29:006 Exercises on light and optics

1) The speed of light is roughly 1 foot per nanosecond. Show that this is true, using the facts that 1 mile = 5280 ft, and 1 second = $10^9$ nanoseconds.

2) The average orbital radius of our ninth planet, PLUTO around the sun is 3660 million miles. How long, in hours, does it take for the sun’s light to reach Pluto?

3) The speed of light is 186,000 miles/s and the speed of sound is roughly 1/5 mile/s. If lightning strikes 10 miles from your location, how long does it take for the light and sound (from the thunder) to reach you?

4) 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

5) 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)
29:006 Solutions to exercises on light

1) speed of light in vacuum = \( c = 186,000 \text{ mi/s} = 3 \times 10^8 \text{ m/s} \)

\[
c = 186,000 \text{ mi/s} \times \frac{5280 \text{ ft/mi}}{10^7 \text{ ns/mi}} = 0.98 \text{ ft/ns} \approx 1 \text{ ft/ns}
\]

2) \( t = \frac{d}{c} = \frac{3660 \times 10^6 \text{ mi}}{186,000 \text{ mi/s}} = 1.97 \times 10^3 \text{s} \times \frac{1 \text{ min}}{60 \text{s}} = 328 \text{ min} \times \frac{1 \text{ hr}}{60 \text{ min}} \approx 5.5 \text{ hr} \)

3) 

\[ t_{\text{sound}} = \frac{d}{v_{\text{sound}}} = \frac{10 \text{ mi}}{0.2 \text{ mi/s}} = 50 \text{s} \]

\[ t_{\text{light}} = \frac{d}{c} = \frac{10 \text{ mi}}{186,000 \text{ mi/s}} = 5.4 \times 10^{-5} \text{s} = 54 \text{ microseconds} \]

4) \( v_{\text{medium}} = \frac{c}{n} \)

a) \( v_{\text{glass}} = \frac{3 \times 10^8 \text{ m/s}}{1.5} = 2.0 \times 10^8 \text{ m/s} \)

b) \( v_{\text{beer}} = \frac{3 \times 10^8 \text{ m/s}}{1.345} = 2.23 \times 10^8 \text{ m/s} \)

c) \( v_{\text{diamond}} = \frac{3 \times 10^8 \text{ m/s}}{2.417} = 1.24 \times 10^8 \text{ m/s} \)

5) \( c = \lambda f \rightarrow f = \frac{c}{\lambda} \)

a) \( f = \frac{3 \times 10^8 \text{ m/s}}{660 \times 10^{-9} \text{ m}} = 4.55 \times 10^{14} \text{ Hz} \)

b) \( f = \frac{3 \times 10^8 \text{ m/s}}{550 \times 10^{-9} \text{ m}} = 5.45 \times 10^{14} \text{ Hz} \)

c) \( f = \frac{3 \times 10^8 \text{ m/s}}{420 \times 10^{-9} \text{ m}} = 7.14 \times 10^{14} \text{ Hz} \)