Chasing Sound Waves

How moving sources and listeners change heard frequency

PHY.4.6 "Explore and explain the Doppler effect as it relates to a moving source and to a moving observer using online simulations, probe systems, and/or real-world experiences."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB As you read, underline each statement about crest spacing and circle each statement about how often crests reach a listener. Number the two different causes of a pitch shift: a moving source and a moving listener.

Why the Siren Changes Pitch

1. An ambulance drives past a student waiting at a bus stop. Before it passes, the siren sounds higher than it does after it passes. The driver has not changed the siren's emitted frequency. The moving ambulance sends each new sound crest from a point closer to the student as it approaches. Crests crowd together ahead of the ambulance, so the student receives more crests each second and hears a higher pitch. Behind the ambulance, crests spread farther apart. After it passes, fewer crests reach the student each second, and the pitch sounds lower. The loudness may change too, but loudness alone cannot explain the pitch shift.

2. Now imagine a fixed bell ringing at a steady rate while a cyclist carries a frequency-reading microphone toward it. The bell sends crests outward with the same spacing in the still air. Because the cyclist meets those crests more often, the microphone records a frequency above the bell's emitted frequency. When the cyclist rides away, the microphone meets fewer crests per second and records a lower frequency. Here the observer moves, not the source, so the spacing between crests in the air does not change. In both cases, sound travels through still air at the same speed; motion changes how often crests arrive.

3. An online wave simulation can help separate these two causes. First keep the listener fixed, move the source toward it and then away, and watch crest spacing near the listener. Next fix the source and move the listener toward it and then away; watch how often the listener crosses crests even though their spacing stays fixed. A class can test the pattern with a steady-tone speaker and a phone's frequency probe: move only one at a time and keep the tone setting unchanged. Compare readings during approach and retreat, not just the loudest moment as the objects pass.

2 ANSWER WITH EVIDENCE

Use the passage

1. Why does the siren sound higher before the ambulance passes the student, even though its emitted frequency stays the same?

2. After the ambulance passes, how do crest spacing and heard pitch change for the student?

3. When the cyclist approaches the fixed bell, what changes at the microphone, and what stays unchanged in the air?

4. In the simulation, what would you watch to tell a moving source from a moving listener if either one produces a higher heard frequency?

3 YOUR TURN

Your own words

Design two tests using a steady-tone speaker and a phone's frequency probe: move only the speaker in one test and only the phone in the other. Describe what you would keep constant, predict the readings during approach and retreat, and explain one difference between the causes.

ANSWER KEY

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PART 1 · READ AND MARK

As you read, underline each statement about crest spacing and circle each statement about how often crests reach a listener. Number the two different causes of a pitch shift: a moving source and a moving listener. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Why does the siren sound higher before the ambulance passes the student, even though its emitted frequency stays the same?	**As the ambulance approaches, crests crowd together ahead of it. More crests reach the student each second, so the heard pitch is higher.**
2	After the ambulance passes, how do crest spacing and heard pitch change for the student?	**Crests behind the ambulance are farther apart, so fewer reach the student each second and the heard pitch is lower.**
3	When the cyclist approaches the fixed bell, what changes at the microphone, and what stays unchanged in the air?	**The microphone meets more crests per second and records a higher frequency. Crest spacing in the air stays unchanged.**
4	In the simulation, what would you watch to tell a moving source from a moving listener if either one produces a higher heard frequency?	**With a moving source, crests crowd together ahead of it. With a moving listener and fixed source, crest spacing stays fixed, but the listener crosses crests more often.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would set a speaker to one steady tone and use a phone's frequency probe in a quiet hallway. In test one, I would keep the phone still and roll the speaker toward it, then away at the same speed. Crests would crowd ahead and spread behind, giving higher then lower readings. In test two, I would fix the speaker and move the phone toward it, then away at that speed. Spacing in the air would stay fixed, but the phone would meet crests more often, then less often.

Accept explanations that distinguish changed crest spacing for a moving source from changed crest encounter rate for a moving observer. Readings should be above the emitted frequency during approach and below it during retreat.