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 $280 \text{ nm} - 320 \text{ nm}$. 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 alternating 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 $\nu$ and in SI units is a reciprocal second $\nu$.

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 5.2.1

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

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

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

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

- CK-12 Foundation by Sharon Bewick, Richard Parsons, Therese Forsythe, Shonna Robinson, and Jean Dupon.