Speed of a Wave
Lesson Notes

Learning Outcomes

- What is wave speed and how is it calculated?
- What variables affect the speed at which waves move?

What is Wave Speed?

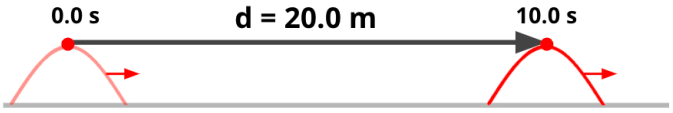
Speed describes how fast (or slow) and object moves.

Mathematically, speed is the distance traveled per time of travel.

"divided by"

$$\text{speed} = \frac{\text{distance traveled}}{\text{time of travel}} \qquad v = \frac{d}{t}$$

Wave speed is the distance a crest of a wave travels per given amount of time. Consider a wave that travels 20.0 m in 10.0 seconds.

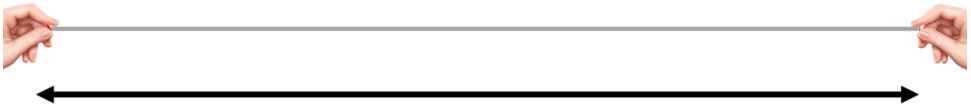


$$v = \frac{20.0\ \text{m}}{10.0\ \text{s}} = \mathbf{2.00\ m/s}$$

A faster wave would cover a greater distance in the same amount of time.

Accounting for Echoes and Wave Reflection

A wave is known to reflect when it confronts an obstacle or the end of its medium.



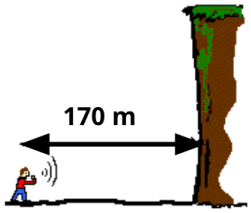
8.0 m between ends
16.0 seconds to move down AND back

$$v = \frac{16.0\ \text{m}}{16.0\ \text{s}}$$

$$v = \mathbf{1.00\ m/s}$$

Practice:

Noah stands 170 meters away from a steep canyon wall. He shouts "Hey" and hears the echo of his voice 1.0 second later. What is the speed of the wave?



$$v = \frac{340\ \text{m}}{1.0\ \text{s}}$$

$$v = \mathbf{340\ m/s}$$

An Experiment with Wave Speed

A wave is shook into a wire using varying frequencies for two different tension values. Wavelength and speeds are measured/calculated. What does the data tell us?

Trial	Tension (N)	Frequency (Hz)	Wavelength (m)	Speed (m/s)
1	2.0	4.05	4.00	16.2
2	2.0	8.03	2.00	16.1
3	2.0	16.2	1.00	16.2
4	5.0	12.8	2.00	25.6
5	5.0	19.3	1.33	25.7
6	5.0	25.5	1.00	25.5

Only 2 speeds

What happened between trials 3 and 4 that caused the v to change?

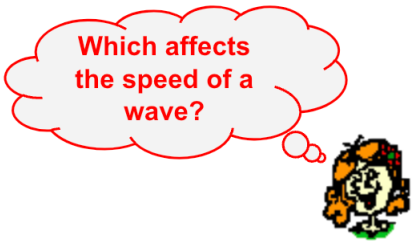
A Δ in tension Δes the speed.

As f ↑, λ ↓ ... but v didn't Δ.

Factors Affecting Wave Speed

Properties of the Wave vs. **Properties of the Medium**

Frequency
Wavelength
Amplitude



Tension, Density, Temperature, Humidity, Depth

- The speed at which mechanical waves travel through a medium is NOT affected by the properties of the medium.
- The speed of a mechanical wave depends upon the properties of the medium through which it is moving.

Wave Speed and Medium Properties

Example 1: Speed of Sound Waves in Air

The speed of sound waves (**v**) in air depends on the **Celsius temperature of air** (**T**). A simplified formula is:

$$v = 331 \text{ m/s} + 0.60 * T$$

Example 2: Speed of Waves in a Guitar String

The speed of waves (**v**) in a string or wire depends on the **tension of the string** (**T**) and the **linear density of the string** (μ). The formula is:

$$v = \sqrt{(T / \mu)}$$