2.8: Wrapping It Up 2 - The Properties of Light

2.8.1: Part I. Wave Generator

We will once again employ our wave generator to create wave signals whose properties you can adjust.

Recall, the x-axis shows the wave's wavelength in meters and the y-axis shows the wave's amplitude. The amplitude of a wave essentially describes its intensity, or strength. Wavelength is the distance between two adjacent peaks of a wave. Frequency describes how many wave patterns or cycles pass by a certain point in 1 second.

You can make changes to the basic properties of the wave that is being generated in the following ways:

- Stop the wave generator to measure the wave at any time. Hover your cursor over the graph and you will see an x-y coordinate display of cursor position on the graph. Notice that the origin of the graph is on the far left, in the middle of the y-axis.
- Below the "stop" button, there are the wavelength and amplitude sliders. Use these sliders to increase or decrease the wave's properties in real time.
- There is also a stopwatch that counts time in seconds. You can start and stop the stopwatch, and also reset it to zero when you need to make a new measurement.

Use the *Wave Generator* to conduct the following measurements, and answer the following questions.

Play Activity

2.8.1.1: A. Measuring the wavelength of a wave.

1. Adjust the wavelength slider until you think the wavelength equals 100 m.

2. Stop the wave generator, and measure the distance between two peaks (or two troughs). Continue to adjust the slider until you are as close as possible to a wavelength of 100 m. After you make your final measurement, click on the "reveal wavelength" button. How close were you to 100 m?

3. Express the accuracy of your measurements as a percent. For example if your wave was 95 m instead of 100 m, your accuracy would be (100 – 95)/100 = 5%.

2.8.1.2: B. Measuring frequency and speed

To determine the frequency, you will need to count the waves as they pass by the orange vertical bar.

- Start the stopwatch when the peak (or trough) of a wave passes the arrow.
- Let it run until at least 3 waves have passed by the arrow.
- Stop the stopwatch, and read out the results for time passed.
- You may want to repeat this activity a few times to make sure you are reading the graph and the stopwatch accurately.

1. Show your work here:

2. What is the frequency that you find for a wave with a wavelength of 100 m?

Hz

3. Using the relationship between speed, frequency, and wavelength and your measured values of wavelength and frequency, what is the speed of the wave?

m/s

4. Predict: How do you think the frequency of a wave with wavelength of 50 m will compare to the frequency of a wave with wavelength 100 m?

5. Predict: How do you think the speed of a wave with wavelength of 50 m will compare to the speed of a wave with wavelength 100 m?

6. Test your predictions using the wave generator. Discuss your results.

2.8.1.3: C. Measuring wavelength and amplitude

1. Predict: How do you think adjusting the amplitude will affect the wavelength? For example, if you increase the amplitude, will the wavelength increase, decrease, or remain the same?

2. Check your predictions using the wave generator: with the wavelength as close to 100 m as you're able to get it, increase the amplitude. After letting the wave generator run long enough, measure the wavelength again. Is there any change?

3. Adjust the amplitude again, this time making it smaller. What happens to the wavelength?

The wavelength increases.

The wavelength decreases.

The wavelength remains the same.

4. How does decreasing the amplitude affect the frequency of a wave?

The frequency increases.

The frequency decreases.

The frequency remains the same.

5. How does decreasing the amplitude affect the speed of a wave?

The speed increases.

The speed decreases.

The speed remains the same.

6. Summarize: how does changing the amplitude (strength) of a wave affect its speed, frequency, and wavelength, if at all?

2.8.2: PART II. LIGHT WAVES

The wave generator cannot accurately portray the frequencies or speed of a light wave because light travels at a much higher speed than we can easily show in an interactive activity: $c = 3 \times 10^8$ m/s. In this next section, you will apply what you have learned about waves in general to specific examples using light waves.

2.8.2.1: A. Wavelength and frequency

1. Calculate: Using the equation $\lambda = c / f$, what will the frequency be for a wave with a wavelength of 100 m? (A light wave with this wavelength is known as a radio wave.)

Hz

2. Calculate: Using the equation $\lambda = c / f$, what will the frequency be if the wavelength is 150 m?

Hz

3. If you doubled the wavelength from 150 m to 300 m, by what factor would the frequency change? Will it be greater or smaller than the frequency you calculated in question 2?

4. In a vacuum, can a light wave have a frequency of 10^{14} Hz and a wavelength of 3 m? Why or why not? Explain.

2.8.2.1.1: B. Measuring light waves and color

1. Red visible light has a wavelength of 7×10^{-7} m. What is its frequency?

Hz

2. If a light wave had a frequency twice that of red visible light, what would be its wavelength in meters? (Light with a frequency this high is known as ultraviolet light.)

m

3. A radio wave is 10 m long; what is its frequency?

Hz

4. A gamma-ray has a frequency equal to 6×10^{20} Hz. What is its wavelength?

m

2.8.2.2: C. Energy, wavelength, frequency, and speed of light

Use the relations $\lambda = c / f$ and $E = hf$ to answer the following conceptual questions. We will compare a photon of red light ($\lambda = 7 \times 10^{-7}$ m) and a photon of ultraviolet light ($\lambda = 1 \times 10^{-8}$ m).

1. How does the wavelength of ultraviolet light compare to that of red light?

The wavelength of ultraviolet light is greater than the wavelength of red light.

The wavelength of ultraviolet light is less than the wavelength of red light.

The wavelength of ultraviolet light is the same as the wavelength of red light.

2. How does the frequency of ultraviolet light compare to that of red light?

The frequency of ultraviolet light is greater than the frequency of red light.

The frequency of ultraviolet light is less than the frequency of red light.

The frequency of ultraviolet light is the same as the frequency of red light.

3. How does the speed of ultraviolet light compare to that of red light?

The speed of ultraviolet light is greater than the speed of red light.

The speed of ultraviolet light is less than the speed of red light.

The speed of ultraviolet light is the same as the speed of red light.

4. How does the energy of ultraviolet light compare to that of red light?

The energy of ultraviolet light is greater than the energy of red light.

The energy of ultraviolet light is less than the energy of red light.

The energy of ultraviolet light is the same as the energy of red light.

5. If I increase the energy of light, how does that affect its speed?

The speed increases.

The speed decreases.

The speed remains the same.
