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NEW JERSEY CENTER
FOR TEACHING & LEARNING

8th Grade

Wave Properties

2015-10-28

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What are Waves?

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What is a Wave?

A wave is a disturbance that travels through space or matter.

What do you notice about the movement of this water?

In a wave, what is actually "waving"?

What causes a wave to form?

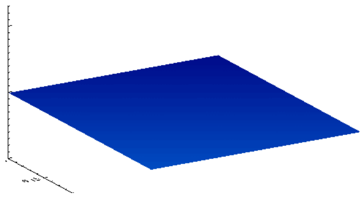
When undisturbed, the water is found in its equilibrium or rest position.

What causes a wave to form?

All waves start by a disturbance in the space or matter they travel through.

This wave starts when the water particles are disturbed and move away from the rest position. They want to "bounce back" to the rest position.

This disturbance moves outward in all directions.



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Pulses vs. Waves

A pulse is a single disturbance that moves outward.

A wave is a series of pulses that produces repeating and periodic disturbances in the medium.

Click here to see a video on pulses and waves

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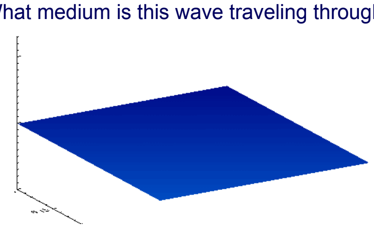
Wave Medium

Mechanical waves are waves that travel through matter.
The type of matter the wave travels through is called a medium.
A medium can be any solid, liquid, or gas.

What medium is this wave traveling through?



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Making Waves

Click here to see a PhET wave simulation

Experiment with different ways to start a wave.

Decrease the "damping" and observe what happens to the wave motion.

Observe the movement of the green beads in the rope.

1 In the PhET simulation, what medium was the wave traveling through?

- A Empty space
- B Air
- C A rope made up of green and red beads
- D Water

1 In the PhET simulation, what medium was the wave traveling through?

- A Empty space
- B Air
- C A rope made up of green and

Answer

C

- D Water

2 A pulse is a single disturbance that travels through a medium.

- True
- False

2 A pulse is a single disturbance that travels through a medium.

- True
- False

Answer

True

3 Which of the following is the best way to start a wave and *keep it going* in the simulation?

- A Give it one manual pulse
- B Select oscillation
- C Give it one automatic pulse

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3 Which of the following is the best way to start a wave and *keep it going* in the simulation?

- A Give it one manual pulse
- B Select oscillation
- C Give it one automatic pulse

Answer

B

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4 Based on the simulation, which of the following is the best definition of the word *oscillate*?

- A To move or travel back and forth
- B To move or travel randomly
- C To move or travel in one direction
- D To move or travel in one abrupt motion

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4 Based on the simulation, which of the following is the best definition of the word *oscillate*?

- A To move or travel back and forth
- B To move or travel randomly
- C To move or travel in one dire
- D To move or travel in one abru

Answer

A

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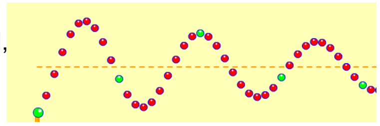
5 In the simulation, how would you describe the movement of the green beads in the rope as it was waving?



- A As the wave moved, the green beads moved forward towards the end of the rope.
- B As the wave moved, the green beads bounced up and down but did not move forward or backward.
- C The green beads moved forward with the wave.
- D The green beads moved backward as the wave moved forward.

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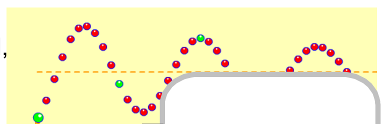
5 In the simulation, how would you describe the movement of the green beads in the rope as it was waving?



- A As the wave moved, the green beads moved forward towards the end of the rope.
- B As the wave moved, the green bea... and down but did not move forward ...
- C The green beads moved forward with the wave.
- D The green beads moved backward as the wave moved forward.

Answer

B

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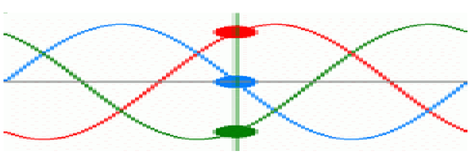
Waves transfer energy and not matter!

As energy moves through a medium in the form of a wave, the particles in the medium vibrate around their rest position.

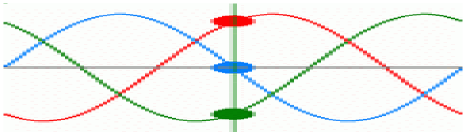


Is the medium moving across or up and down?

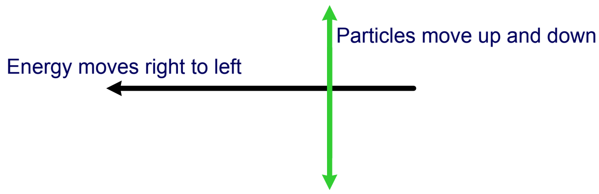
If there were no waves, where would the colored balls be?

Transverse Waves

This wave is classified as a TRANSVERSE WAVE



The particles in a TRANSVERSE WAVE vibrate at right angles to the direction of energy movement.



6 The substance that a mechanical wave moves through is called a(n):

- A vacuum
- B medium
- C propagation
- D amplitude

6 The substance that a mechanical wave moves through is called a(n):

- A vacuum
- B medium
- C propagation
- D amplitude

Answer

B

7 The resting position of a medium when there is NO wave passing through it is known as:

- A Amplitude
- B Inertia
- C Minimum Displacement
- D Equilibrium Position

7 The resting position of a medium when there is NO wave passing through it is known as:

- A Amplitude
- B Inertia
- C Minimum Displacement
- D Equilibrium Position

Answer

D

8 Which of the following is an example of a wave medium?

- A Air molecules and other gases
- B Water
- C A slinky
- D All of the above

8 Which of the following is an example of a wave medium?

- A Air molecules and other gases
- B Water
- C A slinky
- D All of the above

Answer

D

9 The particles in a transverse wave vibrateat a right angle to the direction of wave motion.

- True
- False

9 The particles in a transverse wave vibrateat a right angle to the direction of wave motion.

- True
- False

Answer

True

10 Waves transfer __________.

- A Matter
- B Energy
- C Energy and Matter
- D Objects from one medium to another

10 Waves transfer __________.

- A Matter
- B Energy
- C Energy and Matter
- D Objects from one medium

Answer

B

Parts of a Wave

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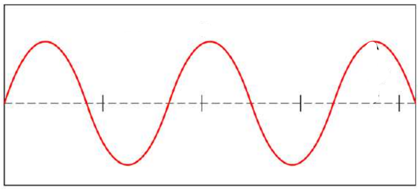
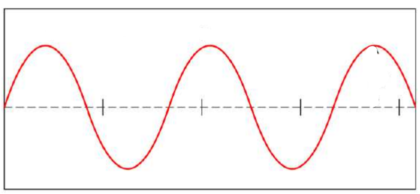
The Anatomy of a Wave

Let's look at the parts of a wave using a transverse wave in a rope as shown below. Do you remember what classifies a wave as transverse?



The Anatomy of a Wave

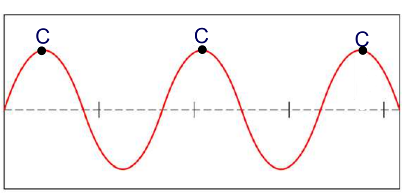
--------- marks the equilibrium/rest position. This is the position the rope would have if there was no disturbance through it.



Once a disturbance is added, the rope will vibrate up and down around this equilibrium position.

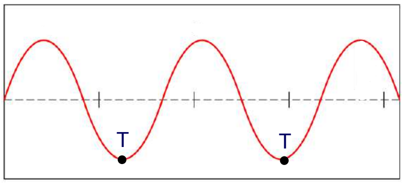
The Anatomy of a Wave

The Crest (C) of a wave is the point on the medium that exhibits the maximum amount of upward (or positive) displacement from the equilibrium position.



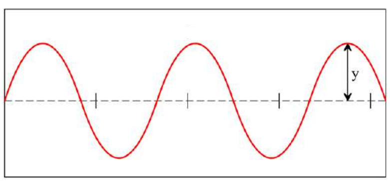
The Anatomy of a Wave

The Trough (T) of a wave is the point on the medium that exhibits the maximum amount of downward (or negative) displacement from the equilibrium position.



The Anatomy of a Wave

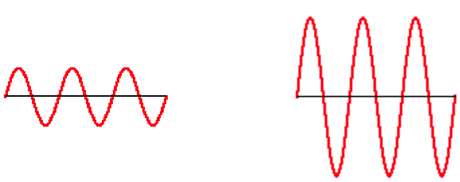
The amplitude (y) of a wave is the maximum distance away from the rest position. It can be measured from the equilibrium position to the crest or to the trough.



What are some units that could be used to measure a wave's amplitude?

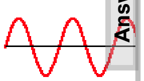
The Anatomy of a Wave

The amplitude (y) of a wave is related to the energy the wave transports. Which of the following waves do you think transports more energy and why?



The Anatomy of a Wave

The amplitude (y) of a wave is related to the energy the wave transports. Wh... transports more ene...



Answer

The one on the right transports more energy because it has a larger amplitude.

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The Anatomy of a Wave

The energy that a wave transports is directly proportional the *square* of the wave's amplitude (y).

$$\text{Energy} \propto \text{Amplitude}^2$$

This means that if the wave amplitude *doubles*, the energy the wave transports will *quadruple*. Can you determine the missing value in the chart below?

Amplitude	Energy
1 unit	2 units
2 units	8 units
3 units	18 units
4 units	

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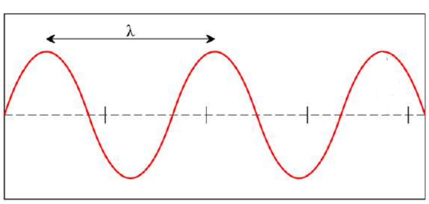
Wavelength

Wavelength (λ) is defined as the distance it takes a wave to complete one complete up and down motion or vibration (one complete wave cycle). It can be measured in various places along the wave.



What units could be used to measure the wavelength of a wave?

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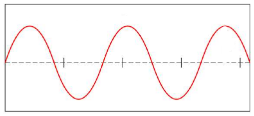
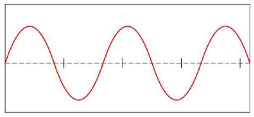
Wavelength

Label the following wavelengths by dragging the arrow line.

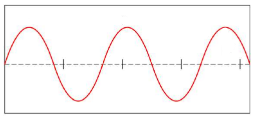
From Crest to Crest



From Trough to Trough



From Starting Point to Ending Point along the Equilibrium Position.



11 The distance for a wave to repeat one complete vibration/cycle is called:

- A Trough
- B Crest
- C Wavelength
- D Amplitude

11 The distance for a wave to repeat one complete vibration/cycle is called:

- A Trough
- B Crest
- C Wavelength
- D Amplitude

Answer

C

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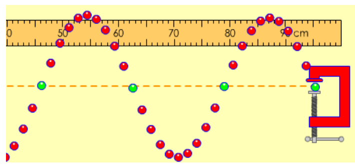
12 The figure below shows a snapshot of a wave. Using a movable ruler, you could measure the wave's



- A Amplitude
- B Crest height
- C Wavelength
- D All of the above

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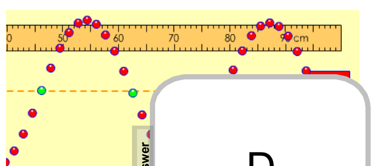
12 The figure below shows a snapshot of a wave. Using a movable ruler, you could measure the wave's



- A Amplitude
- B Crest height
- C Wavelength
- D All of the above

Answer

D

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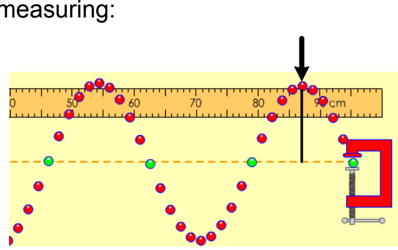
13 The black line is measuring:



- A Frequency
- B Trough
- C Wavelength
- D Amplitude

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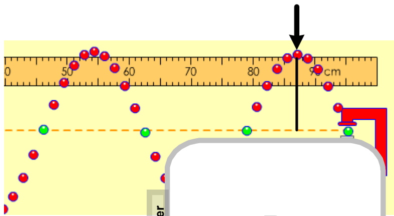
13 The black line is measuring:

- ❍ A Frequency
- ❍ B Trough
- ❍ C Wavelength
- ❍ D Amplitude



Answer

D

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14 The distance between maximum displacement above or below the rest position is called:

- ❍ A Trough
- ❍ B Crest
- ❍ C Wavelength
- ❍ D Amplitude

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14 The distance between maximum displacement above or below the rest position is called:

- ❍ A Trough
- ❍ B Crest
- ❍ C Wavelength
- ❍ D Amplitude

Answer

D

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15 The symbol for wavelength is the Greek letter

- A Lambda (#)
- B Beta (B)
- C Gamma
- D Phi

Slide 37 (Answer) / 144

15 The symbol for wavelength is the Greek letter

- A Lambda (#)
- B Beta (B)
- C Gamma
- D Phi

Answer

A

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16 When the amplitude of a wave triples, the energy the wave transports also triples.

- True
- False

16 When the amplitude of a wave triples, the energy the wave transports also triples.

- True
- False

Answer

False, it gets 9x bigger

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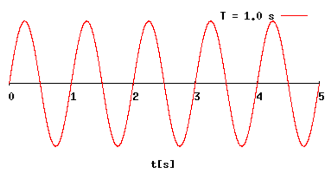
Period of a Wave

The Period (T) of a wave is defined as the time it takes for one vibration or one full wavelength to occur.



What unit is period measured in? (Hint: Look at the animation)

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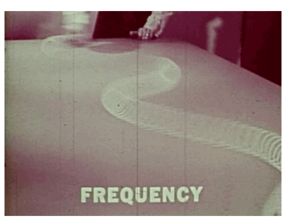
What is Frequency?

The Frequency (f) of a wave is defined as the number of vibrations a wave makes per second.

1 Vibration per Second (1/sec) is called a Hertz (Hz)



The Hertz is the SI unit for measuring frequency of any wave!

If a wave vibrates 20 times per second, its frequency is 20 Hz.

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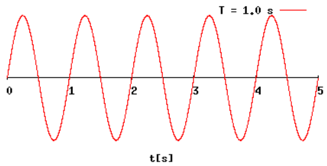
Period and Frequency

Period and frequency are inversely related to each other.

As the period of the wave, T, increases below, what happens to the frequency of vibrations?



Period and Frequency

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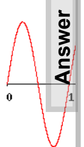

Answer

As period increases, the frequency decreases.
As frequency increases, period decreases!

Period and Frequency

Since period and frequency are inversely related to each other, you can calculate one from the other using the following:

$$T = \frac{1}{f} \quad \text{OR} \quad f = \frac{1}{T}$$

What's the frequency of a wave with a period of 3 seconds?

Period and Frequency

Since period and frequency ... you can calculate one

T= 1/f

What's the frequency ...

Answer

f= 1/3 seconds
f= 0.33 Hz

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17 What's the period of a wave with a frequency of 2 waves per second?

- A 2 sec
- B 2 Hz
- C 0.5 sec
- D 0.5 Hz

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17 What's the period of a wave with a frequency of 2 waves per second?

- A 2 sec
- B 2 Hz
- C 0.5 sec
- D 0.5 Hz

Answer

C

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18 As a waves frequency increases, theperiod also increases.

- True
- False

18 As a waves frequency increases, theperiod also increases.

- True
- False

Answer

False

19 The distance a wave crest or trough isfrom the equilibrium position is known as the wave's_____.

- A Compression
- B Rarefaction
- C Amplitude
- D Wavelength

19 The distance a wave crest or trough isfrom the equilibrium position is known as the wave's_____.

- A Compression
- B Rarefaction
- C Amplitude
- D Wavelength

Answer

C

20 The distance it takes for a wave to complete one vibration is known as _______.

- A Amplitude
- B Crest
- C Trough
- D Wavelength

20 The distance it takes for a wave to complete one vibration is known as _______.

- A Amplitude
- B Crest
- C Trough
- D Wavelength

Answer

D

21 What is the unit for measuring frequency?

- A Meters (m)
- B Seconds (s)
- C Hertz (Hz)
- D Meters per second (m/s)

21 What is the unit for measuring frequency?

- A Meters (m)
- B Seconds (s)
- C Hertz (Hz)
- D Meters per second (m/s)

Answer

C

The Wave Equation

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The Wave Equation

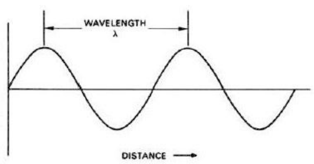
The speed or velocity of an object in motion can be found by taking the distance it travels divided by the time it takes to get there.

$$s = \frac{d}{t}$$

Wave velocity can be found in a similar way.

The Wave Equation

The distance a wave travels can be measured in wavelengths. The symbol for wavelength is the Greek letter Lambda: #



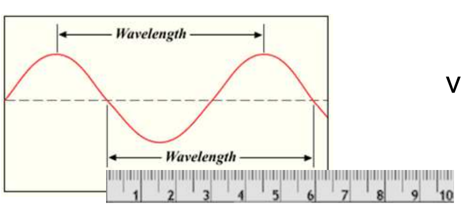
The time it takes a wave to travel a full wavelength is the wave's period. The symbol for period is T.

The wave velocity can be calculated by dividing the wavelength by the period.

$$s = \frac{d}{t} \quad \rightsquigarrow \quad v = \frac{\lambda}{T}$$

The Wave Equation

What is the velocity of a wave that has a wavelength of 6 cm and a period of 2 seconds?



$$v = \frac{\lambda}{T}$$

The Wave Equation

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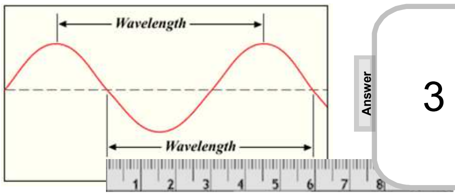
What is the velocity of a wave that has a wavelength of 6 cm and a period of 2 seconds?



Answer

3 cm/s

The Wave Equation

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A more common way to calculate wave speed is to use the number of vibrations per second or frequency instead of the time it takes for a wave to vibrate once.

$$v = \frac{\lambda}{T} \rightarrow v = \lambda f$$

This can be rearranged to solve for each variable:

$$\lambda = \frac{v}{f} \qquad f = \frac{v}{\lambda}$$

Units of The Wave Equation

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The velocity of any wave is calculated by multiplying thewavelength (m) of the wave and the frequency of a wave (vibration/sec or Hz). The units for each variable are shown below.

$$v = \lambda f$$

- v: meters per second (m/s)
- λ: meters (m)
- f: waves per second (or 1/ sec.) (Hz)

22 What is the velocity of a wave that has a wavelength of 2 m and a frequency of 3 Hz?

- A 6 Hz
- B 1.5 m/s
- C 6 m/s
- D 1.5 Hz

22 What is the velocity of a wave that has a wavelength of 2 m and a frequency of 3 Hz?

- A 6 Hz
- B 1.5 m/s
- C 6 m/s
- D 1.5 Hz

Answer

C

23 What is the frequency of a wave traveling at 100 m/s when its wavelength is 3 m?

- A 300 m/s
- B 33.33 Hz
- C 33.33 m
- D 0.003 Hz

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23 What is the frequency of a wave traveling at 100 m/s when its wavelength is 3 m?

- A 300 m/s
- B 33.33 Hz
- C 33.33 m
- D 0.003 Hz

Answer

B

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24 What is the wavelength of a wave that is traveling at 44 m/s when it's frequency is 22 Hz?

- A 2 Hz
- B 968 Hz
- C 2 m
- D 968 m

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24 What is the wavelength of a wave that is traveling at 44 m/s when it's frequency is 22 Hz?

- A 2 Hz
- B 968 Hz
- C 2 m
- D 968 m

Answer

C

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Properties of Waves

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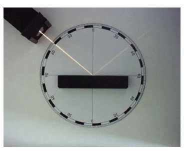
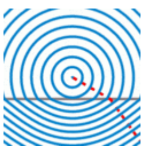
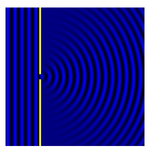
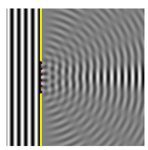
Wave Behavior

Waves exhibit characteristic behaviors when they interact with boundaries

When a wave hits a boundary, they can be:

- reflected
- transmitted
- absorbed
- refracted
- diffracted

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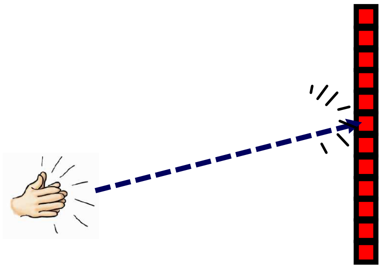
Reflection Observed

When a wave strikes a boundary or an obstacle and bounces back towards the source, the wave and the energy it transports is reflected.

Here we see light waves reflected off of water.

Reflection Observed

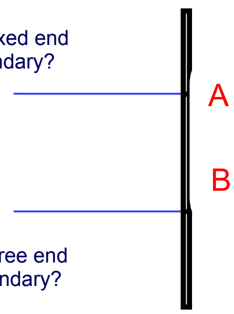
Echoes are reflected sound waves.



Reflection

Another way to view reflection is to utilize a string to observe the way a pulse is reflected from two types of boundaries.

A - What happens to the incident pulse in fixed end reflection before and after it strikes the boundary?

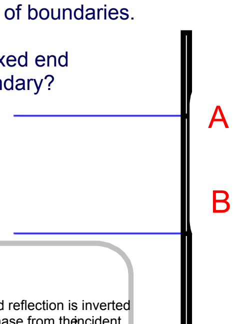


B - What happens to the incident pulse in free end reflection before and after it strikes the boundary?

Reflection

Another way to view reflection is to utilize a string to observe the way a pulse is reflected from two types of boundaries.

A - What happens to the incident pulse in fixed end reflection before and after it strikes the boundary?



B - What happens to the incident reflection before and after it strike

Answer

The fixed end reflection is inverted and out of phase from the incident pulse.
The free end reflection is in phase with the incident pulse.

25 A reflected wave is a wave that hits a boundary and then _________.

- A Bounces back
- B Stops transmitting energy
- C Continues through the boundary

25 A reflected wave is a wave that hits a boundary and then _________.

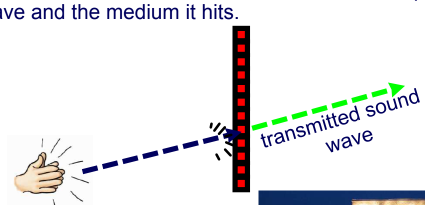
- A Bounces back
- B Stops transmitting energy
- C Continues through the boun

Answer

A

Wave Transmission

When waves hit a boundary, not all of it is reflected. Some of the wave goes through the new material. This is called wave transmission. The amount of the wave that is reflected and transmitted depends on the type of wave and the medium it hits.



Not all of the light waves are reflected from the surface of the water. Some are transmitted through the water down below.

Wave Absorption

As waves travel through any medium, some of its energy is absorbed by the atoms or molecules of the medium. This absorption causes the atoms and molecules to vibrate more creating heat energy. The energy of the wave decreases.

You've probably experienced this when someone is yelling at you from far away. Some of the sound wave is absorbed by the air molecules, so you don't hear them very well.

Can you describe a real life example of when light waves were absorbed by a medium?

26 When a wave encounters a boundary, some of it _________ through the boundary.

- A reflects
- B transmits
- C absorbs

26 When a wave encounters a boundary, some of it _________ through the boundary.

- A reflects
- B transmits
- C absorbs

Answer

B

27 When a wave is absorbed by a medium, the wave's energy ________________ and heat energy in the medium ______________.

- A increases, increases
- B decreases, decreases
- C increases, decreases
- D decreases, increases

27 When a wave is absorbed by a medium, the wave's energy ________________ and heat energy in the medium ______________.

- A increases, increases
- B decreases, decreases
- C increases, decreases
- D decreases, increases

Answer

D

Refraction

Have you ever looked at a straw in a glass and noticed it appears to be broken?

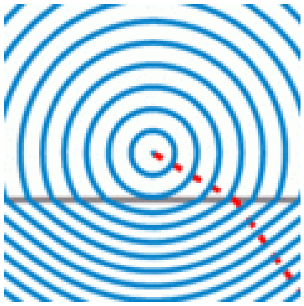
This appearance is due to the bending light waves.

Refraction

Refraction is the change in direction of a wave due to a change in its transmission medium.

What do you think happens to a wave's velocity when it travels from a less dense medium to a more dense medium?

For example, a wave traveling from air to water.



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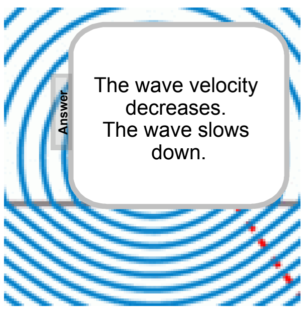
Refraction

Refraction is the change in direction of a wave due to a change in its transmission medium.

What do you think happens to a wave's velocity when it travels from a less dense medium to a more dense medium?

For example, a wave traveling from air to water.



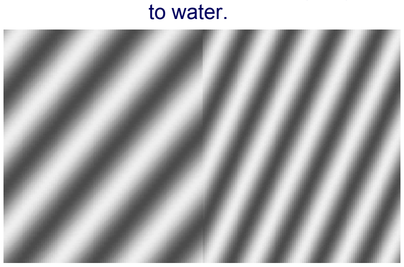
Answer

The wave velocity decreases.
The wave slows down.

Slide 68 (Answer) / 144

Refraction

The images below show a wave (on the left) in a less dense medium traveling to a more dense medium. An example of this could be sound waves going from air to water.



What happens to the wavelength of the waves as they strike the boundary between the two different mediums?

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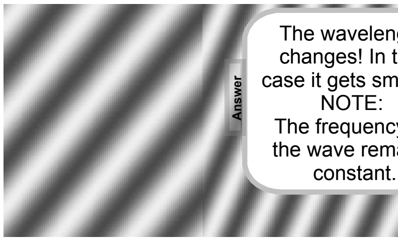
Refraction

The images below show a wave (on the left) in a less dense medium traveling to a more dense medium. An example of this could be sound waves going from air to water.



What happens to the wavelength of the waves as they strike the boundary between the two different mediums?

28 When refraction occurs, the velocity of a wave changes as it passes from one substance to another.

- True
- False

28 When refraction occurs, the velocity of a wave changes as it passes from one substance to another.

- True
- False

Answer: TRUE

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29 When a wave changes media during refraction, ____________.

- A The wavelength changes and the frequency remains constant.
- B The frequency changes, and the wavelength remains constant.
- C Neither wavelength nor frequency change.

Slide 71 (Answer) / 144

29 When a wave changes media during refraction, ____________.

- A The wavelength changes and the frequency remains constant.
- B The frequency changes, and the ... s constant.
- C Neither wavelength nor frequenc...

Answer

A

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30 Which of the following best explains the difference between reflection and refraction?

- A Reflected waves continue moving away from their source, while refracted waves bend toward it
- B Reflected waves bounce back towards their source, while refracted waves continue moving away from their source
- C Reflection occurs as waves pass from one medium to another, while refraction occurs when waves bounce back from a barrier.

30 Which of the following best explains the difference between reflection and refraction?

- A Reflected waves continue moving away from their source, while refracted waves bend toward it
- B Reflected waves bounce back tc while refracted waves continue their source
- C Reflection occurs as waves pass medium to another, while refracti when waves bounce back from a barrier.

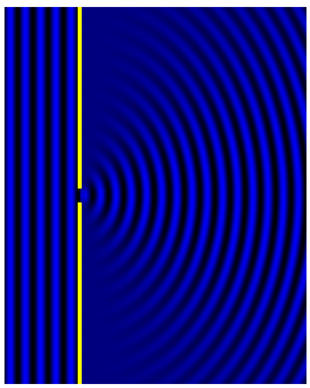
Answer

B

Slide 72 (Answer) / 144

Diffraction

Diffraction is described as the apparent bending of waves around small obstacles and the spreading out of waves past small openings.



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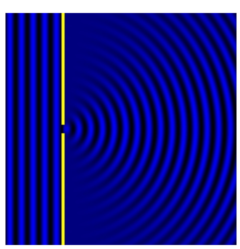
Diffraction

Diffraction is most noticeable when the wavelength of the waves are similar in size to the opening they are passing through.

If there is a big difference in these sizes, diffraction is still present but it is diminished.



Click here to see a video on Diffraction

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Diffraction

Diffraction can occur with any type of wave, and is why, for example, you can still hear someone calling to you if you are hiding behind a tree. The sound waves bend around the tree.

As water moves though the opening shown on the right, the waves diffract. Note the waves spreading out from the opening.

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31 Diffraction is increased when waves pass through a large opening.

- True
- False

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31 Diffraction is increased when waves pass through a large opening.

- True
- False

Answer

FALSE

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32 Diffraction is increased when:

- A the wavelength is larger than the opening
- B the wavelength is smaller than the opening.
- C the wavelength is similar to the opening.

32 Diffraction is increased when:

- A the wavelength is larger than the opening
- B the wavelength is smaller than the opening.
- C the wavelength is similar to the opening.

Answer

C

Wave Interference

What happens when two waves exist in the same medium at the same time?

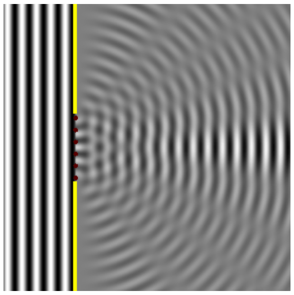
For example, think about the difference in having one music speaker on and two music speakers on.

Both speakers create sound waves that exist in the air at the same time.

Wave Interference

Interference is a phenomenon in which two waves superimpose (add up) to form a resultant wave of greater or lower amplitude.

Notice that after the wave passes through the aperture it diffracts and there are regions in which the waves seem to "disappear."



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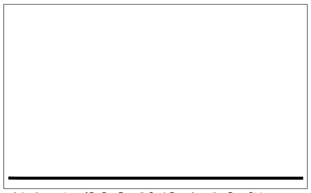
Constructive Interference

Waves that line up to each other everywhere are considered in phase. These waves will add up in amplitude to reinforce each other and they get bigger.

NOTE: The waves ONLY undergo interference when they are in the same spot at the same time and overlap. It seems like they bounce off each other, but each wavereally just continues on in it's original direction.



Animation courtesy of Dr. Dan Russell, Grad. Prog. Acoustics, Penn State

Click here to see a video on Constructive Interference

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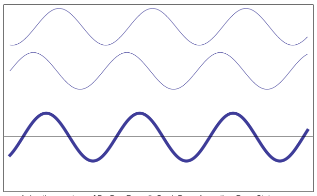
Destructive Interference

Waves that are out of phase (do not line up) with each other will cancel out their amplitudes and they get smaller.

NOTE: The waves ONLY undergo interference when they are in the same spot at the same time. It seems like they bounce off each other, but each wave really just continues on in it's original direction.



Animation courtesy of Dr. Dan Russell, Grad. Prog. Acoustics, Penn State

Click here to see a video on Destructive Interference

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33 Constructive Interference occurs when:

- A Waves cancel out
- B Waves add up
- C Waves have no effect on each other

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33 Constructive Interference occurs when:

- A Waves cancel out
- B Waves add up
- C Waves have no effect on each other

Answer

B

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34 Destructive Interference occurs when:

- A Waves cancel out
- B Waves add up
- C Waves have no effect on each other

34 Destructive Interference occurs when:

- A Waves cancel out
- B Waves add up
- C Waves have no effect on each other

Answer

A

35 Constructive interference results in waves with a greater

- A Wavelength
- B Frequency
- C Amplitude

35 Constructive interference results in waves with a greater

- A Wavelength
- B Frequency
- C Amplitude

Answer

C

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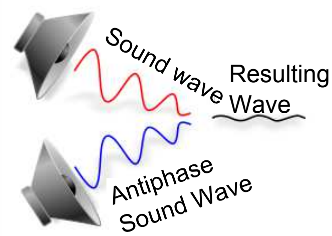
36 Noise canceling headphones block out unwanted sounds by creating sound waves that are antiphase to the unwanted sound waves. This is an example of

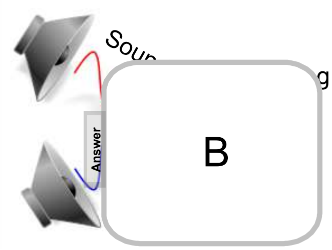
- A Constructive interference
- B Destructive interference



Slide 85 (Answer) / 144

36 Noise canceling headphones block out unwanted sounds by creating sound waves that are antiphase to the unwanted sound waves. This is an example of

- A Constructive interference
- B Destructive interference



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Sound as a Wave

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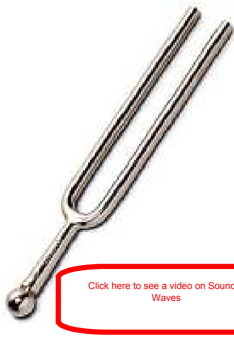
Sound is Created by Vibrating Objects

A tuning fork is an example of an object that can be vibrated to produce sound waves.

As a tuning fork vibrates, the prongs create disturbances in the air.

We call these disturbances sound waves.



Click here to see a video on Sound Waves

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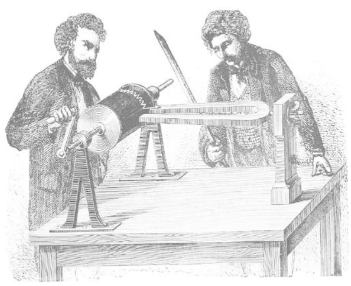
Sound Waves are Caused by Vibrating Objects

As vibrating objects moves "back and forth" they create disturbances in a medium (such as air) which move outward in all directions.

These scientists attached a piece of chalk to a large tuning fork to observe the vibrational pattern on a rotating chalkboard.



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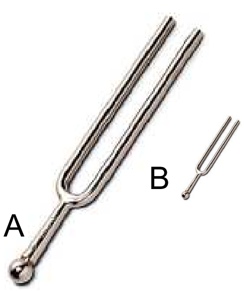
Varying Frequency Sounds

How do you think the length of a vibrating object affect the frequency of the sound produced?



Click to hear the differences in frequency produced by different lengths of vibrating objects.

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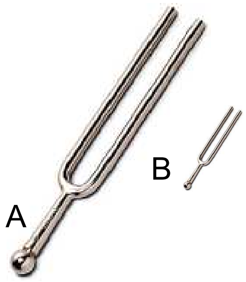
Varying Frequency Sounds

How do you think the length of a vibrating object affect the frequency of the sound produced?



Answer

A longer length yields a lower frequency and vice versa.

Click to hear the differences in frequency produced by different lengths of vibrating objects.

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Frequency of a Sound is Heard as Pitch by the Human Ear!

Higher frequency sounds are heard as higher pitches.

Lower frequency sounds are heard as lower pitches.

Click here to see a video on Sound Wave pitch and loudness

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Amplitude as Loudness

Amplitude is heard by the human ear as loudness!

This graph is a waveform of a sound. The height of the wave varies from beginning to end.

Can you tell where the sound is loudest and softest?

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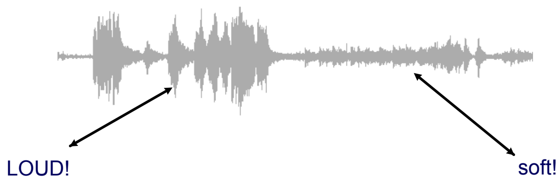
Decibels

Loudness of a sound is measurable.
The SI unit for loudness is the decibel (dB)



Click here to see a video on
Sound Loudness and the Decibel

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37 Higher frequency sounds are produced by large, long vibrating objects and low frequency sounds are produced by smaller, short vibrating objects.

- True
- False

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37 Higher frequency sounds are produced by large, long vibrating objects and low frequency sounds are produced by smaller, short vibrating objects.

- True
- False

Answer

FALSE

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38 The SI unit for sound intensity is:

- A hertz
- B amplitude
- C frequency
- D decibel

38 The SI unit for sound intensity is:

- A hertz
- B amplitude
- C frequency
- D decibel

Answer

D

39 Intensity/Amplitude of sound waves are heard as loudness.

- True
- False

39 Intensity/Amplitude of sound waves are heard as loudness.

- True
- False

Answer

TRUE

40 Perceived pitch is the hearer's response to which wave property?

- A Amplitude
- B Velocity
- C Frequency

40 Perceived pitch is the hearer's response to which wave property?

- A Amplitude
- B Velocity
- C Frequency

Answer

C

Sound as a Mechanical Wave

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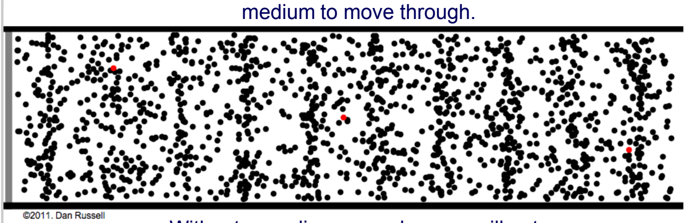
Sound Waves are Mechanical Waves

Sound waves are mechanical because they require a substance or medium to move through.



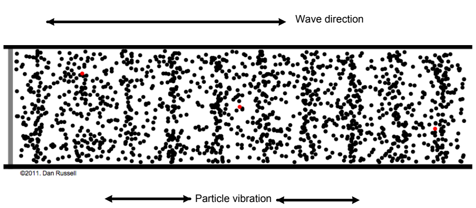
Without a medium, sound waves will not propagate (move from one point to another).

What medium or media do sound waves in our classroom move through?

Click here to see a video on Sound Waves in a Vacuum

Sound is a Longitudinal Wave

In a previous lessons, we saw that the particles in a transverse mechanical wave vibrate at a right angle to the direction that the wave moves.



Sound waves are LONGITUDINAL WAVES.
Longitudinal waves are waves that vibrate the medium parallel (in the same plane) to the direction of wave motion.

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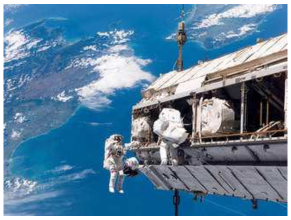
41 Can astronauts working on the exterior of International Space Station hear each other speak (without using radios)? Why or why not?

- Yes
- No



Slide 100 (Answer) / 144

41 Can astronauts working on the exterior of International Space Station hear each other speak (without using radios)? Why or why not?

- Yes
- No

Answer

No, there is no air in outerspace, so the sound waves have no medium to travel through.

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42 Sound waves are:

- A electromagnetic and transverse
- B electromagnetic and longitudinal
- C mechanical and longitudinal
- D mechanical and transverse

42 Sound waves are:

- A electromagnetic and transverse
- B electromagnetic and longitudinal
- C mechanical and longitudinal
- D mechanical and transverse

Answer

C

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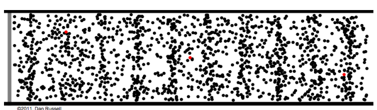
Sound Waves are also Known as Compression Waves

As a vibrating object swings forward, it creates a compression in the medium that moves outward.

When the vibrating objects swings backwards, it creates a region of low pressure called a rarefaction.



Sound waves are made of 2 parts, compressions (high pressure) and rarefactions (low pressure).

Can you identify regions of compression and rarefactions in the air molecules above?

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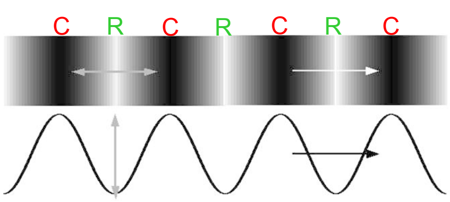
Analogy of Longitudinal and Transverse Waves



We can represent a longitudinal wave (top) with a transverse wave sketch (bottom).

The Compressions (C) can be drawn as CRESTS.
The Rarefactions (R) can be drawn as TROUGHS.

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43 The regions of high pressure in a sound wave are called:

- A rarefactions
- B equilibrium zones
- C compressions

43 The regions of high pressure in a sound wave are called:

- A rarefactions
- B equilibrium zones
- C compressions

Answer

C

44 The regions of low pressure in a sound wave are called:

- A rarefactions
- B equilibrium zones
- C compressions

44 The regions of low pressure in a sound wave are called:

- A rarefactions
- B equilibrium zones
- C compressions

Answer

A

45 In a longitudinal wave, the compression can be drawn as a trough.

- True
- False

45 In a longitudinal wave, the compression can be drawn as a trough.

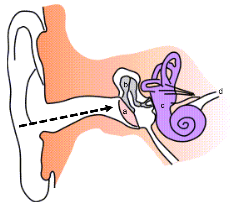
- True
- False

Answer

FALSE

How does the Ear Detect Sound Waves?

The ear is the organ that detects sound. It not only receives sound, but also aids in balance and body position. The ear is part of the auditory system.



Click here to see a video on Hearing

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How does the Ear Detect Sound Waves?

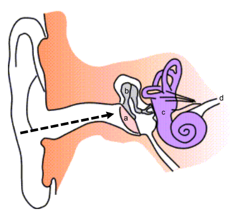
The Path of Hearing

Sound strikes eardrum (a)

Vibrates bones (hammer anvil,stirrup) (b)

Cochlea changes vibrations into electrical impulses (c)

Signal sent through auditory nerve to brain (d)



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46 The ear changes vibrations into electrical impulses.

- True
- False

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46 The ear changes vibrations into electrical impulses.

- True
- False

Answer

TRUE

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Properties of Sound Waves

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Sound wave properties

Sound is a wave that can have all the same wave properties we discussed previously. These properties include:

reflection, refraction, diffraction, and interference.

These basic properties are like fingerprints that help us identify something as a wave.

If something exhibits these properties, physicists consider them waves.

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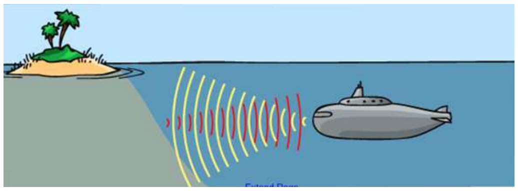
Reflection of Sound

Remember, we call the reflection of sound an echo.
When a sound wave hits a boundary, it is reflected back.

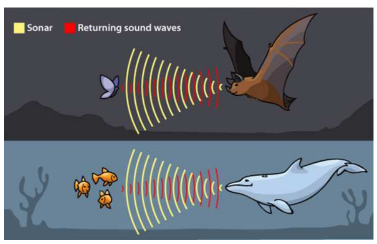


SONAR, uses the reflection of sound waves to map the sea floor of our oceans.

SONAR is an acroynm for SOund NAvigation and Ranging

Echolocation

Animals can "see" how far food is away by judging how fast the sound waves return after reflection. This is called echolocation.



Determining the speed of sound:

To measure the speed of sound in a medium, we divide the distance it travels by the time it takes for the trip.

$$s = \frac{d}{t}$$

The speed of sound varies in different substances.

In general, the speed of sound is faster in solids, and slowest in gases, with liquids falling in the middle.

This is due to the spacing of particles in each type of medium. Particles are very close together in a solid, so sound waves can travel quickly through the medium from particle to particle.

Determining the speed of sound:

To measure the s
medium, we divi
travels by the t

The spe

In general, the sp ... est in gases, with liquids

This is due to the spacing of particles in each type of medium. Particles are very close together in a solid, so sound waves can travel quickly through the medium from particle to particle.

Teacher Notes

A good way to demonstrate this is to have students act as particles in a solid, liquid and then a gas. An object ("sound wave") can get passed from student to student. What will be seen is that the "sound wave" travels fastest through the solid because the particles (the students) are closer together.

47 What is the speed of sound in air if a sound wave travels 1715 meters in 5 seconds?

- A 8575 m/s
- B 343 m/s
- C 343 m
- D 8575 m

47 What is the speed of sound in air if a sound wave travels 1715 meters in 5 seconds?

- A 8575 m/s
- B 343 m/s
- C 343 m
- D 8575 m

Answer

B

48 What is the speed of sound in air if a sound wave travels 2744 meters in 8 seconds?

- A 21952 m/s
- B 343 m/s
- C 343 m
- D 21952 m

48 What is the speed of sound in air if a sound wave travels 2744 meters in 8 seconds?

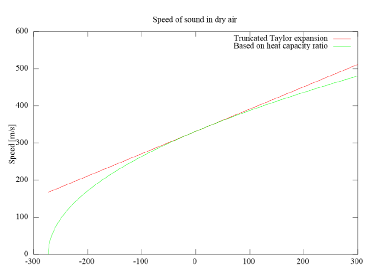
- A 21952 m/s
- B 343 m/s
- C 343 m
- D 21952 m

Answer

B

Speed of sound in air

At room temperature (20 C), the speed of sound is 340 m/s.

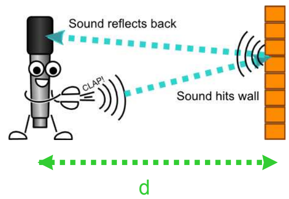


As the temperature increases, the speed of sound increases.
As the temperature decreases, the speed of sound decreases.

Using Echolocation.

d = st

Knowing how long it takes a sound to return after reflection can be helpful in determining how far away an object is, as long as you know the speed of sound in air!



NOTE: This formula gives the distance for "to and from" so if you want the distance we are away from the wall, we have to divide by 2. Why?

49 How far are we away from a wall if a sound returns in 6 seconds? (speed of sound = 343 m/s)

- A 1029 m
- B 2058 m
- C 57 m
- D 343 m

49 How far are we away from a wall if a sound returns in 6 seconds? (speed of sound = 343 m/s)

- A 1029 m
- B 2058 m
- C 57 m
- D 343 m

Answer

A

50 How far are we away from a wall if a sound returns in 10 seconds? (speed of sound = 343 m/s)

- A 1640 m
- B 686 m
- C 3430 m
- D 1715 m

50 How far are we away from a wall if a sound returns in 10 seconds? (speed of sound = 343 m/s)

- A 1640 m
- B 686 m
- C 3430 m
- D 1715 m

Answer

D

The Doppler Effect

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The Doppler Effect

Since the speed of sound in a medium is constant, we can observe the Doppler Effect.

The Doppler effect is named after the Austrian physicist Christian Doppler, who proposed it in 1842 in Prague.

Have you ever heard a firetruck approaching and passing you? What does the siren sound like?

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The Doppler Effect

Since the speed of sound in a medium is constant, we can observe the Doppler Effect.

The Doppler effect is named after the Austrian phys
Christian Doppler, who
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Have you ever hea
Wh
you?

Teacher Notes

The speed of sound in air can generally be considered constant as long as the air doesn't experience changes in temperature or humidity. So as long as the medium of air stays relatively the same, the speed of sound in it will be the same.

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The Doppler Effect

The Doppler Effect is the change in frequency of a wave (or other periodic event) for an observer moving relative to the wave source.

Click here to see a video on the Doppler Effect

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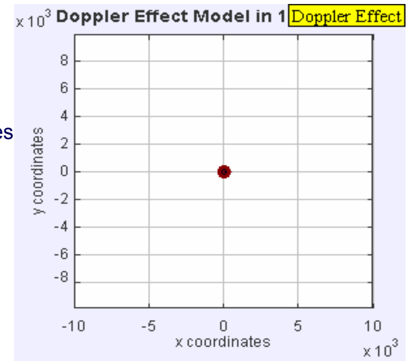
Stationary Sound Sources

When a sound source is stationary, the sound waves move outward in all directions with an equal wavelength.



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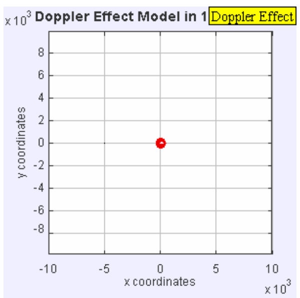
Moving Sound Sources

As the sound source moves right, it "catches up" with the waves that are produced and "moves away" from the waves that move toward the left.

Do you see the way the left and right sides of the model look different?

Can you describe that difference?



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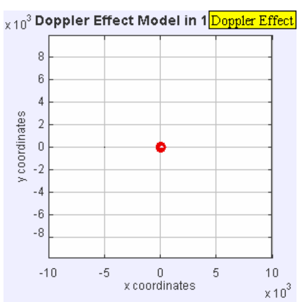
Moving Sound Sources

Since the speed of the sound waves that are produced is constant, and the wavelength is changed both in front as well as in back of the moving source, there is also a change in frequency of the waves.

What does frequency mean?



How would this affect the pitch of the sounds that are heard by an observer standing to the right of the sound source? How about for an observer standing to the left?

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51 The Doppler Effect is a change in frequency and wavelength of a wave when the wave source is in motion compared to the observer.

- True
- False

51 The Doppler Effect is a change in frequency and wavelength of a wave when the wave source is in motion compared to the observer.

- True
- False

Answer

TRUE

52 When a train blowing its horn is moving toward you, you hear:

- A A higher pitch sound
- B The same pitch that is produced
- C A lower pitch sound

52 When a train blowing its horn is moving toward you, you hear:

- A A higher pitch sound
- B The same pitch that is proc
- C A lower pitch sound

Answer

A

53 When a train blowing its horn is moving away from you, you hear:

- A A higher pitch sound
- B The same pitch that is produced
- C A lower pitch sound

53 When a train blowing its horn is moving away from you, you hear:

- A A higher pitch sound
- B The same pitch that is proc
- C A lower pitch sound

Answer

C

54 When a train blowing its horn is not moving compared to you, you hear :

- A A higher pitch sound
- B The same pitch that is produced
- C A lower pitch sound

54 When a train blowing its horn is not moving compared to you, you hear :

- A A higher pitch sound
- B The same pitch that is produced
- C A lower pitch sound

Answer

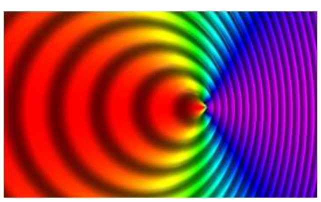
B

What happens when the observer is moving?

The Doppler Effect works for both a moving sound source as well as a moving observer.

We still observe an increase in frequency, even if the observer is moving rather than the sound source!

Click here to see a video on the Doppler Effect



55 You move toward a stationary horn making a sound, you hear:

- A A higher pitch sound
- B The same pitch that is produced
- C A lower pitch sound

55 You move toward a stationary horn making a sound, you hear:

- A A higher pitch sound
- B The same pitch that is p
- C A lower pitch sound

Answer

A

56 An observer is at rest compared to a stationary horn making a sound, the observer hears:

- A A higher pitch sound
- B The same pitch that is produced
- C A lower pitch sound

56 An observer is at rest compared to a stationary horn making a sound, the observer hears:

- A A higher pitch sound
- B The same pitch that is proc
- C A lower pitch sound

Answer

B

57 An observer moves away from a stationary horn making a sound, the observer hears:

- A A higher pitch sound
- B The same pitch that is produced
- C A lower pitch sound

57 An observer moves away from a stationary horn making a sound, the observer hears:

- A A higher pitch sound
- B The same pitch that is pro
- C A lower pitch sound

Answer

C

58 You are standing at a railroad crossing. As the train approaches, the train whistle sounds

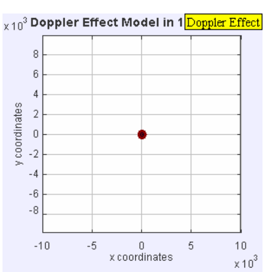
- A Higher pitched as it gets closer
- B The pitch remains the same
- C Lower pitched as it gets closer

58 You are standing at a railroad crossing. As the train approaches, the train whistle sounds

- A Higher pitched as it gets closer
- B The pitch remains the same
- C Lower pitched as it gets closer

Answer: A

Resting Sound Source



If the sound source is at rest, there are equal wavelengths in all directions!

Observers on all sides hear the same frequency sound.

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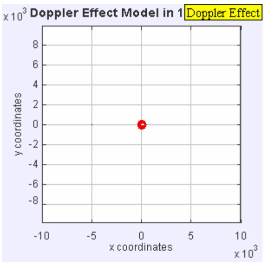
Traveling Slower than the Speed of Sound



If the sound source is moving slower than the speed of sound, then the doppler effect is observed.

The waves in front of the source are compressed.

In back they are expanded!

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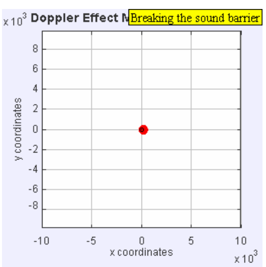
Traveling Faster than the Speed of Sound



If the sound source is moving faster than the speed of sound, it "catches up" with the sound waves that it produces.

The waves all add together "out front" and undergo constructive interference.

Since they add up, we hear a sonic boom when they strike us.

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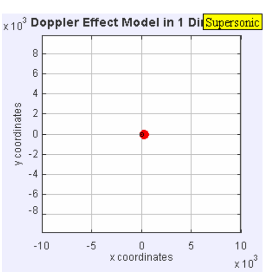
Traveling Faster than the Speed of Sound



Consider a plane moving faster than the speed of sound.

As the plane travels, it passes over an observer on the ground before the sound gets to the observer.

A sonic boom is then heard!

This is called SUPERSONIC FLIGHT!

59 Observers in all locations around astationary sound source hear the same frequency sound.

- True
- False

59 Observers in all locations around astationary sound source hear the same frequency sound.

- True
- False

Answer

TRUE

60 An observer in front of a moving soundsource hears a sound that is ___________ in frequency.

- A lower
- B the same
- C higher

60 An observer in front of a moving sound source hears a sound that is __________ in frequency.

- A lower
- B the same
- C higher

Answer

C

61 An observer behind a moving sound source hears a sound that is __________ in frequency.

- A lower
- B the same
- C higher

61 An observer behind a moving sound source hears a sound that is __________ in frequency.

- A lower
- B the same
- C higher

Answer

A

62 Traveling faster than the speed of soundis called subsonic.

- True
- False

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62 Traveling faster than the speed of soundis called subsonic.

- True
- False

Answer

False

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63 A sonic boom is caused by destructive interference.

- True
- False

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63 A sonic boom is caused by destructive interference.

- True
- False

Answer

False