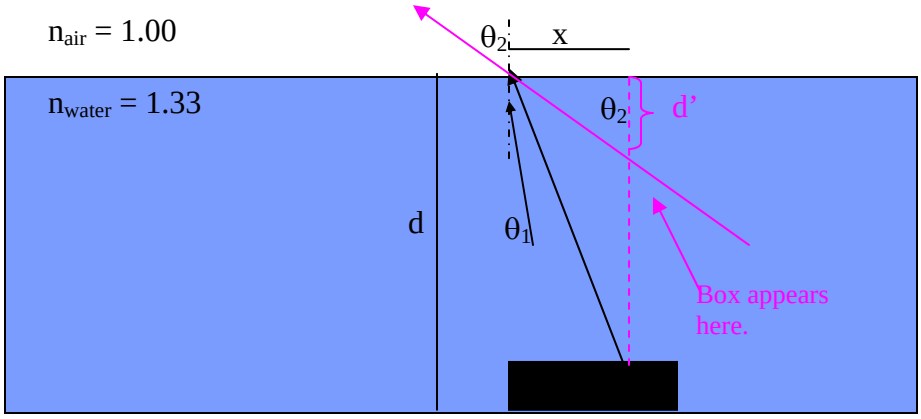
Physics 123
Quiz #1 Solution
September 20, 2006

Name_____

1. A light bulb is located 20cm to the left of a converging lens of focal length 5cm. The location of the image is

a. 2.3 cm b. 6.7 cm c. -7.5 cm d. -6.7 cm

2a. On the diagram below, draw a ray diagram for the location of the image of the box. The object is located a depth *d* below the surface and θ_1 is the angle of incidence of the ray with respect to the normal to the water-air surface.



2b. Derive an expression for the apparent depth, *d'*, of the box in terms of the actual depth, *d*, and the indices of refraction, n_{water} and n_{air}. (Hint: Use the fact that for small angles $\sin\theta \sim \tan\theta$, and use Snell's law.)

Snell's Law: $n_{water}\sin\theta_1 = n_{air}\sin\theta_2 \rightarrow 1.33\sin\theta_1 = \sin\theta_2$ Defining *x* as the distance from the normal to the surface to where the ray originates, we can express θ_1 in terms of *d* and *x* and θ_2 in terms of *x* and *d'* as follows: $\tan\theta_1 = \frac{x}{d}$ and $\tan\theta_2 = \frac{x}{d'}$. Since the angles involved are small, we can use the small angle approximation to get $\sin\theta_1 \approx \tan\theta_1 = \frac{x}{d} \rightarrow x = d\sin\theta_1$ and $\sin\theta_2 \approx \tan\theta_2 = \frac{x}{d'} \rightarrow x = d'\sin\theta_2$.

Therefore, $x = d\sin\theta_1 = d'\sin\theta_2 = d'\frac{n_{water}}{n_{air}}\sin\theta_1$. Thus the apparent depth is given as $d' = \frac{n_{air}}{n_{water}}d$

2c. If the box is located at a depth of 6m below the water's surface, at what depth does it appear to be located? $d' = \frac{n_{air}}{n_{water}}d = \frac{1.00}{1.33}6m = 4.5m$