New Jersey Center for Teaching and Learning

Progressive Science Initiative

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Waves

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Wave Motion

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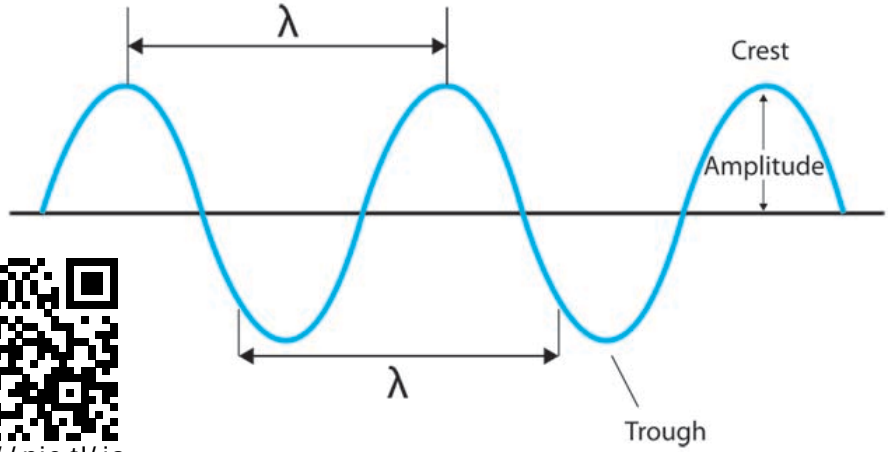
Wave Motion

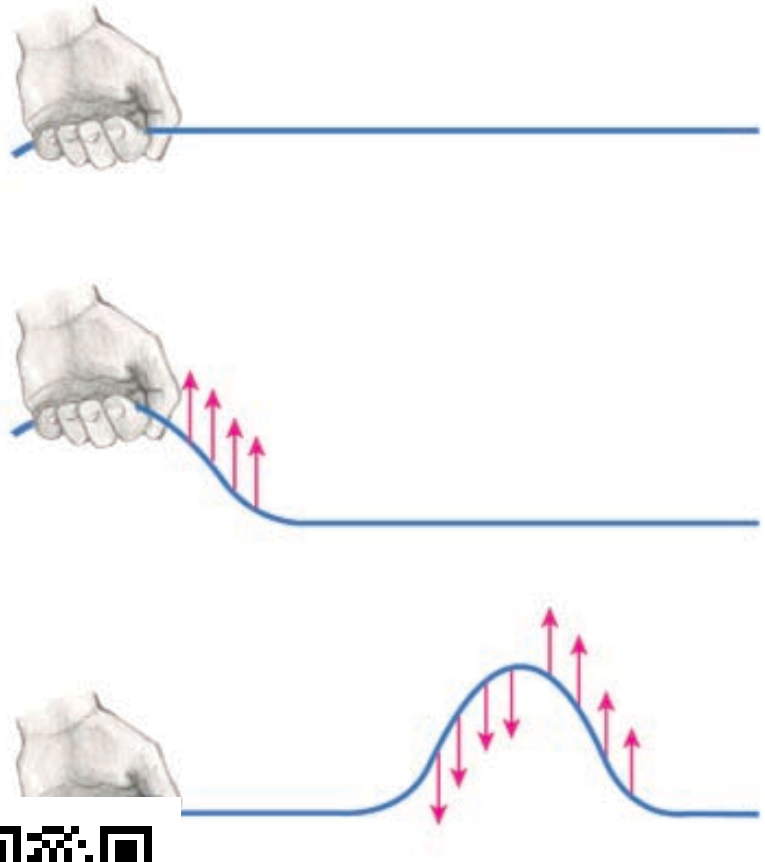


A wave travels along its medium, but the individual particles just move up and down.

http://njc.tl/ia

Wave Motion

All types of traveling waves transport energy.



Study of a single wave pulse shows that it is begun with a vibration and transmitted through internal forces in the medium.

Continuous waves start with vibrations too. If the vibration is SHM, then the wave will be sinusoidal.

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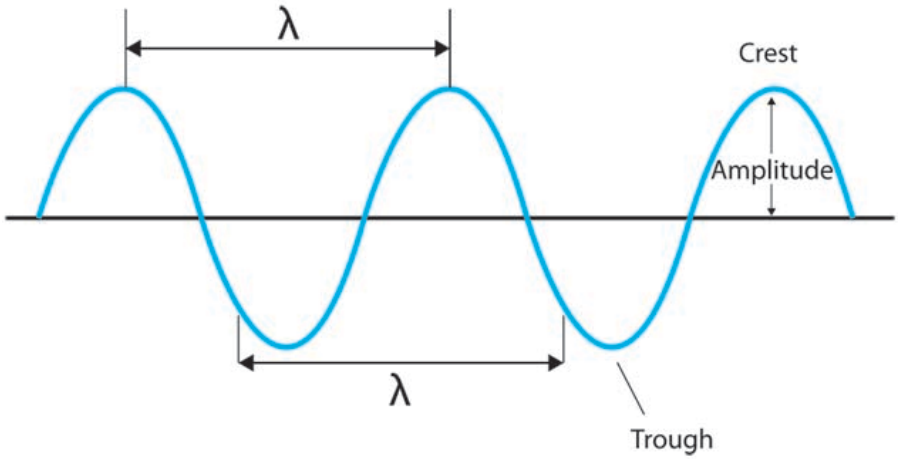
Wave Motion

Wave characteristics:

- Amplitude, A
- Wavelength, λ
- Frequency f and period T
- Wave velocity



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Wave Motion

Wave velocity is the velocity at which wave crests (or any other part of the wave) moves.

A wave crest travels a distance of one wavelength, λ, in one period, T.

$$v = \frac{\Delta x}{\Delta t} = \frac{\lambda}{T}$$

$$f = \frac{1}{T}$$

Wave velocity is: $v = \lambda f$

http://njc.tl/ia

1 What is the wave speed if the period of a wave is4 seconds and the wavelength is 1.8 m?

Answer

http://njc.tl/ib

2 A fisherman noticed that a float makes 30 oscillations in 15 seconds. The distance betweento consecutive crests is 2 m. What is the wave speed?

Answer

http://njc.tl/ic

3 What is the wavelength of a wave traveling with aspeed of 6 m/s and a period of 3s?

Answer

http://njc.tl/id

Wave Motion

The velocity of a wave depends on the medium through which it is traveling.

The velocity of a wave on a stretch string is related to the tension force in the string and the mass per unit length of the string.

$$v = \sqrt{\frac{F_t}{\mu}}$$

Where F_T is the tension in the string and μ is the mass per unit length (m/L).

http://njc.tl/ie

4 What happens to the speed of a wave on a string if the tension of the string is increased by a factor of nine?

- ◯ A It is decreased by a factor of 3.
- ◯ B It is decreased by a factor of 9.
- ◯ C It is increased by a factor of 3.
- ◯ D It is increased by a factor of 9.

Answer

http://njc.tl/if

5 What happens to the speed of a wave on a string if the mass per unit length of the string is increased by a factor of nine?

- ◯ A It is decreased by a factor of 3.
- ◯ B It is decreased by a factor of 9.
- ◯ C It is increased by a factor of 3.
- ◯ D It is increased by a factor of 9.

Answer

http://njc.tl/ig

Types of Waves

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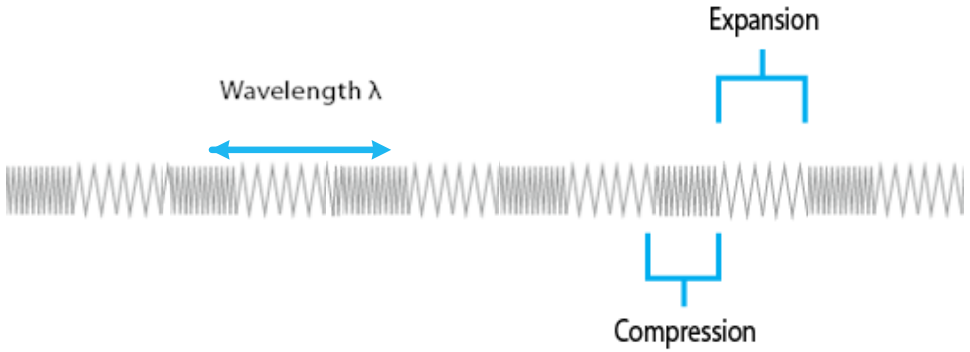
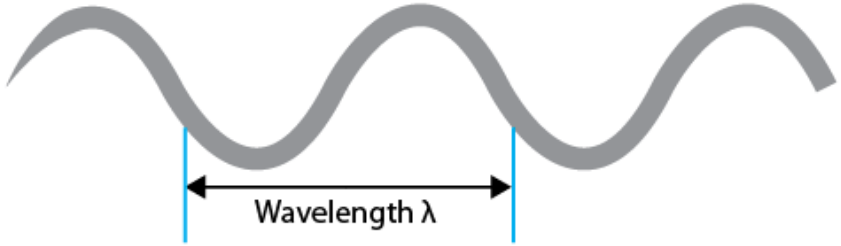
Types of Waves: Transverse and Longitudinal





The motion of particles in a wave can either be perpendicular to the wave direction (transverse) or parallel to it itudinal).

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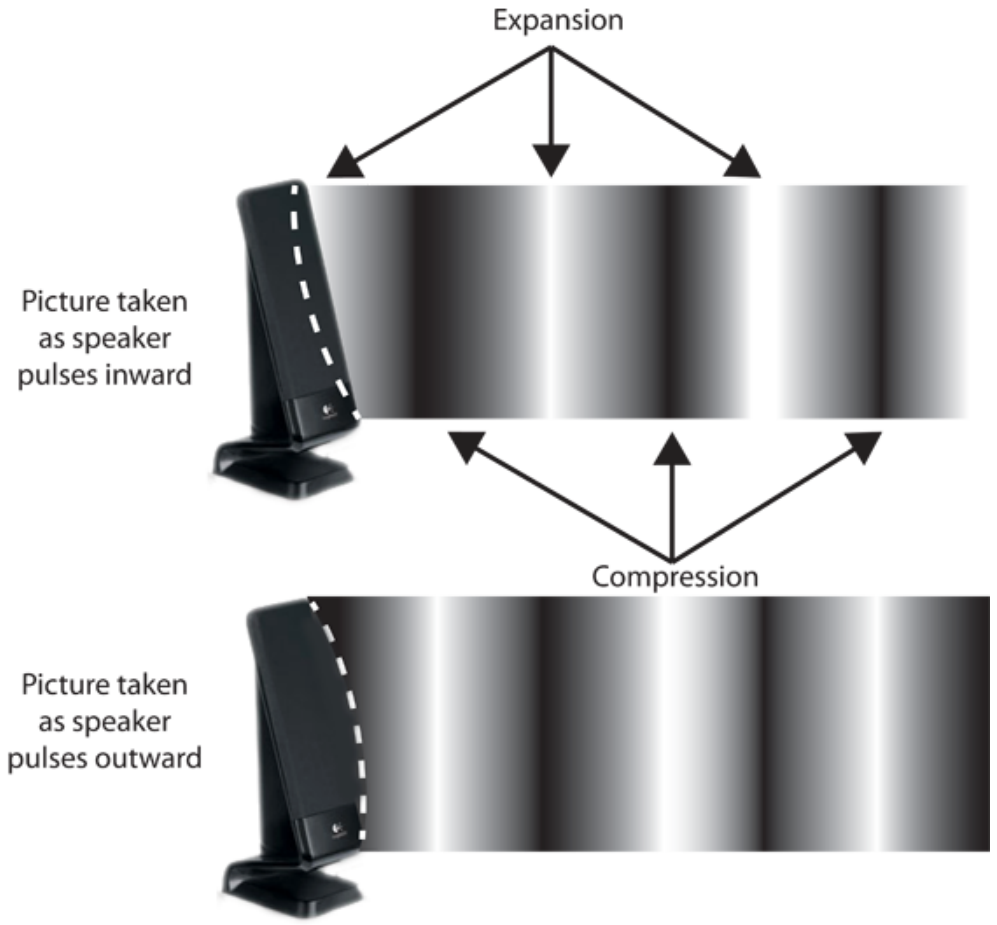
Types of Waves: Transverse and Longitudinal

Sound waves are longitudinal waves:



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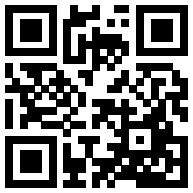
Interference



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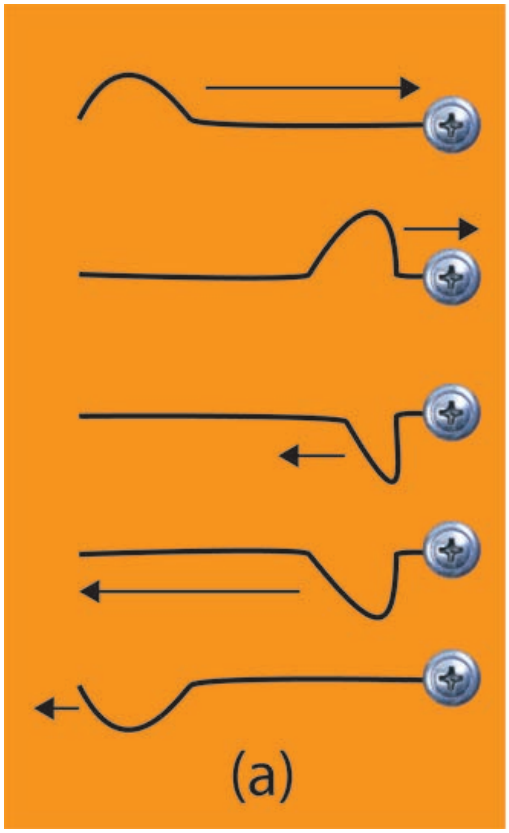
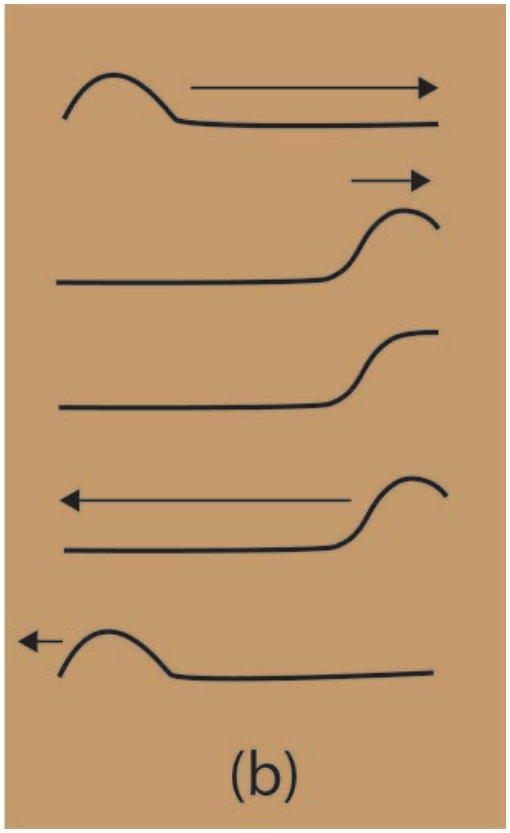
Reflection and Transmission of Waves



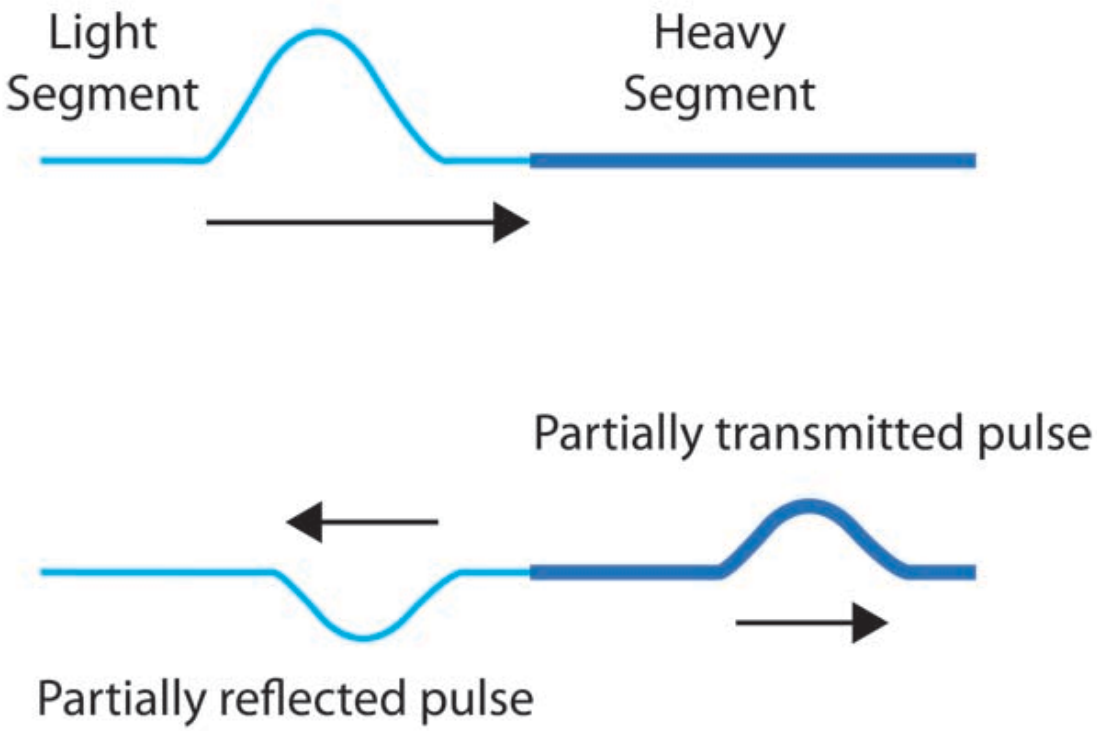


A wave reaching the end of its medium, but where the medium is still free to move, will be reflected (b), and its reflection will be upright.

A wave hitting an obstacle will be reflected (a), and its reflection will be inverted.

http://njc.tl/ii

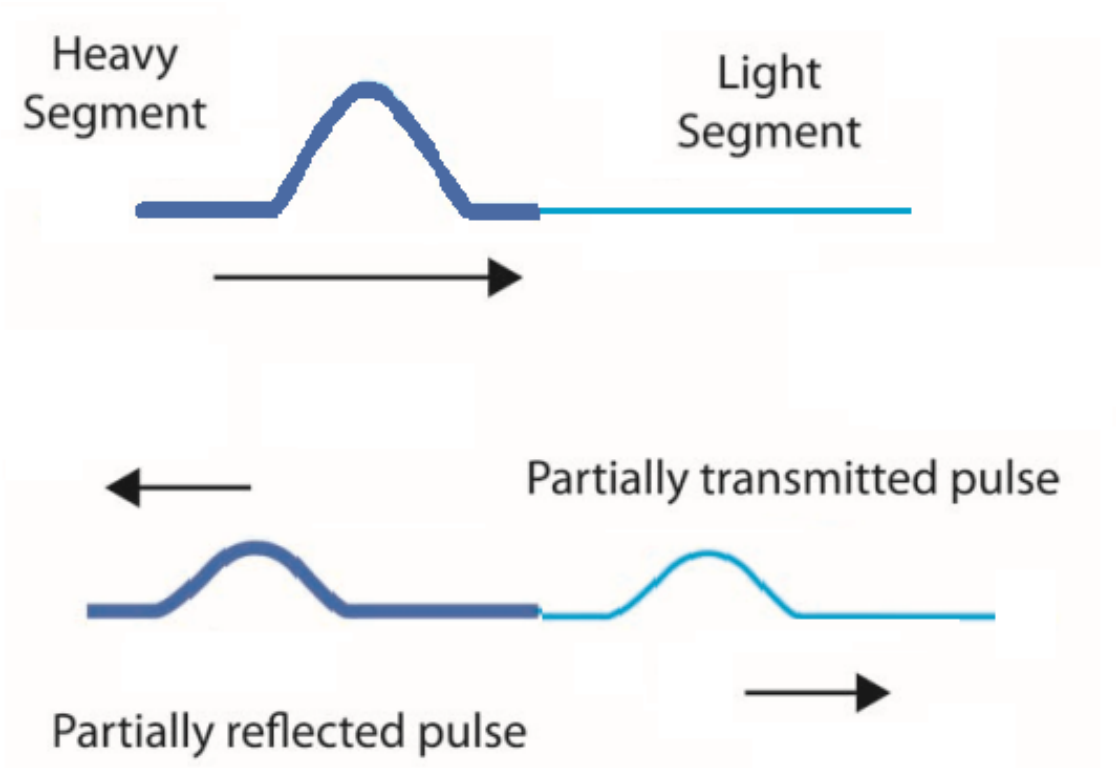
Reflection and Transmission of Waves



A wave encountering a denser medium will be partly
cted and partly transmitted; if the wave speed is less in
denser medium, the wavelength will be shorter.

http://njc.tl/ii

Reflection and Transmission of Waves



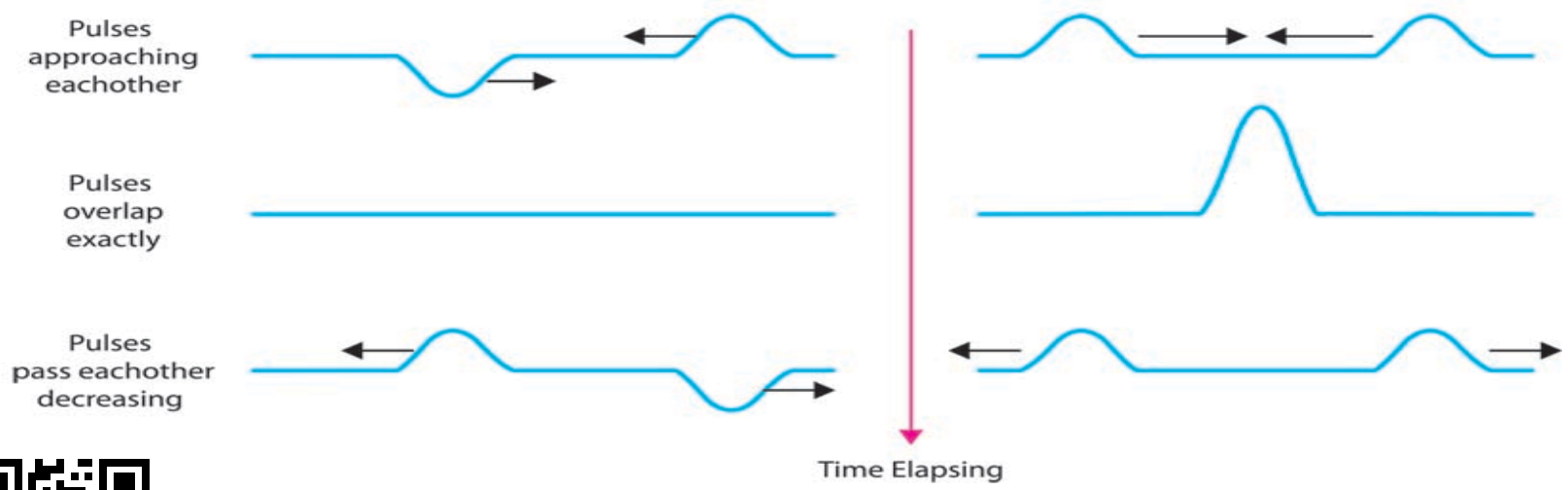
A wave encountering a lighter medium will be partly reflected and partly transmitted; if the wave speed is greater in denser medium, the wavelength will be longer.

http://njc.tl/ii

Interference; Principle of Superposition

The superposition principle says that when two waves pass through the same point, the displacement is the arithmetic sum of the individual displacements.

In the figure below, (a) exhibits destructive interference and (b) exhibits constructive interference.



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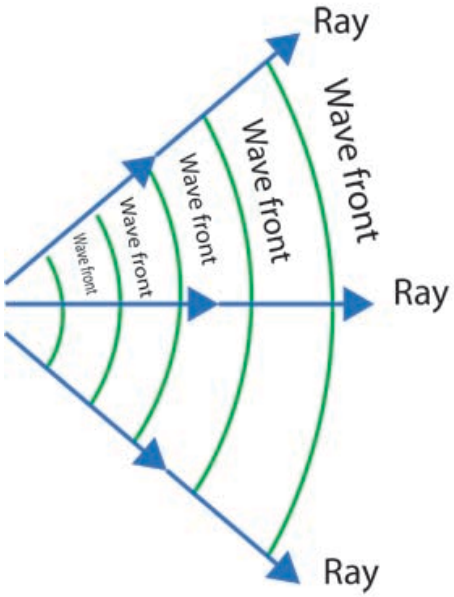
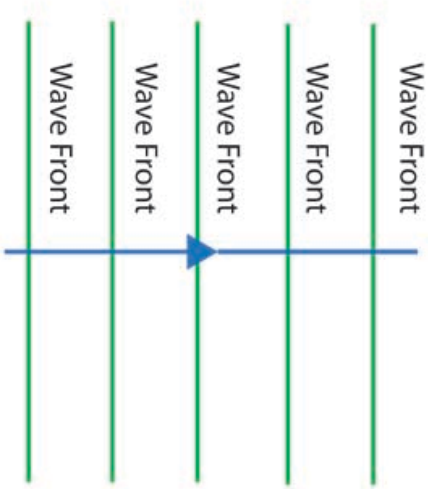
Reflection and Transmission of Waves

Two- or three-dimensional waves can be represented by wave fronts, which are curves of surfaces where all the waves have the same phase.



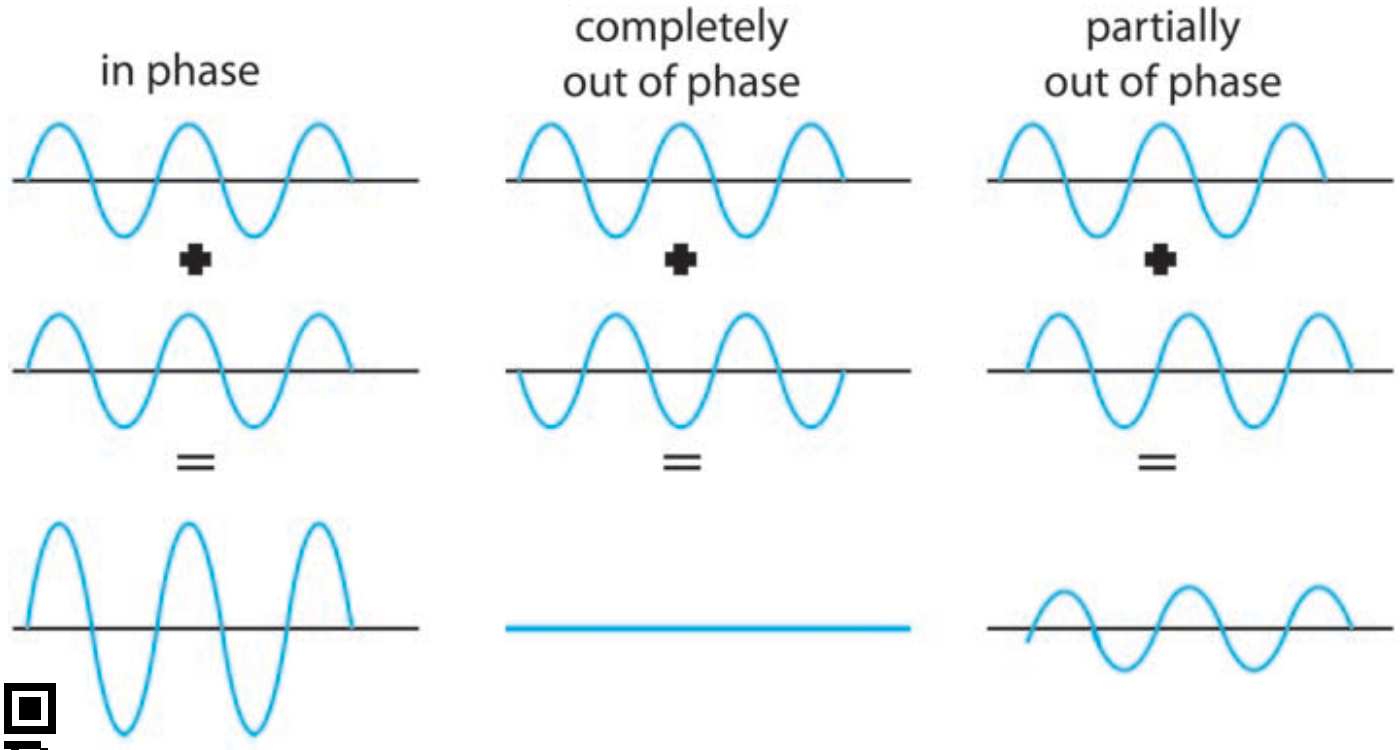


Lines perpendicular to the wave fronts are called rays; they point in the direction of propagation of the wave.

http://njc.tl/ii

Interference; Principle of Superposition

These figures show the sum of two waves. In (a) they add constructively ; in (b) they add destructively ; and in (c) they add partially destructively .



http://njc.tl/ii

6 What is the result at an oscillating point if two waves reach this point one half of a wavelength apart?

- A Constructive interference
- B Destructive interference
- C Partially destructive interference

Answer

http://njc.tl/ij

7 What is the result at an oscillating point if two waves reach this point two full wavelengths apart?

- A Constructive interference
- B Destructive interference
- C Partially destructive interference

Answer

http://njc.tl/ik

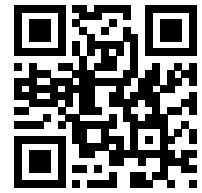
8 What is the result at an oscillating point if two waves reach this point one quarter of a wavelength apart?

- A Constructive interference
- B Destructive interference
- C Partially destructive interference

Answer

http://njc.tl/il

Standing Waves on a String



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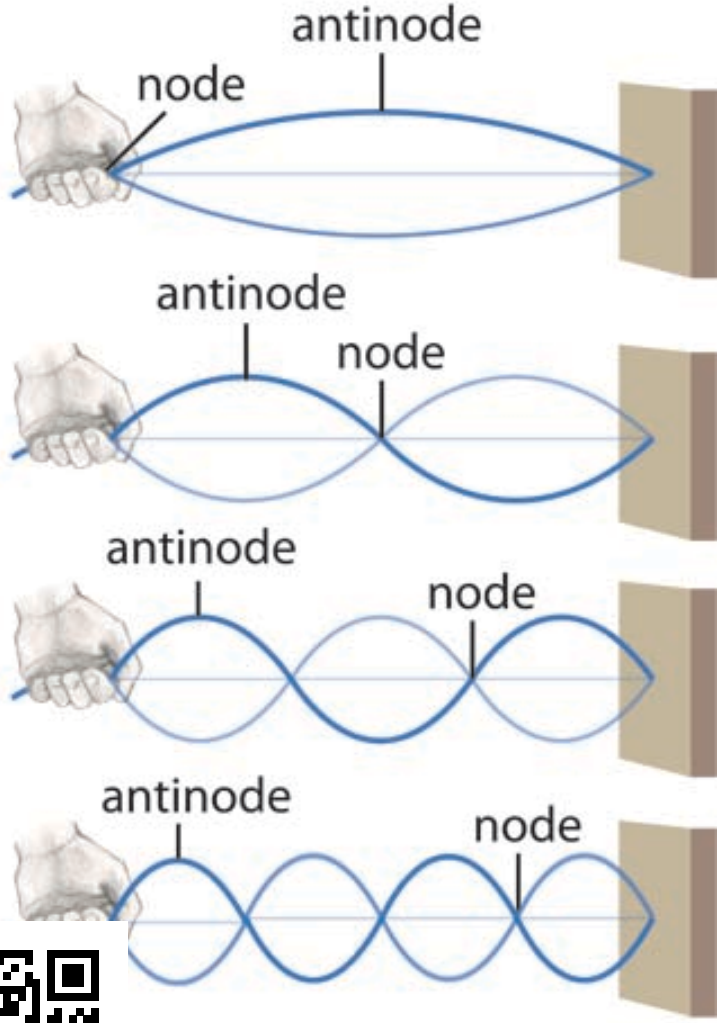
Standing Waves; Resonance



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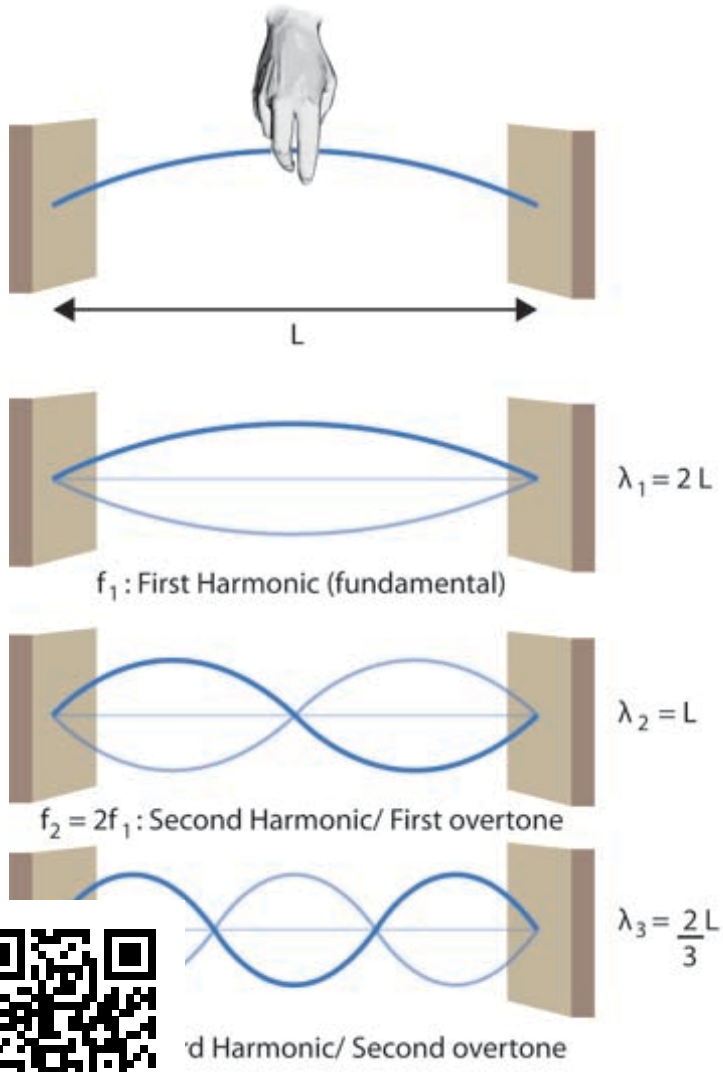
Standing waves occur when both ends of a string are fixed. In that case, only waves which are motionless at the ends of the string can persist.

There are nodes, where the amplitude is always zero, and antinodes, where the amplitude varies from zero to the maximum value.

Standing Waves; Resonance



http://njc.tl/im

The frequencies of the standing waves on a particular string are called resonant frequencies.

They are also referred to as the fundamental and harmonics.

Standing Waves; Resonance

The wavelengths and frequencies of standing waves are:

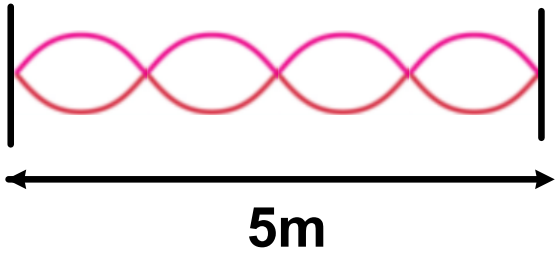
$$\lambda_n = \frac{2L}{n}$$

$$f_n = \frac{v}{\lambda_n} = \frac{v}{\frac{2L}{n}} = n\frac{v}{2L} = nf_1$$

$$n = 1, 2, 3, \ldots$$

http://njc.tl/im

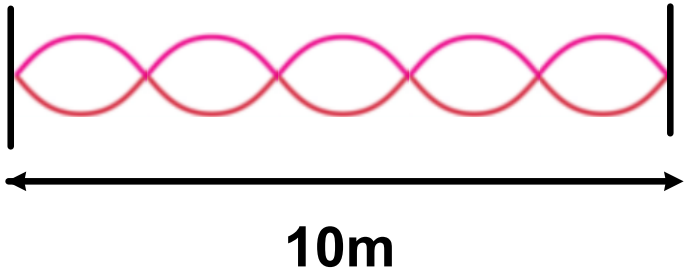
9 What is the wavelength of the wave shown below?



Answer

http://njc.tl/in

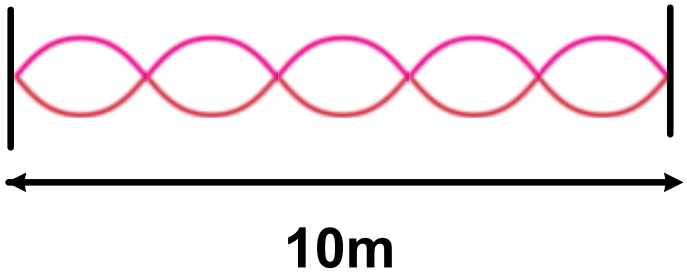
10 What is the wavelength of the wave shown below?



Answer

http://njc.tl/io

11 If the speed of the wave is 8m/s, what is the frequency of this wave?



Answer

http://njc.tl/ip

Summary

Vibrating objects are sources of waves, which may be either a pulse or continuous.

Wavelength: distance between successive crests

Frequency: number of crests that pass a given point per unit time.

Amplitude: maximum height of crest.

Wave velocity: $v = \lambda f$

For a wave on a string:

$$v = \sqrt{\frac{F_t}{\mu}}$$

Summary

Transverse wave: oscillations perpendicular to direction of wave motion.

Longitudinal wave: oscillations parallel to direction of wave motion.

Summary

When two waves pass through the same region of space, they interfere. Interference may be either constructive or destructive.

Standing waves can be produced on a string with both ends fixed. The waves that persist are at the resonant frequencies.

$$\lambda = \frac{2L}{n}$$

Nodes occur where there is no motion; antinodes where the amplitude is maximum.

Waves refract when entering a medium of different wave speed, and diffract around obstacles.