te}$ (3 points)

\[ k_x = k_0 \cos 45° = k_{tx} \]

\[ k_{te} = \sqrt{k_x^2 - k_z^2} = k_0 \sqrt{2 - \frac{1}{2}} = \frac{\sqrt{3}}{2} k_0 = 7.70 \text{[m}^{-1}] \]

(c) the angle of the transmitted ray, relative to the interface normal, $\theta_t$ (1 point)

\[ \eta_1 \sin \theta_2 = \eta_2 \sin \theta_t \]

\[ \theta_t = \sin^{-1} \left( \frac{1}{\sqrt{2}} \sin 45° \right) = 30° \]