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Selected Problem Set 9

1. Given $c_1 = 1.0$, $c_2 = 0.6$, the speed of light in media 1 and 2, a surface normal $\vec{n} = (1,1,1)$, and a ray with direction $\vec{d} = (0,0,1)$, find $\vec{t}$, the direction of refracted light.

   From the notes, we have

   $\vec{t} = \frac{c_2}{c_1}\vec{d} + \left[\frac{c_2}{c_1}\vec{n}\cdot\vec{d} - \sqrt{1 - \left(\frac{c_2}{c_1}\right)^2 (1 - (\vec{n}\cdot\vec{d})^2)}\right]\vec{n}$ *. Insert the correct values in the equation to obtain vector* $\vec{t}$ *.*

2. Give a real-life example of total internal reflection.

   When light moves from a slow light speed material to a faster light speed material, the critical angle for refraction may be attained. This is the angle that the light ray exiting the slower material makes with the material's normal vector. If this angle is pushed at its maximum (90 degrees), the ray then does not exit the slower material; it is instead totally reflected back. The illusory water puddles that can be seen on the road while driving during a hot sunny summer day are a good example of total internal reflection.

3. Using Snell's law, show that $\cos\theta_2 = \sqrt{1 - \left(\frac{c_2}{c_1}\right)^2 \sin^2\theta_1}$

$$\frac{\sin\theta_2}{c_2} = \frac{\sin\theta_1}{c_1}$$
$$\frac{\sin^2\theta_2}{c_2^2} = \frac{\sin^2\theta_1}{c_1^2}$$
$$-\sin^2\theta_2 = -\left(\frac{c_2}{c_1}\right)^2 \sin^2\theta_1$$
$$\cos^2\theta_2 - 1 = -\left(\frac{c_2}{c_1}\right)^2 \sin^2\theta_1$$
$$\cos^2\theta_2 = 1 - \left(\frac{c_2}{c_1}\right)^2 \sin^2\theta_1$$
$$\cos\theta_2 = \sqrt{1 - \left(\frac{c_2}{c_1}\right)^2 \sin^2\theta_1}$$

4. Given that the speed of light in air is 99.97% of c , and 75.19% of c in

water, find the critical angle for a ray of light coming from water and going into the air.

$$\sin^{-1}\left(\frac{c_1}{c_2}\right)=48.75$$ *degrees.*

5. What is the difference between an object with a reflection coefficient of 1 and a mirror?

   There is no difference between the two.