SHEDDING LIGHT ON ELECTROMAGNETIC WAVES! ANSWER KEY

***Instructions**: Show your work completely in your journal when answering the following questions.*

1. Using the chart from the notes:
   a. Which has longer wavelengths: radio waves or visible light waves?
      Radio waves
   b. Which has higher frequencies: ultraviolet waves or gamma rays?
      Gamma rays
   c. Which has more energy: infrared or ultraviolet?
      Ultraviolet

2. Red light has a wavelength of approximately 700 nm. (n = nano = 10^{-9})
   a. Convert this to meters.

$$\boxed{\mathbf{700\ nm = 700 \times 10^{-9} m = 7.00 \times 10^{-7} m}}$$

   b. Calculate the frequency of red light based on its wavelength.

$$v = f\lambda \leadsto f = \frac{v}{\lambda} = \frac{3.00 \times 10^{8}\ ^{m}/_{s}}{7.00 \times 10^{-7} m}$$

$$\boxed{f = 4.29 \times 10^{14} \mathrm{Hz}}$$

   c. If blue light has a wavelength of 400 nm, how does its frequency compare to red light? Which one has more energy?

$$v = f\lambda \leadsto f = \frac{v}{\lambda} = \frac{3.00 \times 10^{8}\ ^{m}/_{s}}{4.00 \times 10^{-7} m}$$

$$\boxed{f = 7.50 \times 10^{14} \mathrm{Hz}}$$

The frequency of blue light is higher than red light; it also has more energy!

3. A block of unknown material is submerged in water. Light in the water is incident on the block at an angle of 31°. The angle of refraction in the block is 27°. What is the index of refraction of the unknown material, and what is the material?

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \leadsto n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2} = \frac{1.3 \sin 31°}{\sin 27°}$$

$$\boxed{n_2 = 1.5}$$

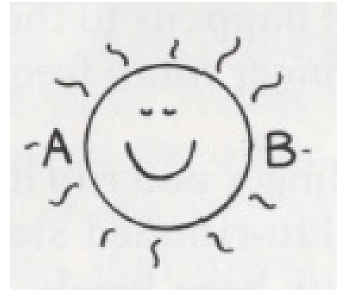
This is the index of refraction for corn oil

4. Using mirrors left on the moon by the Apollo astronauts, the distance from the earth to the moon can be measured if a pulse of light is sent to the moon and the time it takes for its round trip is measured. If a pulse of light takes 2.562 seconds for a round trip, calculate the distance the moon is from the earth.

$$d = v \cdot t = (3.00 \times 10^{8}\ ^{m}/_{s})\left(\frac{2.562\ s}{2}\right)$$

$$\boxed{d = 3.843 \times 10^{8}\ m = 3.843 \times 10^{5}\ km = 238{,}793\ mi}$$

5. Light coming from point A at the edge of the Sun is found by astronomers to have a slightly higher frequency than light from point B. What does this tell us about the Sun's motion?
   Well, we know that the Sun is creating light with higher energy on one side versus the other. So, this must be the Doppler Effect! Higher frequency that the source means that the source is moving towards an observer; so that means that point A is moving towards us relatively.



6. The numbers on your radio correspond to the frequency of the radio waves emitted by the stations.
   a. 106.9 FM (Warm Favorites) sends out a wave with a frequency of 106.9 MHz, or 106,900,000 Hz (a lot!). What is the wavelength of that wave?

$$v = f\lambda \leadsto \lambda = \frac{v}{f} = \frac{3.00 \times 10^8\ ^{m}/_{s}}{106.9 \times 10^6 \text{Hz}}$$

$$\boxed{\lambda = 2.806 \text{ m}}$$

   b. Now calculate the wavelength for the KJR Sports radio station that broadcasts at 710 kHz.

$$v = f\lambda \leadsto \lambda = \frac{v}{f} = \frac{3.00 \times 10^8\ ^{m}/_{s}}{710 \times 10^3 \text{Hz}}$$

$$\boxed{\lambda = 423 \text{ m}}$$

   c. If the energy of an EM wave is determined by its frequency, which has more energy, AM radio or FM radio?
   The FM radio waves have higher frequency and therefore more energy.

   d. A long wave radio station is broadcasting at a frequency of 165 KHz. What is the period of this wave? How long is it (what is its wavelength)? Why do you think it is called long wave radio?

$$T = \frac{1}{f} = \frac{1}{165 \times 10^3 \text{Hz}}$$

$$T = 6.06 \times 10^{-6} \text{ s}$$

$$v = f\lambda \leadsto \lambda = \frac{v}{f} = \frac{3.00 \times 10^8\ ^{m}/_{s}}{165 \times 10^3 \text{Hz}}$$

$$\boxed{\lambda = 1818 \text{ m}}$$

It's called a long wave radio because the wavelength is almost 2 kilometers! That's more than a mile long!