A surfer needs to understand the properties of waves.

Frequency and Period

What determines the frequency of a wave?
Any periodic motion has a **frequency**, which is the number of complete cycles in a given time.

A wave's frequency equals the frequency of the vibrating source producing the wave.

Frequency and Period

Any motion that repeats at regular time intervals is called **periodic motion.**

- The time required for one cycle is called the **period.**
- Frequency is the number of complete cycles in a given time.
- Frequency is measured in cycles per second, or **hertz** (Hz).

Frequency and Period

- A wave vibrating at one cycle per second has a frequency of 1.0 Hz.

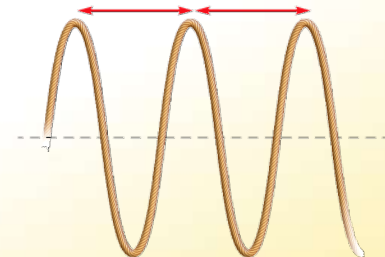- A wave vibrating at two cycles per second has a frequency of 2.0 Hz.

Frequency = 1.0 hertz

A One cycle per second
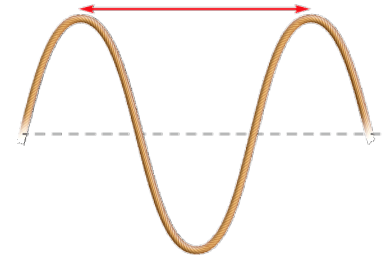
Frequency = 2.0 hertz

B Two cycles per second

Wavelength

How are frequency and wavelength related? **Wavelength** is the distance between a point on one wave and the same point on the next cycle of the wave.

**Increasing the frequency of a wave decreases its wavelength.**

Wavelength

For a transverse wave, wavelength is measured between adjacent crests or between adjacent troughs.

For a longitudinal wave, wavelength is the distance between adjacent compressions or rarefactions.

Wavelength

Wavelength can be measured from any point on a wave to the same point on the next cycle of the wave.

Long wavelength

Short wavelength

Rest position
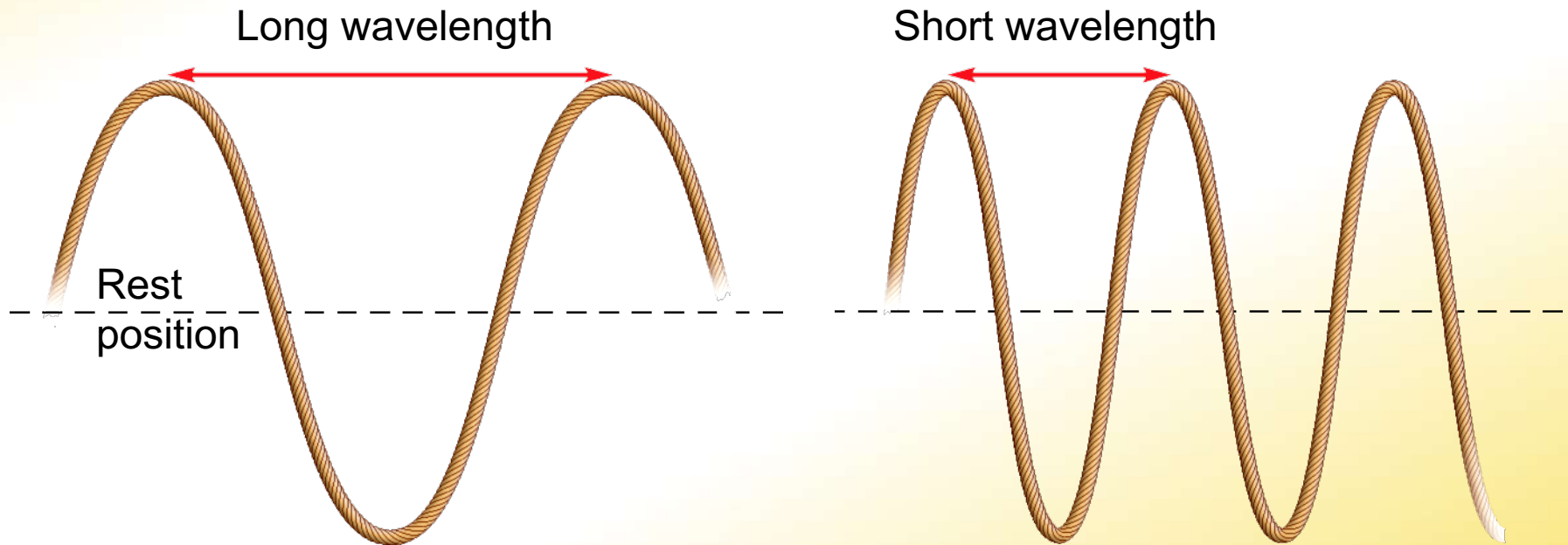
Wave Speed

How are frequency, wavelength, and speed related?

If you assume that waves are traveling at a constant speed, then wavelength is inversely proportional to frequency.

Wave Speed

When the wavelength is in meters, and the frequency is in hertz, the units for speed are meters per second.

The speed of a wave is also calculated by dividing its wavelength by its period.

Speed of Waves

$$\text{Speed} = \text{Wavelength} \times \text{Frequency}$$

Wave Speed

Math Skills

Speed of Mechanical Waves

One end of a rope is vibrated to produce a wave with a wavelength of 0.25 meter. The frequency of the wave is 3.0 hertz. What is the speed of the wave?

Wave Speed

Math Skills

① **Read and Understand**

What information are you given?

Wave Speed

Math Skills

① Read and Understand

What information are you given?

Wavelength = 0.25 m

Frequency = 3.0 Hz

Wave Speed

Math Skills

② **Plan and Solve**

What unknown are you trying to calculate?

What formula contains the given quantities and the unknown?

Wave Speed

Math Skills

2 Plan and Solve

What unknown are you trying to calculate?

$$\text{Speed} = ?$$

What formula contains the given quantities and the unknown?

$$\text{Speed} = \text{Wavelength} \times \text{Frequency}$$

Wave Speed

Math Skills

2 **Plan and Solve**

Replace each variable with its known value.

Wave Speed

Math > Skills

② **Plan and Solve**

Replace each variable with its known value.

(Hint: *1Hz* = $\frac{1}{s}$)

$$\text{Speed} = 0.25 \text{ m} \times 3.0 \text{ Hz}$$

$$= 0.25 \text{ m} \times 3.0 \, \frac{1}{s}$$

$$\text{Speed} = 0.75 \text{ m/s}$$

Wave Speed

Math Skills

3 **Look Back and Check**

Is your answer reasonable?

Wave Speed

Math Skills

3 Look Back and Check

Is your answer reasonable?

Because the frequency is 3.0 hertz, the wave should travel a distance of 3 wavelengths in 1 second. This distance is 0.75 meters, which agrees with the calculated speed of 0.75 m/s.

Wave Speed

Math Practice

1. A wave on a rope has a wavelength of 2.0 m and a frequency of 2.0 Hz. What is the speed of the wave?

Answer:

Wave Speed

Math Practice

1. A wave on a rope has a wavelength of 2.0 m and a frequency of 2.0 Hz. What is the speed of the wave?

Answer:

The speed is 2.0 m × 2.0 Hz = 4.0 m/s

Wave Speed

Math Practice

2. A motorboat is tied to a dock with its motor running. The spinning propeller makes a surface wave in the water with a frequency of 4 Hz and a wavelength of 0.1 m. What is the speed of the wave?

Answer:

Wave Speed

Math Practice

2. A motorboat is tied to a dock with its motor running. The spinning propeller makes a surface wave in the water with a frequency of 4 Hz and a wavelength of 0.1 m. What is the speed of the wave?

Answer:

The speed is 0.1 m × 4 Hz = 0.4 m/s

Wave Speed

Math Practice

3. What is the speed of a wave in a spring if it has a wavelength of 10 cm and a period of 0.2 s?

(*Hint:* Use the equation

$$Speed = \frac{Wavelength}{Period}.)$$

Answer:

Wave Speed

Math Practice

3. What is the speed of a wave in a spring if it has a wavelength of 10 cm and a period of 0.2 s?

(*Hint:* Use the equation

$$\text{Speed} = \frac{\text{Wavelength}}{\text{Period}} .)$$

Answer:

The speed is 10 cm/0.2 s = 50 cm/s

Wave Speed

Math Practice

4. What is the wavelength of an earthquake wave if it has a speed of 5 km/s and a frequency of 10 Hz?

Answer:

Wave Speed

Math Practice

4. What is the wavelength of an earthquake wave if it has a speed of 5 km/s and a frequency of 10 Hz?

Answer:

The wavelength is (5 km/s)/10 Hz = 0.5 km.

Wave Speed

The speed of a wave can change if it enters a new medium, or if variables such as pressure and temperature change.

For many kinds of waves, the speed of the waves is roughly constant for a range of different frequencies.

The wave with the lower frequency has a longer wavelength.

Amplitude

How is the amplitude of a wave related to the wave's energy?
The **amplitude** of a wave is the maximum displacement of the medium from its rest position.

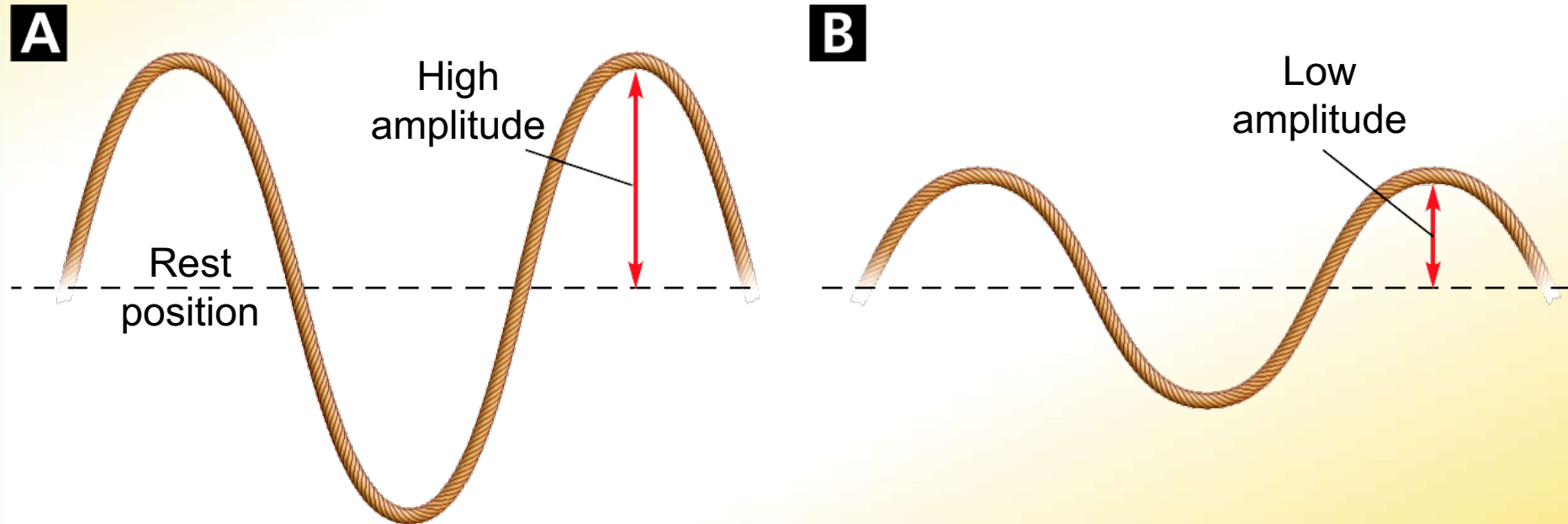**The more energy a wave has, the greater is its amplitude.**

Amplitude

The amplitude of a transverse wave is the distance from the rest position to a crest or a trough.

It takes more energy to produce a wave with higher crests and deeper troughs.

Amplitude

The more energy a wave has, the greater is its amplitude.

Amplitude

The amplitude of a longitudinal wave is the maximum displacement of a point from its rest position.

The more energy the wave has, the more the medium will be compressed or displaced.

Assessment Questions

- While wading in shallow waters, six waves crash into your legs in a 24-second span. What is the frequency of the waves?

  - 4 Hz
  - 18 Hz
  - 0.25 Hz
  - 2 Hz

Assessment Questions

- While wading in shallow waters, six waves crash into your legs in a 24-second span. What is the frequency of the waves?

  - 4 Hz

  - 18 Hz

  - 0.25 Hz

  - 2 Hz

    ANS:C

Assessment Questions

- What is the speed of an earthquake wave if it has a wavelength of 2.3 km and a frequency of 3 Hz?
  - 6.9 km
  - 5.3 km
  - 6.0 km
  - 1.3 km

Assessment Questions

- What is the speed of an earthquake wave if it has a wavelength of 2.3 km and a frequency of 3 Hz?

  - 6.9 km
  - 5.3 km
  - 6.0 km
  - 1.3 km

  ANS:B

Assessment Questions

- Which wave property increases as the energy of a wave increases?

  - period
  - frequency
  - wavelength
  - amplitude

Assessment Questions

- Which wave property increases as the energy of a wave increases?
  - period
  - frequency
  - wavelength
  - amplitude

  ANS:D