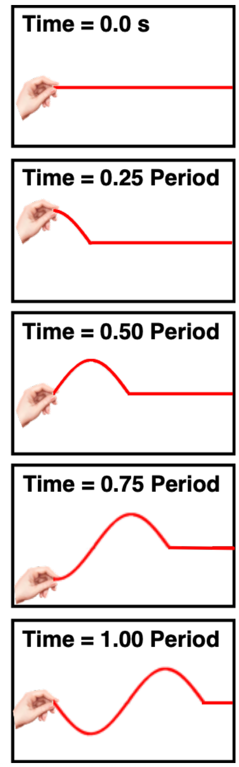
Wavelength, Frequency, and Speed
Lesson Notes

Learning Outcomes

- In what way are wavelength, frequency and speed mathematically related?
- How can the relationship be used?

The BIG Equation

In the **time** of 1 period (time to complete one full back-and-forth cycle), the wave travels a **distance** of 1 wavelength from the source.



$$\text{speed} = \frac{d}{t} \rightarrow \text{speed} = \frac{\lambda}{T}$$

Period and frequency are reciprocals: **T = 1/f**. So by substitution:

$$\text{speed} = \frac{\lambda}{1/f} \rightarrow \text{speed} = f \bullet \lambda$$

In summary:

$$\text{speed} = \text{frequency} \bullet \text{wavelength} \rightarrow v = f \bullet \lambda$$

The Wave Equation … Three Ways

The wave quation can be used to solve for …

Speed (v) → $v = f \bullet \lambda$

Ocean waves are observed to reach the shore 15 times every minute. Their wavelength is 12 meter. What is the speed?

$v = (15/60\ \text{Hz}) \bullet (12\ \text{m})$

$v = 3.0\ \text{m/s}$

Frequency (f) → $f = v / \lambda$

Waves in a vibrating guitar string have a wavelength of 1.05 m. They travel at 420 m/s. What frequency is produced?

$f = (420\ \text{m/s}) / (1.05\ \text{m})$

$f = 400\ \text{Hz}$

Wavelength (λ) → $\lambda = v / f$

Sound waves travel at 345 m/s. What is the wavelength of waves produced by the vibrations of a 256-Hz tuning fork?

$\lambda = (345\ \text{m/s}) / (256\ \text{Hz})$

$\lambda = 1.35\ \text{m}$

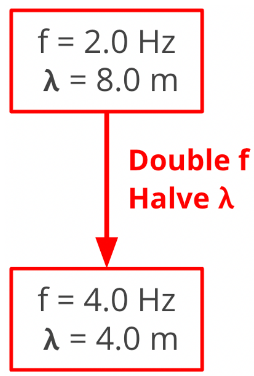
What Affects Wave Speed?

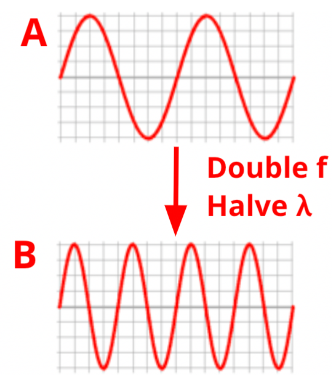
- Wave speed depends upon the properties of the medium.
- Changing frequency only changes the wavelength; it doesn't change the speed.
- Frequency and wavelength are inversely proportional.

Medium	Frequency	Wavelength	Speed
Zn, 1-in. dia. coils	2.2 Hz	1.6 m	3.5
Zn, 1-in. dia. coils	4.4 Hz	0.80 m	3.5
Cu, 1-in. dia. coils	2.1 Hz	1.20 m	2.5
Cu, 1-in. dia. coils	4.2 Hz	0.60 m	2.5
Zn, 3-in. dia. coils	2.2 Hz	1.82 m	4.0
Zn, 3-in. dia. coils	4.2 Hz	0.95 m	4.0

Frequency Effects

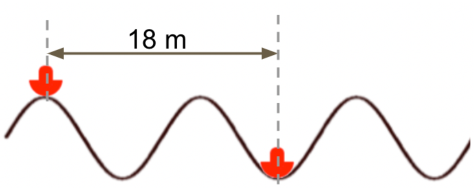
- For different waves in the same medium:
  "The factor by which the frequency is changed is the inverse of the factor by which the speed is changed."
- For the same medium (same speed), doubling the frequency will halve the wavelength.
- Speed (**v**) is the constant; frequency (**f**) and wavelength (**λ**) are inversely related.





Example Problem – Rocking the Boat

Two boats - A and B - are anchored a horizontal distance of 18 meters apart. Incoming water waves force the boats to oscillate up and down, making one complete cycle every 10.0 seconds. When Boat A is at its peak, Boat B is at its low point and there is one crest between them. Determine the wavelength, frequency and speed.



"one complete cycle every 10.0 seconds"

f = 1 cycle/10.0 s ➡ **f = 0.100 Hz**

18 m = 1.5•λ ➡ **λ = 12 m**

v = f•λ = (0.100 Hz)•(12 m)

v = 1.2 m/s