Experiment #13 Speed of Sound Pre-lab Questions

- **A common way to measure the distance to lightning is to start counting, one count per second, as soon as you see the flash. Stop counting when you hear the thunder and divide by five to get the distance in miles. Use this information to estimate the speed of sound in m/s.**

$$velocity = \frac{distance}{time}$$

$$distance = \frac{time}{5\,\frac{\sec}{mile}}$$

$$velocity = \frac{\left(\frac{time}{5\ \sec/mi}\right)}{time} = \frac{1}{5}\,\frac{miles}{\sec}$$

use the conversion of 1 mile = 1609 m to find the answer.

From the problem we are given that the speed of sound is:

$$v_{Sound} = 0.2\,\frac{mi}{\sec}$$

By using the conversion factor, this is a relatively trivial problem:

$$v_{Sound} = 0.2\,\frac{mi}{\sec}\left(\frac{1609\ m}{1\ mi}\right) = 321.8\,\frac{m}{s}$$

$$\boxed{v_{Sound} = 321.8\,\frac{m}{s}}$$

- **Compare this to the accepted value of 340.29 m/s at sea level.**

We can perform a percent difference to compare the approximate speed of sound, used to tell how far away lightning is, to the accepted value at sea level.

$$\%\ difference = \frac{|v_{Theory}| - |v_{Measured}|}{|v_{Theory}|} x100\%$$

$$\%\ difference = \frac{\left|340.29\ \frac{m}{s}\right| - \left|321.8\ \frac{m}{s}\right|}{\left|340.29\ \frac{m}{s}\right|} x100\%$$

$$\boxed{\%\ difference = 5.434\%}$$

So, we can see that the estimate is a little "off"; but that's ok, because of its simplicity. If we were to say take the time and divide it by 4.6 seconds … that'd be a lot harder to do in a moments notice. ☺ Given the "necessity" for accuracy, this is still a fairly good approximation for determining the speed of sound. (With regards to the next question below, have you ever notices that the temperature drops during a thunder storm? Do you think this would have an impact on the value of the speed of sound?)

- **The speed of sound in air depends on the temperature of the air:**

$$v_{Sound} = 331.4\ \frac{m}{s} + 0.6 \frac{m}{s\ ^oC}(Temp)$$

  - **Compute the speed of sound at 0°C.**
  - **Compute the speed of sound at 1°C. How many meters per second does the speed of sound increase for every degree Celsius?**

At zero degrees centigrade, the speed of sound is:

$$v_{Sound} = 331.4\ \frac{m}{s} + 0.6 \frac{m}{s\ ^oC}(0^o\ C)$$

$$\boxed{v_{Sound} = 331.4\ \frac{m}{s}}$$

At one degrees centigrade, the speed of sound is:

$$v_{Sound} = 331.4\ \frac{m}{s} + 0.6 \frac{m}{s\ ^oC}(1^o\ C)$$

$$\boxed{v_{Sound} = 332.0\ \frac{m}{s}}$$

For every increase of the temperature by 1 degree centigrade, the speed of sound increases by 0.6 m/s. (Notice this is the slope of the line for the equation given above.)