Phys102 Assignment Cover Sheet

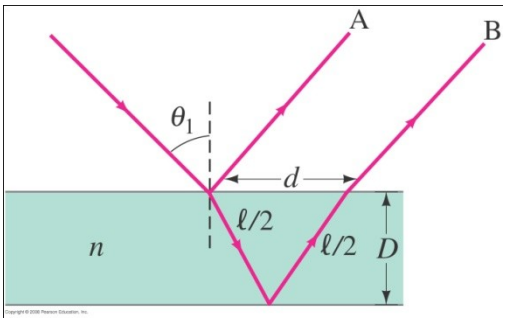
First Name:_____ Last Name:_____ Mark: _____

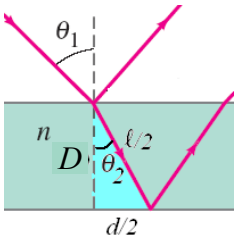
Student ID:_____ Date: _____ Section: _____

Phys102 Written Assignment #7

Textbook (Giancoli, SFU edition), page864, question #72.

72. A slab of thickness D, whose two faces are parallel, has index of refraction n. A ray of light incident from air onto one face of the slab at incident angle θ_1 splits into two rays A and B. Ray A reflects directly back into the air, while B travels a total distance l within the slab before reemerging from the slab's face a distance d from its point of entry. (*a*) Derive expressions for θ_1 and d in terms of D, n, and θ_1. (*b*) For normal incidence (i.e., θ_1=0°) show that your expressions yield the expected values for θ_1 and d.





[Solution] (*a*) We use Snell's law to calculate the refracted angle within the medium. Then using the right triangle formed by the ray within the medium, we can use the trigonometric identities to write equations for the horizontal displacement and path length.

$$\sin\theta_1 = n\sin\theta_2 \quad \rightarrow \quad \sin\theta_2 = \frac{\sin\theta_1}{n}$$

$$\cos\theta_2 = \frac{D}{l/2} \quad \rightarrow \quad l = \frac{2D}{\cos\theta_2} = \frac{2D}{\sqrt{1-\sin^2\theta_2}} = \boxed{\frac{2nD}{\sqrt{n^2-\sin^2\theta_1}}}$$

$$\sin\theta_2 = \frac{d/2}{l/2} \quad \rightarrow \quad d = l\sin\theta_2 = \frac{2nD}{\sqrt{n^2-\sin^2\theta_1}}\frac{\sin\theta_1}{n} = \boxed{\frac{2D\sin\theta_1}{\sqrt{n^2-\sin^2\theta_1}}}$$

(*b*) Evaluate the above expressions for $\theta_1 = 0°$.

$$l = \frac{2nD}{\sqrt{n^2-\sin^2\theta_1}} = \frac{2nD}{\sqrt{n^2}} = 2D \;\; ; \;\; \sin\theta_2 = \frac{d/2}{l/2} \quad \rightarrow \quad d = \frac{2D\sin\theta_1}{\sqrt{n^2-\sin^2\theta_1}} = 0$$

These are the expected values.