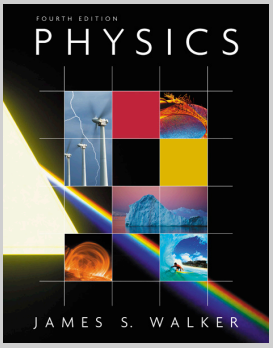

ConcepTest Clicker Questions

Chapter 14

Physics, 4th Edition

James S. Walker

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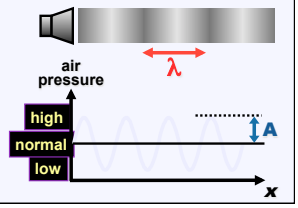
Question 14.1 Sound It Out

Does a longitudinal wave, such as a sound wave, have an amplitude?

a) yes
b) no
c) it depends on the medium the wave is in

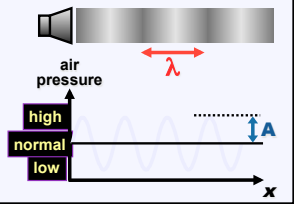


Question 14.1 Sound It Out

Does a longitudinal wave, such as a sound wave, have an amplitude?

a) yes
b) no
c) it depends on the medium the wave is in

All wave types—transverse, longitudinal, surface—have all of these properties: wavelength, frequency, amplitude, velocity, period.



Question 14.2 The Wave

At a football game, the "wave" might circulate through the stands and move around the stadium. In this wave motion, people stand up and sit down as the wave passes. What type of wave would this be characterized as?

a) polarized wave
b) longitudinal wave
c) lateral wave
d) transverse wave
e) soliton wave

Question 14.2 The Wave

At a football game, the "wave" might circulate through the stands and move around the stadium. In this wave motion, people stand up and sit down as the wave passes. What type of wave would this be characterized as?

a) polarized wave
b) longitudinal wave
c) lateral wave
d) transverse wave
e) soliton wave

The people are moving up and down, and the wave is traveling around the stadium. Thus, the motion of the wave is perpendicular to the oscillation direction of the people, and so this is a transverse wave.

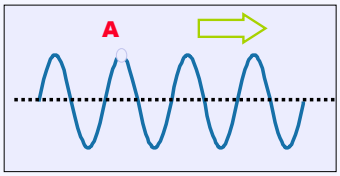
Follow-up: What type of wave occurs when you toss a pebble in a pond?

Question 14.3a Wave Motion I

Consider a wave on a string moving to the right, as shown below.

What is the direction of the velocity of a particle at the point labeled A ?

a)
b)
c)
d)
e) zero



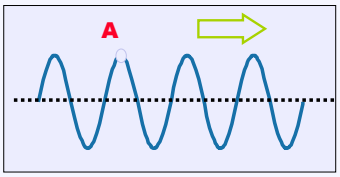
Question 14.3a Wave Motion I

Consider a wave on a string moving to the right, as shown below.

What is the direction of the velocity of a particle at the point labeled **A** ?

a) →
b) ↘
c) ↓
d) ↑
e) zero

The velocity of an oscillating particle is (momentarily) ~~zero~~ at its maximum displacement.



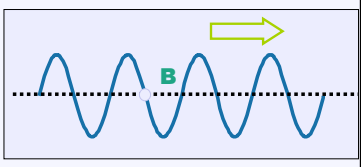
Follow-up: What is the acceleration of the particle at point A?

Question 14.3b Wave Motion II

Consider a wave on a string moving to the right, as shown below.

What is the direction of the velocity of a particle at the point labeled **B** ?

a) →
b) ↘
c) ↓
d) ↑
e) zero



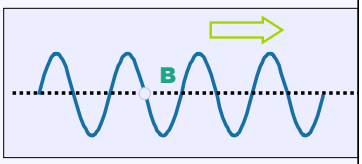
Question 14.3b Wave Motion II

Consider a wave on a string moving to the right, as shown below.

What is the direction of the velocity of a particle at the point labeled **B** ?

a) →
b) ↘
c) ↓
d) ↑
e) zero

The wave is moving to the right, so the particle at B has to start moving upward in the next instant of time.

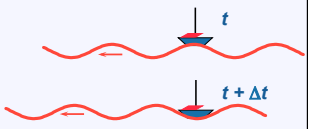


Follow-up: What is the acceleration of the particle at point B?

Question 14.4 Out to Sea

A boat is moored in a fixed location, and waves make it move up and down. If the spacing between wave crests is 20 m and the speed of the waves is 5 m/s, how long does it take the boat to go from the top of a crest to the bottom of a trough ?

a) 1 second
b) 2 seconds
c) 4 seconds
d) 8 seconds
e) 16 seconds



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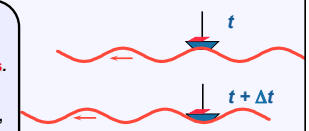
a) 1 second
b) 2 seconds
c) 4 seconds
d) 8 seconds
e) 16 seconds

We know that $v = f\lambda = \lambda / T$, hence $T = \lambda / v$. If $\lambda = 20$ m and $v = 5$ m/s, then $T = 4$ secs.

The time to go from a crest to a trough is only $T/2$ (half a period), so it takes 2 secs !!

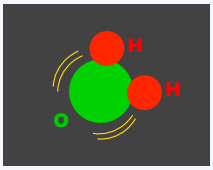


Question 14.5 Lunch Time

Microwaves travel with the speed of light, $c = 3 \times 10^8$ m/s. At a frequency of 10 GHz these waves cause the water molecules in your burrito to vibrate. What is their wavelength?

1 GHz = 1 Gigahertz = 10^9 cycles/sec

a) 0.3 mm
b) 3 cm
c) 30 cm
d) 300 m
e) 3 km



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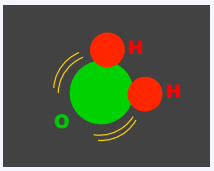
a) 0.3 mm
b) 3 cm
c) 30 cm
d) 300 m
e) 3 km

We know $v_{wave} = \frac{\lambda}{T} = f\lambda$

so $\lambda = \frac{v}{f} = \frac{3 \times 10^8 \text{ m/s}}{10 \times 10^9 \text{ Hz}}$

$\lambda = 3 \times 10^{-2}$ m = 3 cm



Question 14.6a Wave Speed I

A wave pulse can be sent down a rope by jerking sharply on the free end. If the tension of the rope is increased, how will that affect the speed of the wave?

a) speed increases
b) speed does not change
c) speed decreases

Question 14.6a Wave Speed I

A wave pulse can be sent down a rope by jerking sharply on the free end. If the tension of the rope is increased, how will that affect the speed of the wave?

a) speed increases
b) speed does not change
c) speed decreases

The wave speed depends on the square root of the tension, so if the tension increases, then the wave speed will also increase.

Question 14.6b Wave Speed II

A wave pulse is sent down a rope of a certain thickness and a certain tension. A second rope made of the same material is twice as thick, but is held at the same tension. How will the wave speed in the second rope compare to that of the first?

a) speed increases
b) speed does not change
c) speed decreases

Question 14.6b Wave Speed II

A wave pulse is sent down a rope of a certain thickness and a certain tension. A second rope made of the same material is twice as thick, but is held at the same tension. How will the wave speed in the second rope compare to that of the first?

a) speed increases
b) speed does not change
c) speed decreases

The wave speed goes inversely as the square root of the mass per unit length, which is a measure of the inertia of the rope. So in a thicker (more massive) rope at the same tension, the wave speed will decrease.

Question 14.6c Wave Speed III

A length of rope *L* and mass *M* hangs from a ceiling. If the bottom of the rope is jerked sharply, a wave pulse will travel up the rope. As the wave travels upward, what happens to its speed? Keep in mind that the rope is *not* massless.

a) speed increases
b) speed does not change
c) speed decreases

Question 14.6c Wave Speed III

A length of rope *L* and mass *M* hangs from a ceiling. If the bottom of the rope is jerked sharply, a wave pulse will travel up the rope. As the wave travels upward, what happens to its speed? Keep in mind that the rope is ***not*** massless.

a) speed increases
b) speed does not change
c) speed decreases

The tension in the rope is not constant in the case of a massive rope! The tension increases as you move up higher along the rope, because that part of the rope has to support all of the mass below it! Because the tension increases as you go up, so does the wave speed.

Question 14.7a Sound Bite I

When a sound wave passes from air into water, what properties of the wave will change?

a) the frequency *f*
b) the wavelength λ
c) the speed of the wave
d) both *f* and λ
e) both v_{wave} and λ

Question 14.7a Sound Bite I

When a sound wave passes from air into water, what properties of the wave will change?

a) the frequency *f*
b) the wavelength λ
c) the speed of the wave
d) both *f* and λ
e) both v_{wave} and λ

Wave speed must change (different medium). Frequency does not change (determined by the source). Now, $v = f\lambda$ and because v has changed and f is constant then **λ must also change**.

Follow-up: Does the wave speed increase or decrease in water?

Question 14.7b Sound Bite II

We just determined that the wavelength of the sound wave will change when it passes from air into water. How will the wavelength change?

a) wavelength will increase
b) wavelength will not change
c) wavelength will decrease

Question 14.7b Sound Bite II

We just determined that the wavelength of the sound wave will change when it passes from air into water. How will the wavelength change?

a) wavelength will increase
b) wavelength will not change
c) wavelength will decrease

The speed of sound is greater in water, because the force holding the molecules together is greater. This is generally true for liquids, as compared to gases. If the speed is greater and the frequency has not changed (determined by the source), then the wavelength must also have increased ($v = f\lambda$).

Question 14.8a Speed of Sound I

Do sound waves travel faster in water or in ice?

a) water
b) ice
c) same speed in both
d) sound can only travel in a gas

Question 14.8a Speed of Sound I

Do sound waves travel faster in water or in ice?

a) water
b) ice
c) same speed in both
d) sound can only travel in a gas

Speed of sound depends on the inertia of the medium and the restoring force Because ice and water both consist of water molecules, the inertia is the same for both. However, the force holding the molecules together is greater in ice (because it is a solid), so the restoring force is greater. Because $v = \sqrt{(\text{force} / \text{inertia})}$, the speed of sound must be greater in ice!

Question 14.8b Speed of Sound II

Do you expect an echo to return to you more quickly or less quickly on a hot day, as compared to a cold day?

a) more quickly on a hot day
b) equal times on both days
c) more quickly on a cold day

Question 14.8b Speed of Sound II

Do you expect an echo to return to you more quickly or less quickly on a hot day, as compared to a cold day?

a) more quickly on a hot day
b) equal times on both days
c) more quickly on a cold day

The speed of sound in a gas increases with temperature. This is because the molecules are bumping into each other faster and more often, so it is easier to propagate the compression wave (sound wave).

Question 14.8c Speed of Sound III

If you fill your lungs with helium and then try talking, you sound like Donald Duck. What conclusion can you reach about the speed of sound in helium?

a) speed of sound is less in helium
b) speed of sound is the same in helium
c) speed of sound is greater in helium
d) this effect has nothing to do with the speed in helium

Question 14.8c Speed of Sound III

If you fill your lungs with helium and then try talking, you sound like Donald Duck. What conclusion can you reach about the speed of sound in helium?

a) speed of sound is less in helium
b) speed of sound is the same in helium
c) speed of sound is greater in helium
d) this effect has nothing to do with the speed in helium

The higher pitch implies a higher frequency. In turn, because $v = f\lambda$, this means that the speed of the wave has increased (as long as the wavelength, determined by the length of the vocal chords, remains constant).

Follow-up: Why is the speed of sound greater in helium than in air?

Question 14.9 Wishing Well

You drop a rock into a well, and you hear the splash 1.5 s later. If the depth of the well were doubled, how long after you drop the rock would you hear the splash in this case?

a) more than 3 s later
b) 3 s later
c) between 1.5 s and 3 s later
d) 1.5 s later
e) less than 1.5 s later

Question 14.9 Wishing Well

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a) more than 3 s later
b) 3 s later
c) between 1.5 s and 3 s later
d) 1.5 s later
e) less than 1.5 s later

Because the speed of sound is so much faster than the speed of the falling rock, we can essentially ignore the travel time of the sound. As for the falling rock, it is accelerating as it falls, so it covers the bottom half of the deeper well much quicker than the top half. The total time will not be exactly 3 s, but somewhat less.

Follow-up: How long does the sound take to travel the depth of the well?

Question 14.10a Sound Intensity I

You stand a certain distance away from a speaker and you hear a certain intensity of sound. If you double your distance from the speaker, what happens to the sound intensity at your new position?

a) drops to ½ its original value
b) drops to ¼ its original value
c) drops to $^1/_8$ its original value
d) drops to $^1/_{16}$ its original value
e) does not change at all

Question 14.10a Sound Intensity I

You stand a certain distance away from a speaker and you hear a certain intensity of sound. If you double your distance from the speaker, what happens to the sound intensity at your new position?

a) drops to ½ its original value
b) drops to ¼ its original value
c) drops to $^1/_8$ its original value
d) drops to $^1/_{16}$ its original value
e) does not change at all

For a source of a given power P, the intensity is given by $I = P/4\pi r^2$. So if the distance doubles, the intensity must decrease to one-quarter its original value.

Follow-up: What distance would reduce the intensity by a factor of 100?

Question 14.10b Sound Intensity II

You hear a fire truck with a certain intensity, and you are about 1 mile away. Another person hears the same fire truck with an intensity that is about 10 times less. Roughly, how far is the other person from the fire truck?

a) about the same distance
b) about 3 miles
c) about 10 miles
d) about 30 miles
e) about 100 miles

Question 14.10b Sound Intensity II

You hear a fire truck with a certain intensity, and you are about 1 mile away. Another person hears the same fire truck with an intensity that is about 10 times less. Roughly, how far is the other person from the fire truck?

a) about the same distance
b) about 3 miles
c) about 10 miles
d) about 30 miles
e) about 100 miles

Remember that intensity drops with the inverse square of the distance, so if intensity drops by a factor of 10, the other person must be √10 farther away, which is about a factor of 3.

$$\frac{I_2}{I_1} = \frac{P/4\pi r_2^2}{P/4\pi r_1^2} = \frac{r_1^2}{r_2^2}$$

Question 14.11a Decibel Level I

When Mary talks, she creates an intensity level of 60 dB at your location. Alice talks with the same volume, also giving 60 dB at your location. If both Mary and Alice talk simultaneously from the same spot, what would be the new intensity level that you hear?

a) more than 120 dB
b) 120 dB
c) between 60 dB and 120 dB
d) 60 dB
e) less than 60 dB

Question 14.11a Decibel Level I

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a) more than 120 dB
b) 120 dB
c) between 60 dB and 120 dB
d) 60 dB
e) less than 60 dB

Recall that a difference of 10 dB in intensity level β corresponds to a factor of 10^1 in intensity. Similarly, a difference of 60 dB in β corresponds to a factor of 10^6 in intensity!! In this case, with two voices adding up, the intensity increases by only a factor of 2, meaning that the intensity level is higher by an amount equal to $\Delta\beta = 10 \log(2) = 3$ dB. The new intensity level is $\beta = 63$ dB.

Question 14.11b Decibel Level II

A quiet radio has an intensity level of about 40 dB. Busy street traffic has a level of about 70 dB. How much greater is the intensity of the street traffic compared to the radio?

a) about the same
b) about 10 times
c) about 100 times
d) about 1000 times
e) about 10,000 times

Question 14.11b Decibel Level II

A quiet radio has an intensity level of about 40 dB. Busy street traffic has a level of about 70 dB. How much greater is the intensity of the street traffic compared to the radio?

a) about the same
b) about 10 times
c) about 100 times
d) about 1000 times
e) about 10,000 times

increase by 10 dB ⟹ increase intensity by factor of 10^1 (10)

increase by 20 dB ⟹ increase intensity by factor of 10^2 (100)

increase by 30 dB ⟹ increase intensity by factor of 10^3 (1000)

Follow-up: What decibel level gives an intensity a million times greater?

Question 14.11c Decibel Level III

Intensity level is given by $\beta = 10 \log(I/I_0)$ with $I_0 = 10^{-12}$ W/m^2. The usual threshold of human hearing is defined as intensity level of β = 0 dB. What does this actually mean in terms of sound intensity?

a) intensity is undefined at that level
b) intensity is 10^0 W/m^2
c) intensity is 0.0 W/m^2
d) intensity is 10^{-12} W/m^2
e) intensity is 1.0 W/m^2

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d) intensity is 10^{-12} W/m^2
e) intensity is 1.0 W/m^2

In order for β to be equal to zero, the term $\log(I/I_0)$ must also be zero. This occurs when the argument is 1.0, because log(1.0) = 0. In other words, the value of I must be equal to I_0.

Question 14.12a Pied Piper I

You have a long pipe and a short pipe. Which one has the higher frequency?

a) the long pipe
b) the short pipe
c) both have the same frequency
d) depends on the speed of sound in the pipe

Question 14.12a Pied Piper I

You have a long pipe and a short pipe. Which one has the higher frequency?

a) the long pipe
b) the short pipe
c) both have the same frequency
d) depends on the speed of sound in the pipe

A shorter pipe means that the standing wave in the pipe would have a shorter wavelength. Because the wave speed remains the same, the frequency has to be higher in the short pipe.

Question 14.12b Pied Piper II

A wood whistle has a variable length. You just heard the tone from the whistle at maximum length. If the air column is made shorter by moving the end stop, what happens to the frequency?

a) frequency will increase
b) frequency will not change
c) frequency will decrease

Question 14.12b Pied Piper II

A wood whistle has a variable length. You just heard the tone from the whistle at maximum length. If the air column is made shorter by moving the end stop, what happens to the frequency?

a) frequency will increase
b) frequency will not change
c) frequency will decrease

A shorter pipe means that the standing wave in the pipe would have a shorter wavelength. Because the wave speed remains the same, and we know that $v = f\lambda$, then we see that the frequency has to increase when the pipe is made shorter.

Question 14.12c Pied Piper III

If you blow across the opening of a partially filled soda bottle, you hear a tone. If you take a big sip of soda and then blow across the opening again, how will the frequency of the tone change?

a) frequency will increase
b) frequency will not change
c) frequency will decrease

Question 14.12c Pied Piper III

If you blow across the opening of a partially filled soda bottle, you hear a tone. If you take a big sip of soda and then blow across the opening again, how will the frequency of the tone change?

a) frequency will increase
b) frequency will not change
c) frequency will decrease

By drinking some of the soda, you have effectively increased the length of the air column in the bottle. A longer pipe means that the standing wave in the bottle would have a longer wavelength. Because the wave speed remains the same, and we know that $v = f\lambda$, then we see that the frequency has to be lower.

Follow-up: Why doesn't the wave speed change?

Question 14.13 Open and Closed Pipes

You blow into an open pipe and produce a tone. What happens to the frequency of the tone if you close the end of the pipe and blow into it again?

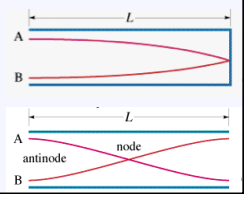
a) depends on the speed of sound in the pipe
b) you hear the same frequency
c) you hear a higher frequency
d) you hear a lower frequency

Question 14.13 Open and Closed Pipes

You blow into an open pipe and produce a tone. What happens to the frequency of the tone if you close the end of the pipe and blow into it again?

a) depends on the speed of sound in the pipe
b) you hear the same frequency
c) you hear a higher frequency
d) you hear a lower frequency

In the open pipe, ½ of a wave "fits" into the pipe, and in the closed pipe, only ¼ of a wave fits. Because the wavelength is larger in the closed pipe, the frequency will be lower



Follow-up: What would you have to do to the pipe to increase the frequency?

Question 14.14 Out of Tune

When you tune a guitar string, what physical characteristic of the string are you actually changing?

a) the tension in the string
b) the mass per unit length of the string
c) the composition of the string
d) the overall length of the string
e) the inertia of the string

Question 14.14 Out of Tune

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a) the tension in the string
b) the mass per unit length of the string
c) the composition of the string
d) the overall length of the string
e) the inertia of the string

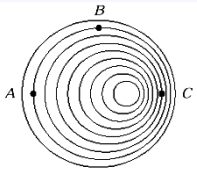
By tightening (or loosening) the knobs on the neck of the guitar, you are changing the tension in the string. This alters the wave speed and therefore alters the frequency of the fundamental standing wave because $f = v/2L$.

Follow-up: To increase frequency, do you tighten or loosen the strings?

Question 14.15a Doppler Effect I

Observers A, B, and C listen to a moving source of sound. The location of the wave fronts of the moving source with respect to the observers is shown below. Which of the following is true?

a) frequency is highest at A
b) frequency is highest at B
c) frequency is highest at C
d) frequency is the same at all three points



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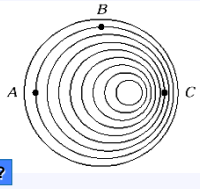
b) frequency is highest at B
c) frequency is highest at C
d) frequency is the same at all three points

The number of wave fronts hitting observer C per unit time is greatest—thus the observed frequency is highest there.



Follow-up: Where is the frequency lowest?

Question 14.15b Doppler Effect II

You are heading toward an island in a speedboat and you see your friend standing on the shore, at the base of a cliff. You sound the boat's horn to alert your friend of your arrival. If the horn has a rest frequency of f_0, what frequency does your friend hear ?

a) lower than f_0
b) equal to f_0
c) higher than f_0

Question 14.15b Doppler Effect II

You are heading toward an island in a speedboat and you see your friend standing on the shore, at the base of a cliff. You sound the boat's horn to alert your friend of your arrival. If the horn has a rest frequency of f_0, what frequency does your friend hear ?

a) lower than f_0
b) equal to f_0
c) higher than f_0

Due to the approach of the source toward the stationary observer, the frequency is shifted higher. This is the same situation as depicted in the previous question.

Question 14.15c Doppler Effect III

In the previous question, the horn had a rest frequency of f_0, and we found that your friend heard a higher frequency f_1 due to the Doppler shift. The sound from the boat hits the cliff behind your friend and returns to you as an echo. What is the frequency of the echo that you hear?

a) lower than f_0
b) equal to f_0
c) higher than f_0 but lower than f_1
d) equal to f_1
e) higher than f_1

Question 14.15c Doppler Effect III

In the previous question, the horn had a rest frequency of f_0, and we found that your friend heard a higher frequency f_1 due to the Doppler shift. The sound from the boat hits the cliff behind your friend and returns to you as an echo. What is the frequency of the echo that you hear?

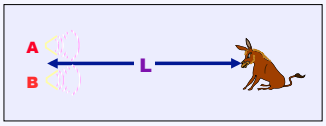
a) lower than f_0
b) equal to f_0
c) higher than f_0 but lower than f_1
d) equal to f_1
e) higher than f_1

The sound wave bouncing off the cliff has the same frequency f_1 as the one hitting the cliff (what your friend hears). For the echo, you are now a moving observer approaching the sound wave of frequency f_1 so you will hear an even higher frequency.

Question 14.16 Interference

Speakers A and B emit sound waves of $\lambda = 1$ m, which interfere constructively at a donkey located far away (say, 200 m). What happens to the sound intensity if speaker A steps back 2.5 m?

a) intensity increases
b) intensity stays the same
c) intensity goes to zero
d) impossible to tell



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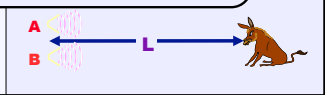
d) impossible to tell

If $\lambda = 1$ m, then a shift of 2.5 m corresponds to 2.5λ, which puts the two waves out of phase, leading to destructive interference. The sound intensity will therefore go to zero.

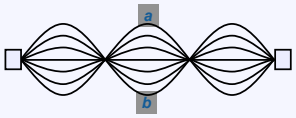
Follow-up: What if you move back by 4 m?



Question 14.17a Standing Waves I

A string is clamped at both ends and plucked so it vibrates in a standing mode between two extreme positions *a* and *b*. Let upward motion correspond to positive velocities. When the string is in position *b*, the instantaneous velocity of points on the string:

a) is zero everywhere
b) is positive everywhere
c) is negative everywhere
d) depends on the position along the string



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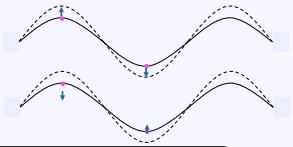
Observe two points:
Just before *b*
Just after *b*

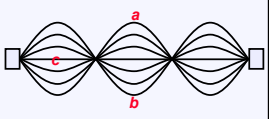


Both points change direction before and after *b*, so at *b* all points must have zero velocity.

Question 14.17b Standing Waves II

A string is clamped at both ends and plucked so it vibrates in a standing mode between two extreme positions *a* and *b*. Let upward motion correspond to positive velocities. When the string is in position *c*, the instantaneous velocity of points on the string:

a) is zero everywhere
b) is positive everywhere
c) is negative everywhere
d) depends on the position along the string

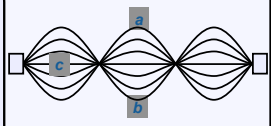


Question 14.17b Standing Waves II

A string is clamped at both ends and plucked so it vibrates in a standing mode between two extreme positions *a* and *b*. Let upward motion correspond to positive velocities. When the string is in position *c*, the instantaneous velocity of points on the string:

a) is zero everywhere
b) is positive everywhere
c) is negative everywhere
d) depends on the position along the string

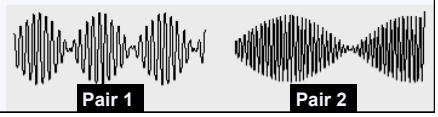
When the string is flat, all points are moving through the equilibrium position and are therefore at their maximum velocity. However, the direction depends on the location of the point. Some points are moving upward rapidly, and some points are moving downward rapidly.



Question 14.18 Beats

The traces below show beats that occur when two different pairs of waves interfere. For which case is the *difference in frequency* of the original waves *greater*?

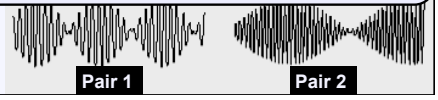
a) pair 1
b) pair 2
c) same for both pairs
d) impossible to tell by just looking



Question 14.18 Beats

The traces below show beats that occur when two different pairs of waves interfere. For which case is the *difference in frequency* of the original waves *greater*?

a) pair 1
b) pair 2
c) same for both pairs
d) impossible to tell by just looking

Recall that the beat frequency is the difference in frequency between the two waves: $f_{beat} = f_2 - f_1$.

Pair 1 has the greater beat frequency (more oscillations in same time period), so pair 1 has the greater frequency difference