

ConceptTest 16.1a Sound Bite I



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

- 1) the frequency f
- 2) the wavelength λ
- 3) the speed of the wave
- 4) both f and λ
- 5) both v_{wave} and λ

ConceptTest 16.1a Sound Bite I

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- 3) the speed of the wave
- 4) both f and λ
- 5) 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?

ConceptTest 16.2a Speed of Sound I



Do sound waves travel
faster in water or in ice?

- (1) water
- (2) ice
- (3) same speed in both
- (4) sound can only travel in a gas

ConceptTest 16.2a Speed of Sound I

Do sound waves travel faster in water or in ice?

(1) water

(2) ice

(3) same speed in both

(4) sound can only travel in a gas

Speed of sound depends on the **inertia** of the medium and the **restoring force**. In ice and water, the inertia is similar. 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!**

ConceptTest 16.2b **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?

- 1) more quickly on a hot day
- 2) equal times on both days
- 3) more quickly on a cold day

ConceptTest 16.2b 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?

- 1) more quickly on a hot day
- 2) equal times on both days
- 3) 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).

ConceptTest 16.2c **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?

- 1) speed of sound is less in helium
- 2) speed of sound is the same in helium
- 3) speed of sound is greater in helium
- 4) this effect has nothing to do with the speed in helium

ConceptTest 16.2c 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?

- 1) speed of sound is less in helium
- 2) speed of sound is the same in helium
- 3) speed of sound is greater in helium
- 4) 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).

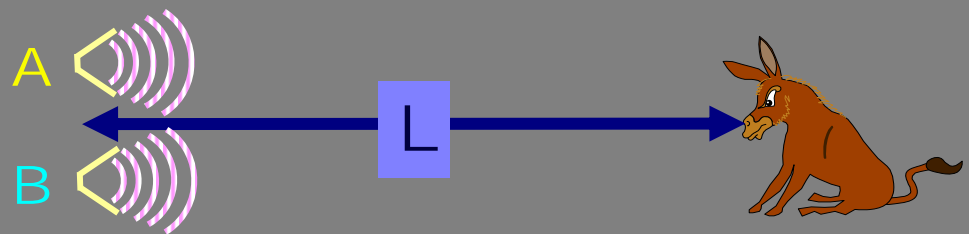
Follow-up: Why is the speed of sound greater in helium than in air?

ConceptTest 16.9 Interference



Speakers **A** and **B** emit sound waves of $\lambda = 1 \text{ m}$, 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?

- 1) intensity increases
- 2) intensity stays the same
- 3) intensity goes to zero
- 4) impossible to tell



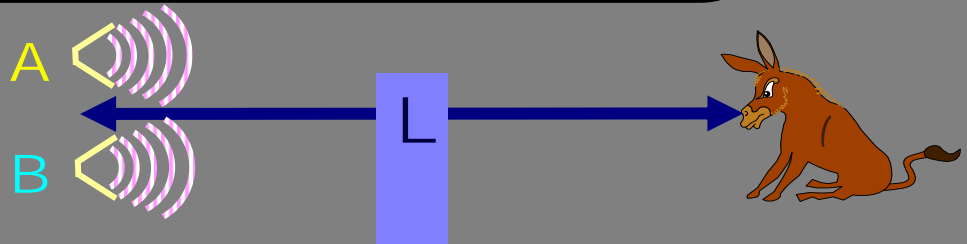
ConceptTest 16.9 Interference

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If $\lambda = 1 \text{ m}$, 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?



ConceptTest 16.7 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?

- 1) depends on the speed of sound in the pipe
- 2) you hear the same frequency
- 3) you hear a higher frequency
- 4) you hear a lower frequency

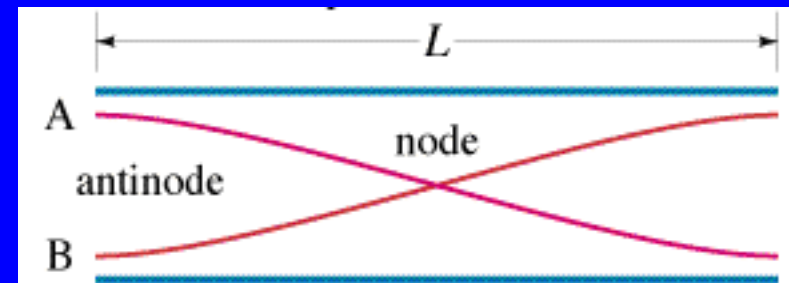
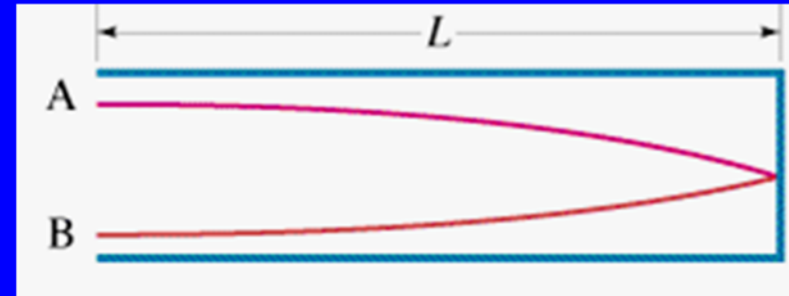
ConceptTest 16.7 Open and Closed Pipes

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?

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In the **open pipe**, $\frac{1}{2}$ of a wave “fits” into the pipe, and in the **closed pipe**, only $\frac{1}{4}$ 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?



ConcepTest 16.5a **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?

- 1) more than 120 dB
- 2) 120 dB
- 3) between 60 dB and 120 dB
- 4) 60 dB
- 5) less than 60 dB

ConceptTest 16.5a 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?

- 1) more than 120 dB
- 2) 120 dB
- 3) between 60 dB and 120 dB
- 4) 60 dB
- 5) 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.

ConceptTest 16.5b 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?

- 1) about the same
- 2) about 10 times
- 3) about 100 times
- 4) about 1000 times
- 5) about 10,000 times

ConceptTest 16.5b 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?

1) about the same

2) about 10 times

3) about 100 times

4) about 1000 times

5) about 10,000 times

increase by 10 dB $\Rightarrow\Rightarrow$ increase intensity by factor of 10^1 (10)

increase by 20 dB $\Rightarrow\Rightarrow$ increase intensity by factor of 10^2 (100)

increase by 30 dB $\Rightarrow\Rightarrow$ increase intensity by factor of 10^3 (1000)

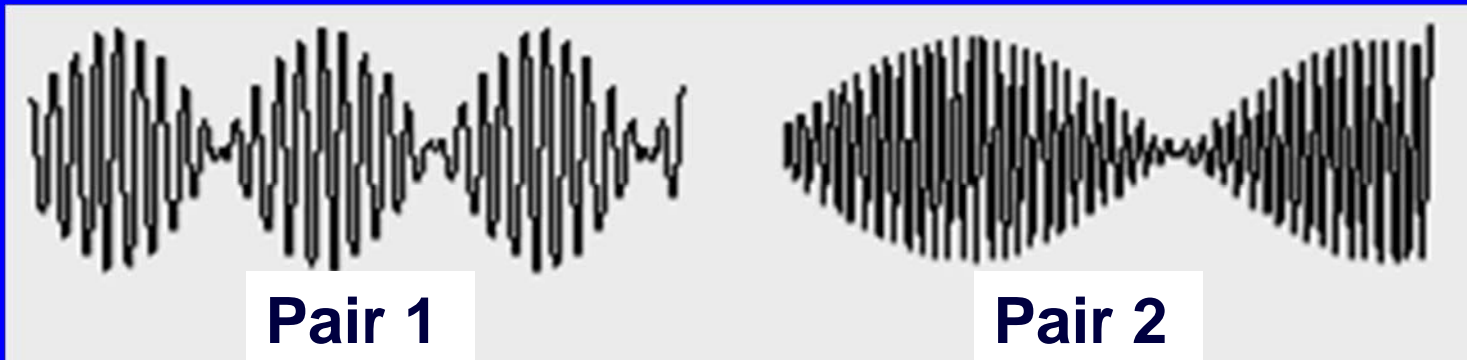
Follow-up: What decibel level gives an intensity a million times greater?

ConceptTest 16.10 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*?

- 1) pair 1
- 2) pair 2
- 3) same for both pairs
- 4) impossible to tell by just looking



ConceptTest 16.10 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*?

1) pair 1

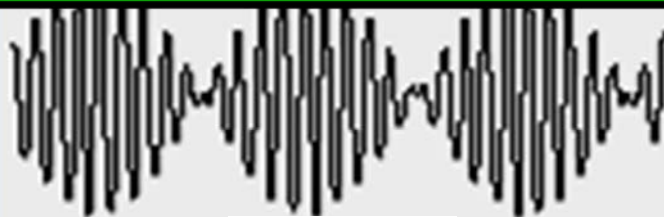
2) pair 2

3) same for both pairs

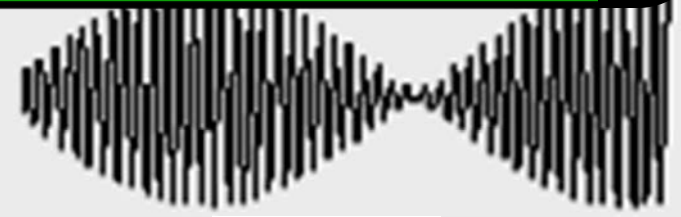
4) impossible to tell by just looking

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

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



Pair 1



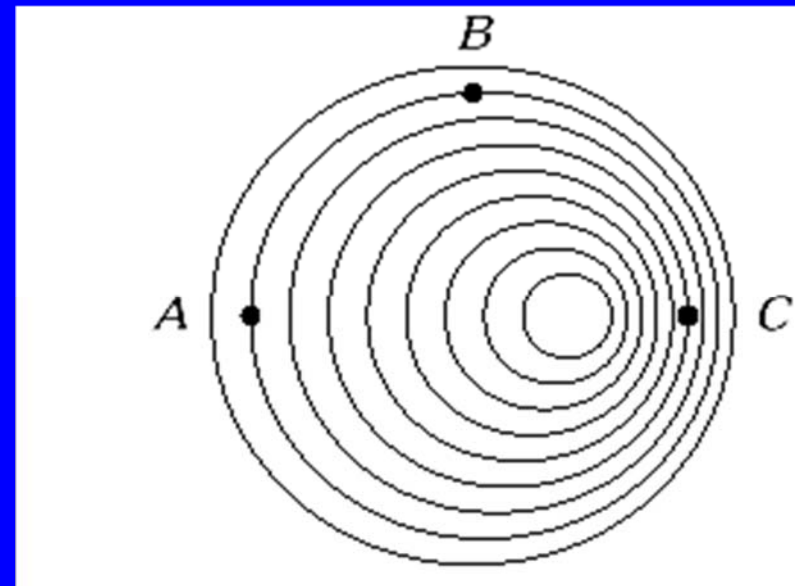
Pair 2

ConceptTest 16.11a 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?

- 1) frequency is highest at A
- 2) frequency is highest at B
- 3) frequency is highest at C
- 4) frequency is the same at all three points

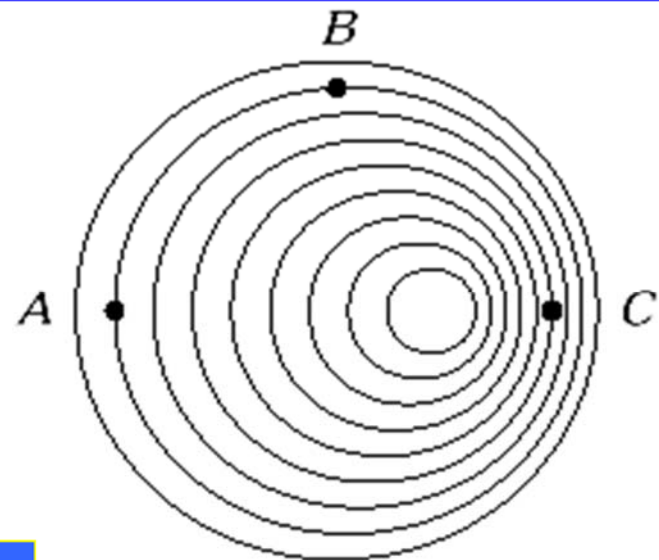


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- 3) frequency is highest at C
- 4) frequency is the same at all three points

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?

ConceptTest 16.11b 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 ?

- 1) lower than f_0
- 2) equal to f_0
- 3) higher than f_0

ConceptTest 16.11b 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 ?

1) lower than f_0

2) equal to f_0

3) 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.

ConceptTest 16.11c 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?

- 1) lower than f_0
- 2) equal to f_0
- 3) higher than f_0 but lower than f_1
- 4) equal to f_1
- 5) higher than f_1

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- 2) equal to f_0
- 3) higher than f_0 but lower than f_1
- 4) equal to f_1
- 5) 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**.