Doppler effect: modelling moving wave sources

Student activity • observation and reasoning

YEAR 11 / LESSON 66 / PHYSICS + SCIENCE (DOUBLE AWARD)

The question

Why do observers ahead of and behind a moving source receive different frequencies?

Construct equal-time wavefront diagrams on paper. The activity uses no swinging sound source.

Equipment

- Squared paper, ruler, compass and pencil

Paper modelling only. Use drawing compasses carefully, keep points capped when stored and do not swing sound sources or objects on strings.

Course coverage: Shared Physics / Double Award: 3.8. Relative source motion and observed frequency.

Plan, model or apparatus sketch

Draw the relevant wavefront, particle or energy-transfer model and label its assumptions.

Method and reasoning

Read the whole sequence before starting

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1. On squared paper mark a stationary source. Draw four circular wavefronts representing pulses emitted at equal time intervals, with radii 2, 4, 6 and 8 cm at one common observation time.

2. On a second sheet mark source positions x = 0, 1, 2 and 3 cm along a straight line. These are successive emission positions, one second apart.

3. At the common observation time one second after the fourth emission, draw radii 8, 6, 4 and 2 cm centred respectively at those four positions. The model wave speed is 2 cm s^{-1} and source speed 1 cm s^{-1}.

4. Mark a stationary observer ahead and another behind the source path. Compare wavefront spacings along that line: fronts are closer ahead and farther apart behind.

5. Explain why a fixed observer ahead encounters fronts more frequently while the source approaches, and why a rear observer receives them less frequently. Keep the emitted frequency unchanged in your explanation.

6. State the model limitations: two-dimensional circles, a uniform stationary medium and a subsonic source. Explain that a change in loudness alone is not evidence of a Doppler frequency shift.

Cleanup

- Close compasses and return equipment; retain the labelled model.

Record your evidence

Blank spaces are for your own work

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Reference and task data

The diagram is a scale model, not a sound-speed measurement. Emission interval is 1 s and wave speed is fixed in the medium. At the chosen instant, forward spacing is 1 cm and rear spacing is 3 cm. The source does not carry previously emitted wavefronts along with it.

Emission position / cm	Radius / cm	Reason
0	8	
1	6	
2	4	
3	2	

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Which frequency is unchanged in the model?

2. Why are older wavefronts larger?

3. Which observer receives a higher frequency while approached?

4. Does the wave speed in this uniform medium change ahead of the source?

5. Is louder sound necessarily higher frequency?

6. Why is the newest wavefront centred at a different point?