

St. Vincent College  
**PH 241: Optics**

**Exam 3**  
10/9/2009

1. A lightwave travels from point A to point B in vacuum. Suppose we then introduce into its path a flat glass plate ( $n = 1.50$ ) of thickness 1 mm. If the wavelength of the light in vacuum is 500 nm, what is the difference between the number of waves between A and B with and without the glass plate in place?

2. Show that the component of the electric field parallel to the boundary between two dielectrics is continuous across the interface. Be sure to *explain* all of the steps that you take to reach the conclusion.

3. A laser beam of diameter  $D$  in air strikes a piece of glass ( $n_g$ ) at an angle  $\theta_i$ . Determine the diameter of the beam in the glass.

4. A very narrow laser beam is incident on a horizontal mirror at an angle of  $58^\circ$ . The reflected beam strikes a wall at a spot 5 m away from the point of incidence where the beam hit the mirror.

a) How far horizontally is the wall from the point of incidence?

b) This type of setup can be used to “magnify” very small rotations, such as if the mirror is attached to a galvanometer in order to measure very small changes in voltage. If the mirror rotates  $0.5^\circ$  such that the point at which the reflected beam strikes the wall is now higher, by how much does the vertical position at which the reflected beam strikes the wall change?

### Possibly Useful Information

Permittivity of Free Space:  $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2$

Coulomb Constant:  $k_e = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$

Permeability of Free Space:  $\mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m}/\text{A}$

Speed of light in vacuum:  $c = 2.99792458 \times 10^8 \text{ m/s}$

1 inch = 2.54 cm, exactly.

$$\vec{A} \times (\vec{B} \times \vec{C}) = \vec{B}(\vec{A} \cdot \vec{C}) - \vec{C}(\vec{A} \cdot \vec{B})$$

$$(\vec{A} \times \vec{B}) \times \vec{C} = \vec{B}(\vec{A} \cdot \vec{C}) - \vec{A}(\vec{B} \cdot \vec{C})$$

$$(\vec{A} \times \vec{B}) \cdot (\vec{C} \times \vec{D}) = (\vec{A} \cdot \vec{C})(\vec{B} \cdot \vec{D}) - (\vec{A} \cdot \vec{D})(\vec{B} \cdot \vec{C})$$

$$(\vec{A} \times \vec{B}) \times (\vec{C} \times \vec{D}) = \vec{C}\{\vec{A} \cdot (\vec{B} \times \vec{D})\} - \vec{D}\{\vec{A} \cdot (\vec{B} \times \vec{C})\}$$