

## 10. Waves: Frequency and Energy

Much like making a spring oscillate up and down, or making waves in a rope by shaking one end, the frequency of any wave is directly proportional to the energy in the wave. For example, think about making a wave in a rope that is lying on the floor. As you move one end of the rope back and forth you begin to make traveling waves through the rope. As you shake the rope more quickly, the frequency of the waves increases while the wavelength decreases. If you keep doing this – you’re going to get tired. This is because you are putting more energy into moving the rope and increasing the waves’ frequency.

Go to the following applet:

<http://quantum.bu.edu/CDF/101/06-Spectroscopy-3.cdf>

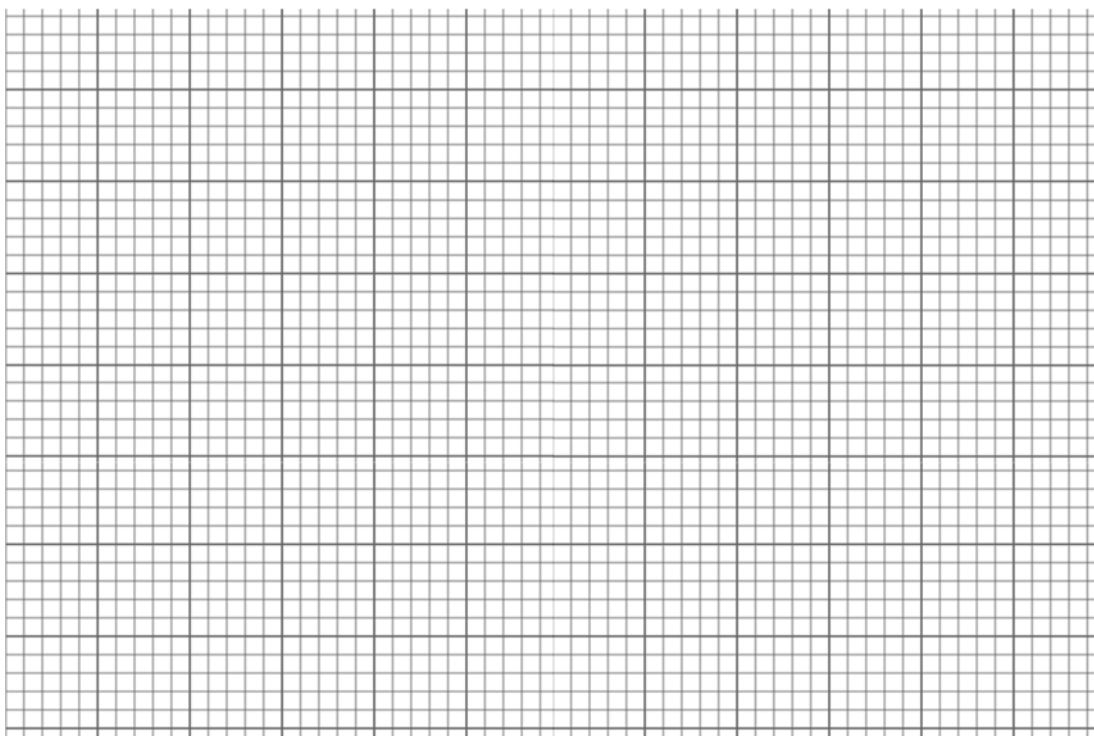
On the top of the graph, you will see a slider that allows you to change the frequency of the wave (remember, the units for frequency are Hz, or  $s^{-1}$ ). You will notice that as the frequency changes, the wavelength changes as well. This is because the speed of the waves has been set to the speed of light ( $c = 3.00 \times 10^8$  m/s). As you change the frequency, the corresponding energy for that wave will show up at the top of the graph in eV.

Note: eV stands for “electron volt” which is a measure of energy. The name comes from its definition: the measure of energy that an electron gains when from a 1-volt electric potential difference.  $1 \text{ J} = 6.24 \times 10^{18} \text{ eV}$

1) Using the applet, find 10 values of frequency and their respective energies and fill in the table below.

$\nu$ [Hz]	$E$ [eV]

2) Using the graph area, make a graph of energy as a function of frequency. Make sure to label your axes using units and the appropriate magnitudes.



3) From the graph, what is the relationship between energy and frequency?

4) Calculate the slope of this graph. Make sure to give the proper units.

The value you just calculated is Planck's constant ( $h$ ) and is how the energy of light relates to its frequency. As you know, the different frequencies of light determine the type of light. As a result, different types of light have different energies.

5) What is  $h$  in units that contain joules (J) instead of electron volts?