During the summer, almost everyone enjoys going to the beach. They can swim, have picnics, and work on their tans. But if you get too much sun, you can burn. A particular set of solar wavelengths are especially harmful to the skin. This portion of the solar spectrum is known as UV B, with wavelengths of $280 \text{–} 320 \text{ nm}$. Sunscreens are effective in protecting skin against both the immediate skin damage and the long-term possibility of skin cancer.

### Waves

Waves are characterized by their repetitive motion. Imagine a toy boat riding the waves in a wave pool. As the water wave passes under the boat, it moves up and down in a regular and repeated fashion. While the wave travels horizontally, the boat only travels vertically up and down. The figure below shows two examples of waves.

Figure \(\PageIndex{1}\): (A) A wave consists of alternation crests and troughs. The wavelength $$\lambda$$ is defined as the distance between any two consecutive identical points on the waveform. The amplitude is the height of the wave. (B) A wave with a short wavelength (top) has a high frequency because more waves pass a given point in a certain amount of time. A wave with a longer wavelength (bottom) has a lower frequency.

A wave cycle consists of one complete wave - starting at the zero point, going up to a wave crest, going back down to a wave trough, and back to the zero point again. The wavelength of a wave is the distance between any two corresponding points on adjacent waves. It is easiest to visualize the wavelength of a wave as the distance from one wave crest to the next. In an equation, wavelength is represented by the Greek letter lambda $$\lambda$$.

Depending on the type of wave, wavelength can be measured in meters, centimeters, or nanometers ($$1 \text{ m} = 10^9 \text{ nm}$$). The frequency, represented by the Greek letter nu $$\nu$$, is the number of waves that pass a certain point in a specified amount of time. Typically, frequency is measured in units of cycles per second or waves per second. One wave per second is also called a Hertz $$\text{Hz}$$ and in SI units is a reciprocal second $$\text{s}^{-1}$$.

Figure B above shows an important relationship between the wavelength and frequency of a wave. The top wave clearly has a shorter wavelength than the second wave. However, if you picture yourself at a stationary point watching these waves pass by, more waves of the first kind would pass by in a given amount of time. Thus the frequency of the first wave is greater than that of the second wave. Wavelength and frequency are therefore inversely related. As the wavelength of a wave increases, its frequency decreases. The equation that relates the two is:

$$c = \lambda \nu$$

The variable $$c$$ is the speed of light. For the relationship to hold mathematically, if the speed of light is used in $$\text{m/s}$$, the wavelength must be in meters and the frequency in Hertz.
Example (PageIndex{1})

The color orange within the visible light spectrum has a wavelength of about (620 \text{ nm}). What is the frequency of orange light?

Solution

Step 1: List the known quantities and plan the problem.

Known

- Wavelength \( \lambda = 620 \text{ nm} \)
- Speed of light \( c = 3.00 \times 10^8 \text{ m/s} \)
- Conversion factor \( 1 \text{ m} = 10^9 \text{ nm} \)

Unknown

- Frequency

Convert the wavelength to \( \text{m} \), then apply the equation \( c = \lambda \nu \) and solve for frequency. Dividing both sides of the equation by \( \lambda \) yields:

\[
\nu = \frac{c}{\lambda}
\]

Step 2: Calculate

\[
620 \text{ nm} \times \left( \frac{1 \text{ m}}{10^9 \text{ nm}} \right) = 6.20 \times 10^{-7} \text{ m}
\]

\[
\nu = \frac{c}{\lambda} = \frac{3.0 \times 10^8 \text{ m/s}}{6.20 \times 10^{-7}} = 4.8 \times 10^{14} \text{ Hz}
\]

Step 3: Think about your result.

The value for the frequency falls within the range for visible light.

Summary

- All waves can be defined in terms of their frequency and intensity.
- \( c = \lambda \nu \) expresses the relationship between wavelength and frequency.

Contributors and Attributions

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