**PHYS 1200 Physics of Everyday Experience**

**Review questions and exercises for Lecture 29 (L&O-1)**

1. Astronomers express very long distances in light years (LY), which is the distance that light travels in one year. The nearest star system to our solar system is Alpha Centauri which is 4.37 LY from our Sun. How far in meters is Alpha Centauri to the Sun.
2. What is the index of refraction?
3. (a) What is the range of wavelengths of visible light? (b) Where do UV wavelengths lie relative to visible light? (c) Where do the IR wavelengths lie relative to visible light?
4. What is the phenomenon of refraction and how is it characterized by the index of refraction?
5. (a) How is a ray of light bent when it goes from air into glass? (b) How is a ray of light bent when it goes from water into air?
6. What is total internal reflection? What is a practical application of this phenomenon?
7. What should have been the distance between Galileo and his assistant Massimo so that he would have measured a time delay of 20 seconds between when he sent his light signal and received Massimo's light signal back? Is this feasible?
8. Calculate the speed of light in:

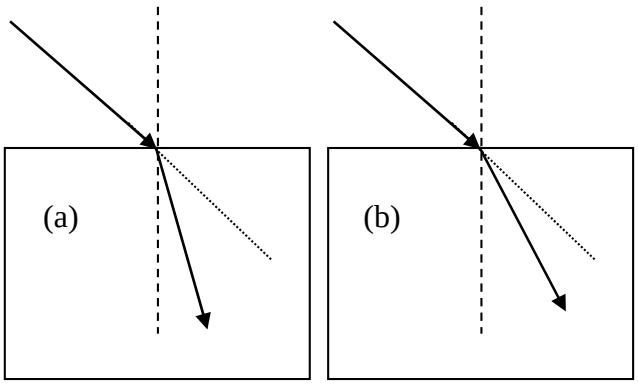
   (a) glass with index of refraction 1.5

   (b) beer with index of refraction 1.345

   (c) diamond with index of refraction 2.417
9. Calculate the frequencies for the following colors of visible light:

   (a) red, $\lambda$ = 660 nm (b) green, $\lambda$ = 550 nm (c) violet, $\lambda$ = 420 nm

   (1 nm = 1 nanometer = $10^{-9}$ m)
10. Light rays enter two slabs of glass at the same angle of incidence. One piece of glass has an index of refraction $n_1 = 1.4$, while the other has an index of refraction $n_2 = 1.6$. The diagrams below show the refracted (bent) rays for these slabs of glass. Which diagram corresponds to which piece of glass?



Answers and Solutions

1. In 1 LY, light travels a distance in meters = ct, where t is the number of seconds in one year:

$$1\ LY = ct = \left(3\times10^{8}\ m/s\right)\times\left(365\,days\times24\,hr/day\times60\,\text{min}/hr\times60\,s/\text{min}\right)$$
$$= \left(3\times10^{8}\ m/s\right)\times\left(3.15\times10^{7}\ s\right) = 9.46\times10^{15}\ m$$
$$\text{so } 4.7\ \text{LY} = 4.7\times9.46\times10^{15}\ m = 4.45\times10^{16}\ m$$

2. The index of refraction n is the ratio of the speed of light in vacuum to the speed of light in a medium: n = c/v.

3. (a) the wavelengths of visible light range from approximately 400 nm to 700 nm. (b) UV wavelengths smaller than 400 nm, and (c) IR wavelengths are longer than 700 nm.

4. Refraction is the bending of a light ray as it enters the boundary between two materials. The amount of bending depends on the indices of refraction of the two media.

5. (a) A ray propagating from air into glass is bent toward the normal. (b) A ray foing from water into air is bent away from the normal. The normal is the imaginary line that is perpendicular to the boundary surface.

6. Total internal reflection is an optical phenomenon that occurs when a light ray starting in a medium of index of refraction $n_1$ is reflected at the boundary of another medium with index of refraction $n_2 < n_1$. This only occurs if the angle of incidence is greater than some critical value that depends on the materials. Fiber optics communications is based on this phenomenon.

7. Suppose Galileo and Massimo are separated by a distance D. The total distance that the light beam travels is 2D. So 2D = c t = $3\text{x}10^8$ m/s x 20 s = $6\text{x}10^9$ m→ D = $3\text{x}10^9$ m. (This is larger than the diameter of the earth!).

8. (a) v = c/n = ( $3\text{x}10^8$ m/s) / 1.5 = $2\text{x}10^8$ m/s

   (b) v = c/n = ( $3\text{x}10^8$ m/s) / 1.345 = $2.23\text{x}10^8$ m/s

   (c) v = c/n = ( $3\text{x}10^8$ m/s) / 2.417 = $1.24\text{x}10^8$ m/s

9. (a) f = c/λ = ( $3\text{x}10^8$ m/s )/ $6.60\text{x}10^{-7}$ m = $4.55\text{x}10^{14}$ Hz

   (b) f = c/λ = ( $3\text{x}10^8$ m/s )/ $5.50\text{x}10^{-7}$ m = $5.45\text{x}10^{14}$ Hz

   (c) f = c/λ = ( $3\text{x}10^8$ m/s )/ $4.20\text{x}10^{-7}$ m = $7.14\text{x}10^{14}$ Hz

10. The light ray is bent more in material (a) than in material (b), so (a) is the material with the *higher* index of refraction.