

Sound Lab

Simulation: edtechsims.com/sound

Name: _____ Class: _____ Date: _____



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Part A: Sound Waves (Tab 1)

On the sim: Open Tab 1. Read Key Concepts, then watch the loudspeaker push the air particles. Follow the red tracer particle.

A1 Fig. 1 shows the air particles in front of a vibrating loudspeaker.

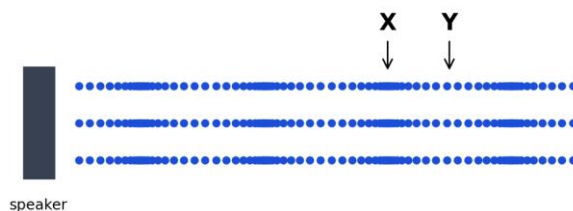


Fig. 1

(a) Name the regions labelled X and Y.

[2]

X:

Y:

(b) On Fig. 1, draw a double-headed arrow to show one wavelength. Label it λ .

[1]

A2 Describe the motion of the red tracer particle. Does it travel from the loudspeaker to the listener?

[2]

.....

A3 Complete the sentences.

[3]

Sound is a _____ wave: the particles vibrate _____ to the direction in which the wave travels.

Sound is produced by _____ objects.

A4 Use the frequency slider. Record the wavelength for three frequencies, then calculate $f \times \lambda$. [3]

Frequency f / Hz	Wavelength λ / m	$f \times \lambda$ / (m/s)

What do you notice about $f \times \lambda$?

.....

Check Your Understanding score: _____ / _____

Part B: Sound Needs a Medium (Tab 2)

On the sim: Open Tab 2. Ring the bell, then pump the air out of the bell jar. Then run the speed race through air, water and steel.

B1 Describe what you hear as the air is pumped out. Explain why the hammer is still seen moving. [3]

.....

.....

.....

B2 Why can astronauts not hear an explosion in space? [1]

.....

B3 Record the speed of sound and the time taken to travel 1 km in each medium. [3]

Medium	Speed of sound / (m/s)	Time to travel 1 km / s
Air		
Water		
Steel		

B4 Explain why sound travels fastest in solids and slowest in gases. [2]

.....

.....

Check Your Understanding score: _____ / _____

Part C: Pitch & Loudness (Tab 3)

On the sim: Open Tab 3. Use the CRO Tone Studio: change the frequency and amplitude sliders and listen. Then play Compare the Traces and Test Your Hearing Range.

C1 Complete the sentences. [4]

The pitch of a sound depends on its _____. A higher frequency gives a _____ pitch.

The loudness of a sound depends on its _____. A larger amplitude gives a _____ sound.

C2 Set the timebase to 1 ms/div. Choose a frequency, then count the divisions for one complete wave. [3]

Frequency set / Hz	Divisions for one wave	Period T / ms	$f = 1 / T$ / Hz

C3 Record your hearing range from the hearing test. [2]

Lowest: Hz Highest: Hz

Compare the Traces score: _____ / 8 Check Your Understanding score: _____ / _____

Part D: Echo Method (Tab 4)

On the sim: Open Tab 4. Set a distance to the wall, start clapping in time with the echoes, and time 20 intervals with the stopwatch. Repeat for three readings.

D1 Complete Table 1. [4]

Reading	Distance d / m	Time for 20 intervals / s	Time for 1 interval t / s	$v = 2d / t$ (m/s)
1				
2				
3				

Average speed of sound:

D2 Why is the distance multiplied by 2 in $v = 2d / t$? [1]

.....
.....

D3 Why are 20 intervals timed instead of just one? [2]

.....
.....

D4 Suggest why the wall should be at least 50 m away. [1]

.....

Check Your Understanding score: _____ / _____

Part E: Ultrasound (Tab 5)

On the sim: Open Tab 5. Move the ship, send a pulse and read the echo time. Calculate the depth, then reveal the seabed after five readings.

E1 What is ultrasound? [1]

.....

E2 Record your sonar readings in Table 2. [4]

Position	Echo time t / s	Speed of sound in water / (m/s)	Depth = $v \times t \div 2$ / m
1			
2			
3			
4			
5			

E3 Did your map match the hidden seabed? Suggest one reason why your map may differ. [2]

.....

E4 State two other uses of ultrasound. [2]

.....

.....

Check Your Understanding score: _____ / _____

Part F: Practice Questions

F1 A student stands 85 m from a tall wall and claps. She hears the echo 0.50 s later. Calculate the speed of sound in air. [2]

speed = ... m/s

F2 Fig. 2 shows the trace of a sound on a CRO. The timebase is set to 1 ms/div.

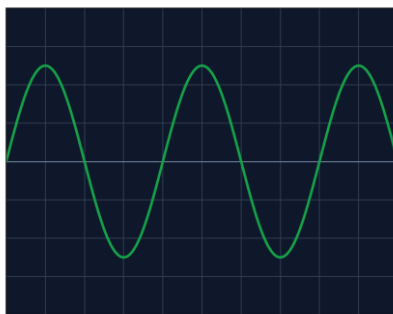


Fig. 2

(a) Calculate the frequency of the sound.

[2]

frequency = ... Hz

(b) The sound is made louder and its pitch is raised. On Fig. 2, sketch the new trace.

[2]

F3 Fig. 3 shows the CRO traces of two sounds, P and Q, on the same settings.

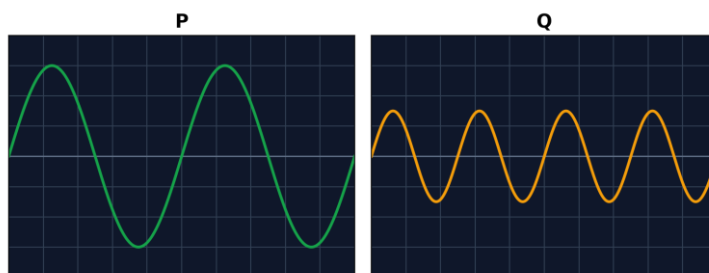


Fig. 3

(a) Which sound is louder? Explain.

[1]

.....

(b) Which sound has the higher pitch? Explain.

[1]

.....

F4 A ship sends an ultrasound pulse to the seabed. The echo returns 0.80 s later. The speed of sound in sea water is 1500 m/s. Calculate the depth of the sea.

[2]

depth = ... m

F5 During a storm, thunder is heard 3.0 s after the lightning is seen. Calculate the distance to the lightning, and explain why the lightning is seen first. (Speed of sound in air = 340 m/s.)

[3]

.....

.....

.....

Answer Key: Sound Lab

Part A: Sound Waves (Tab 1)

On the sim: Open Tab 1. Read Key Concepts, then watch the loudspeaker push the air particles. Follow the red tracer particle.

A1 Fig. 1 shows the air particles in front of a vibrating loudspeaker.

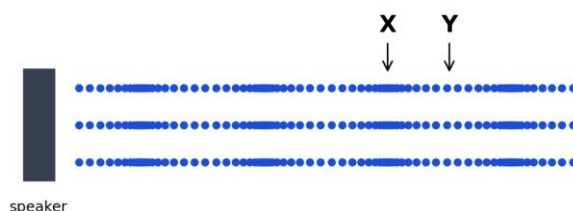


Fig. 1

(a) Name the regions labelled X and Y. [2]

X: compression. Y: rarefaction.

(b) On Fig. 1, draw a double-headed arrow to show one wavelength. Label it λ . [1]

From the centre of one compression to the centre of the next (or rarefaction to rarefaction).

A2 Describe the motion of the red tracer particle. Does it travel from the loudspeaker to the listener? [2]

It vibrates back and forth about a fixed position, parallel to the direction the sound travels. It does not travel to the listener; only energy is transferred.

A3 Complete the sentences. [3]

Sound is a **longitudinal** wave: the particles vibrate **parallel** to the direction in which the wave travels.

Sound is produced by **vibrating** objects.

A4 Use the frequency slider. Record the wavelength for three frequencies, then calculate $f \times \lambda$. [3]

Frequency f / Hz	Wavelength λ / m	$f \times \lambda$ / (m/s)

Values from the sim. $f \times \lambda$ stays constant (the speed of sound in air); as f increases, λ decreases.

Check Your Understanding: score from the sim.

Part B: Sound Needs a Medium (Tab 2)

On the sim: Open Tab 2. Ring the bell, then pump the air out of the bell jar. Then run the speed race through air, water and steel.

B1 Describe what you hear as the air is pumped out. Explain why the hammer is still seen moving. [3]

The sound gets softer and fades away. The bell is still vibrating (light can travel through the vacuum, so we still see it), but sound needs a medium and there are almost no air particles to pass on the vibrations.

B2 Why can astronauts not hear an explosion in space? [1]

Space is a vacuum; there is no medium for sound to travel through.

B3 Record the speed of sound and the time taken to travel 1 km in each medium. [3]

Medium	Speed of sound / (m/s)	Time to travel 1 km / s
Air		
Water		
Steel		

Values from the sim (about 340, 1500 and 5000+ m/s). Time = $1000 \div \text{speed}$.

B4 Explain why sound travels fastest in solids and slowest in gases. [2]

Particles in a solid are closest together and strongly held, so vibrations are passed from particle to particle most quickly. In a gas the particles are far apart.

Check Your Understanding: score from the sim.

Part C: Pitch & Loudness (Tab 3)

On the sim: Open Tab 3. Use the CRO Tone Studio: change the frequency and amplitude sliders and listen. Then play Compare the Traces and Test Your Hearing Range.

C1 Complete the sentences. [4]

The pitch of a sound depends on its **frequency**. A higher frequency gives a **higher** pitch.

The loudness of a sound depends on its **amplitude**. A larger amplitude gives a **louder** sound.

C2 Set the timebase to 1 ms/div. Choose a frequency, then count the divisions for one complete wave. [3]

Frequency set / Hz	Divisions for one wave	Period T / ms	$f = 1 / T$ / Hz

Values from the sim; the calculated f should match the frequency set.

C3 Record your hearing range from the hearing test. [2]

Student's own values; the normal human range is about 20 Hz to 20 kHz. Sound above 20 kHz is ultrasound.

Scores from the sim.

Part D: Echo Method (Tab 4)

On the sim: Open Tab 4. Set a distance to the wall, start clapping in time with the echoes, and time 20 intervals with the stopwatch. Repeat for three readings.

D1 Complete Table 1. [4]

Reading	Distance d / m	Time for 20 intervals / s	Time for 1 interval t / s	$v = 2d / t$ / (m/s)
1				
2				
3				

Values from the sim; v should be about 335–350 m/s.

D2 Why is the distance multiplied by 2 in $v = 2d / t$? [1]

In one interval the sound travels to the wall and back, a total distance of $2d$.

D3 Why are 20 intervals timed instead of just one? [2]

The time for one echo is very short, so reaction-time errors would be large compared with it. Timing many intervals makes the reaction-time error small compared with the total time, so the result is more accurate.

D4 Suggest why the wall should be at least 50 m away. [1]

So that the echo is heard clearly separated from the clap, and the time is long enough to measure accurately.

Check Your Understanding: score from the sim.

Part E: Ultrasound (Tab 5)

On the sim: Open Tab 5. Move the ship, send a pulse and read the echo time. Calculate the depth, then reveal the seabed after five readings.

E1 What is ultrasound? [1]

Sound with a frequency above 20 kHz, beyond the upper limit of human hearing.

E2 Record your sonar readings in Table 2. [4]

Position	Echo time t / s	Speed of sound in water / (m/s)	Depth = $v \times t \div 2$ / m
1			
2			
3			
4			
5			

Values from the sim. Depth = $v \times t \div 2$ because the pulse travels down to the seabed and back.

E3 Did your map match the hidden seabed? Suggest one reason why your map may differ. [2]

Open response, e.g. only five points were measured, so features between the points were missed.

E4 State two other uses of ultrasound. [2]

Any two: prenatal scanning of a fetus; detecting cracks or flaws in metals; cleaning jewellery or instruments; medical imaging of organs.

Check Your Understanding: score from the sim.

Part F: Practice Questions

F1 A student stands 85 m from a tall wall and claps. She hears the echo 0.50 s later. Calculate the speed of sound in air. [2]

$$v = 2d \div t = (2 \times 85) \div 0.50 = 340 \text{ m/s}$$

F2 Fig. 2 shows the trace of a sound on a CRO. The timebase is set to 1 ms/div.

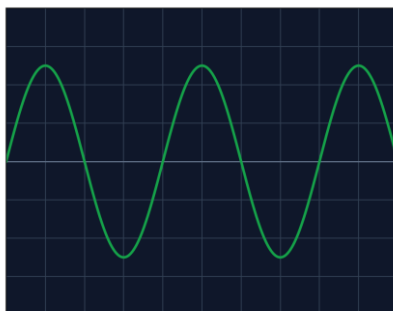


Fig. 2

(a) Calculate the frequency of the sound. [2]

One wave = 4 div, so $T = 4 \times 1 \text{ ms} = 4 \text{ ms} = 0.004 \text{ s}$. $f = 1 \div 0.004 = 250 \text{ Hz}$.

(b) The sound is made louder and its pitch is raised. On Fig. 2, sketch the new trace. [2]

A trace with a larger amplitude (taller) and a shorter period (more waves across the screen).

F3 Fig. 3 shows the CRO traces of two sounds, P and Q, on the same settings.

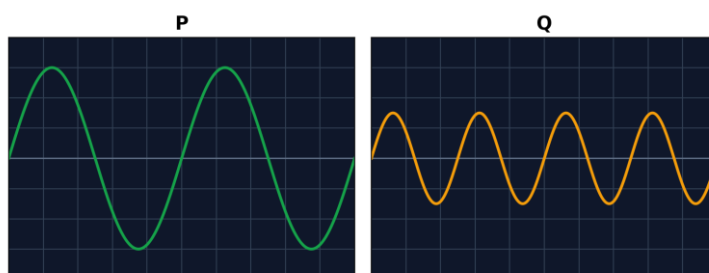


Fig. 3

(a) Which sound is louder? Explain. [1]

P. Its trace has the larger amplitude.

(b) Which sound has the higher pitch? Explain. [1]

Q. It has more waves on the screen, so a higher frequency.

F4 A ship sends an ultrasound pulse to the seabed. The echo returns 0.80 s later. The speed of sound in sea water is 1500 m/s. Calculate the depth of the sea. [2]

$$\text{Depth} = (1500 \times 0.80) \div 2 = 600 \text{ m}$$

F5 During a storm, thunder is heard 3.0 s after the lightning is seen. Calculate the distance to the lightning, and explain why the lightning is seen first. (Speed of sound in air = 340 m/s.) [3]

Distance = $340 \times 3.0 = 1020 \text{ m}$. Light travels much faster than sound ($3 \times 10^8 \text{ m/s}$), so the light reaches the observer almost instantly.