

Wave speed required practical

AQA GCSE Combined Trilogy 8464 and Separate Physics 8463 | Paper 2 | Both tiers

Worked answers and marking guidance | 29 parts | 47 marks

Specification points covered

8463 4.6.1.1 / 8464 6.6.1.1: transverse oscillations and wave energy transfer
8463 4.6.1.2 / 8464 6.6.1.2: wavelength, amplitude, frequency, period and wave speed
Practical follow-up: wave measurements in water and a solid — 8463 RP8 / 8464 RP20

A science centre is commissioning two wave displays: a ripple tank and a vibrating solid elastic cord. Your measurements and instructions must help a technician check the displays before visitors arrive.

Original PhysicsUK practice, not an official AQA resource. Both qualifications and both tiers complete all sections. Credit equivalent methods and consistent error carried forward. The loop-to-wavelength rule is supplied; no A-level standing-wave theory is needed.

1 Checking the visitor explanations

A small cork floats at a fixed horizontal position in the ripple tank. It oscillates vertically as straight wave crests travel horizontally to the right.

1(a) State what a travelling wave transfers from one place to another. **[1 mark]**

Answer / mark points: Energy. [1] The medium is not carried along with the wave.

1(b) State what is meant by the period of an oscillation. **[1 mark]**

Answer / mark points: The time for one complete oscillation. [1] It is not the number of oscillations per second.

1(c) The cork moves up and down while the crests move to the right. Explain why this observation is consistent with a transverse wave. **[2 marks]**

Answer / mark points: The cork oscillates vertically, showing the direction of particle oscillation. [1] This direction is perpendicular to the horizontal direction of wave travel/energy transfer. [1] The two directions must be compared.

1(d) The cork's highest position is 6.0 mm above its undisturbed position. Its lowest position is 6.0 mm below. State the amplitude. **[1 mark]**

Answer / mark points: 6.0 mm (0.0060 m). [1] Amplitude is maximum displacement from the undisturbed position, not the 12 mm peak-to-peak distance.

1(e) A trainee labels this 6.0 mm vertical displacement as the wavelength. Explain why that label is wrong and describe the distance that should be measured for wavelength. **[2 marks]**

Answer / mark points: The 6.0 mm is a vertical displacement/amplitude, not a spatial repeat distance along wave travel. [1]
Measure horizontally between adjacent crests (or adjacent equivalent points) in the tank. [1]
"Between two waves" without identifying equivalent points is insufficient.

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2 Reading a calibrated water-wave image

Figure 1 is a top view at one instant. Each vertical line represents a crest. P and Q label the first and last crests shown. The scale is calibrated in the actual water-surface plane; it is not a magnified screen image.

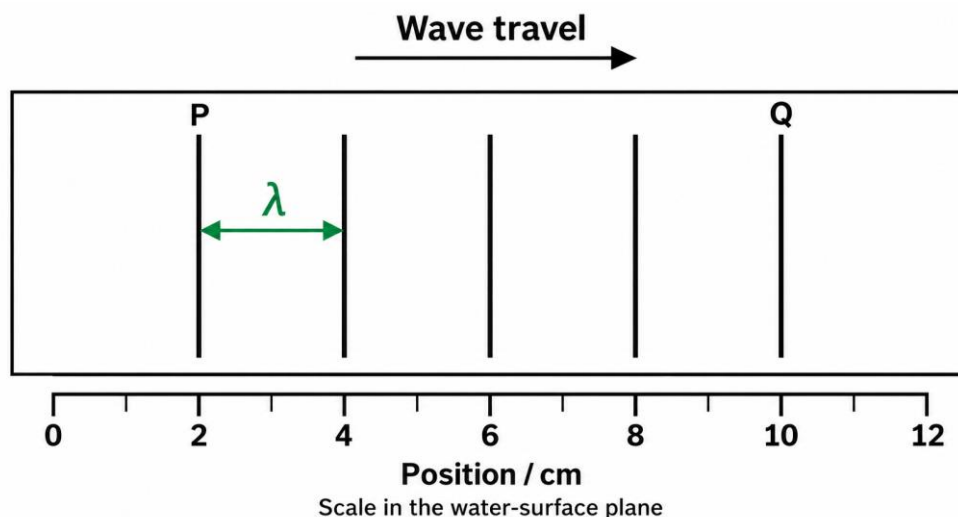


Figure 1

2(a) How many complete wavelengths lie between P and Q? **[1 mark]**

Answer / mark points: Four complete wavelengths. [1] Five crests enclose four intervals.

2(b) Use the scale readings at P and Q to calculate the wavelength in metres. Show your working. **[2 marks]**

Answer / mark points: P to Q = $10 - 2 = 8.0$ cm; $\lambda = 8.0 / 4 = 2.0$ cm. [1]
 $\lambda = 0.020$ m. [1] Accept an adjacent-crest method with a clear reading and conversion. For this Show your working task, a bare answer earns at most 1 mark.

2(c) A trainee calculates $8.0 \text{ cm} \div 5 = 1.6 \text{ cm}$. Explain the counting error and state which divisor should be used. **[2 marks]**

Answer / mark points: The trainee has counted crests rather than complete crest-to-crest intervals. [1]
 Use 4, because five crests enclose four complete wavelengths. [1] Do not accept an unexplained replacement number for both marks.

2(d) To measure crest spacing, should a ruler be parallel or perpendicular to the straight crests? **[1 mark]**

Answer / mark points: Perpendicular to the crests. [1] This is parallel to wave travel in this top-view image.

2(e) Explain why this single still image is not sufficient to determine the frequency. **[1 mark]**

Answer / mark points: It contains no elapsed-time information/no count of waves passing a point per unit time. [1] Wavelength is spatial; frequency needs time.



3 Using the camera's real recording time

A camera records the same cork for ten COMPLETE oscillations in each trial. Table 1 gives elapsed times from the recording timestamps, not playback times. The driver setting and water depth stay the same. For 3(d), use a wavelength of 0.020 m.

Table 1

Trial	Time for ten complete oscillations / s
1	1.96
2	2.04
3	2.00

3(a) Calculate the mean elapsed time for ten complete oscillations. **[1 mark]**

Answer / mark points: Mean time = $(1.96 + 2.04 + 2.00) / 3 = 2.00$ s. [1] This is the time for ten oscillations, not one.

3(b) Use the mean elapsed time to calculate the frequency. **[1 mark]**

Answer / mark points: $f = 10 / 2.00 = 5.0$ Hz. [1] Dividing time by count would give the period instead.

3(c) Calculate the period of the cork's oscillation. **[1 mark]**

Answer / mark points: $T = 1 / 5.0 = 0.20$ s. [1] Also accept $T = 2.00 / 10 = 0.20$ s.

3(d) Use the stated wavelength of 0.020 m and your frequency to calculate the wave speed. **[1 mark]**

Answer / mark points: $v = f\lambda = 5.0 \times 0.020 = 0.10$ m s⁻¹. [1] This is wave speed, not the cork's vertical speed.

3(e) A slowed video takes 8.0 s to play the ten oscillations. A trainee uses $10 \div 8.0 = 1.25$ Hz. Explain why this is not the actual frequency and identify the correct time to use. **[2 marks]**

Answer / mark points: The 8.0 s is a deliberately enlarged playback time, not the time taken by the physical oscillations. [1]
Use the real elapsed recording time, 2.00 s (giving 5.0 Hz). [1] Replaying slowly helps counting but does not change the original frequency.

3(f) Explain why timing ten oscillations rather than one can reduce the effect of reaction-time error when using a stopwatch. **[2 marks]**

Answer / mark points: The total timed interval is longer. [1]
A similar absolute start/stop reaction-time error is therefore a smaller fraction of that total; divide the total by ten to obtain the period. [1] Timing more oscillations does not make the operator's reaction time zero.



4 Commissioning the solid-cord display

Figure 2 shows a snapshot of the vibrating cord. P to Q is 1.20 m long. A clear loop pattern stays in position while the cord vibrates at 25 Hz. Use this rule: each loop span is HALF a wavelength; two adjacent loop spans make one complete wavelength. Do not derive this rule.

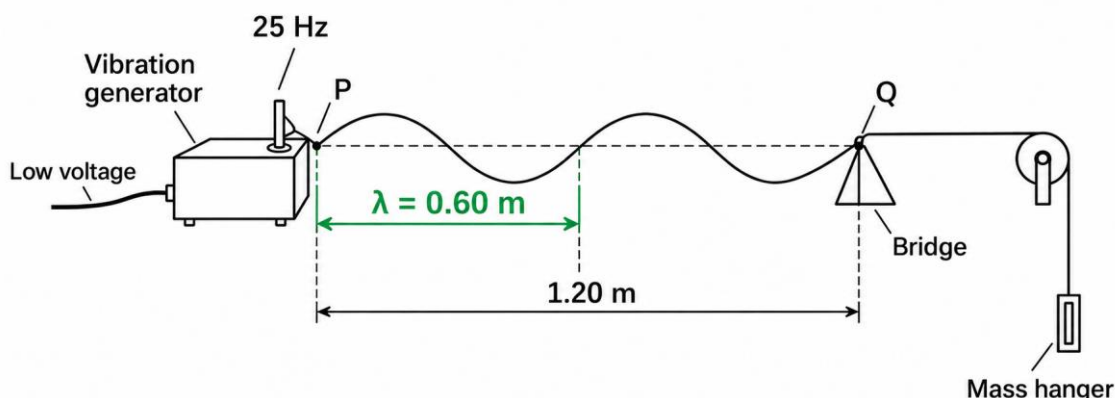


Figure 2

4(a) How many complete wavelengths fit between P and Q in Figure 2? **[1 mark]**

Answer / mark points: Two complete wavelengths: four half-wave loop spans. [1] Do not divide the full length by four to obtain a full wavelength.

4(b) Calculate the wavelength and then the wave speed along the cord. **[2 marks]**

Answer / mark points: $\lambda = 1.20 / 2 = 0.60$ m. [1]
 $v = 25 \times 0.60 = 15$ m s⁻¹. [1] Equivalently, $\lambda = 2 \times 1.20 / 4$.

4(c) Calculate the period of the vibration generator at 25 Hz. **[1 mark]**

Answer / mark points: $T = 1 / 25 = 0.040$ s. [1] A frequency of 25 Hz is not a period of 25 s.

4(d) A painted mark on the cord moves up and down. Does it travel along the cord at the calculated wave speed? Explain. **[1 mark]**

Answer / mark points: No: the mark oscillates about its fixed position; the calculated speed describes travelling wave disturbances/energy along the cord, not material carried from P to Q. [1 for decision with the distinction] The loop pattern itself can remain in place.

4(e) At another setting, the wave speed is 15 m s⁻¹ and the wavelength is 30 cm. Calculate the frequency. **[2 marks]**

Answer / mark points: $\lambda = 30$ cm = 0.30 m. [1]
 $f = v / \lambda = 15 / 0.30 = 50$ Hz. [1] Using 30 without converting would give 0.50, with inconsistent units.



5 Checking other test settings

Each part below is an independent commissioning check. Use only its stated values. The water and solid displays need not have the same wave speed.

5(a) A new water-wave test gives a frequency of 8.0 Hz. Five complete wavelengths span 6.0 cm. Calculate the wavelength in metres and the wave speed. **[2 marks]**

Answer / mark points: $\lambda = 6.0 / 5 = 1.2 \text{ cm} = 0.012 \text{ m}$. [1 for wavelength in metres]
 $v = 8.0 \times 0.012 = 0.096 \text{ m s}^{-1}$. [1] Five complete intervals are explicitly given in this test; they are not five crests.

5(b) A different solid-cord test has six half-wave loop spans over 1.50 m at 40 Hz. Use the rule in section 4 to calculate the wavelength and the wave speed. **[2 marks]**

Answer / mark points: Six half-wave loop spans contain three full wavelengths, so $\lambda = 1.50 / 3 = 0.50 \text{ m}$. [1]
 $v = 40 \times 0.50 = 20 \text{ m s}^{-1}$. [1] No tension or resonance equation is required.

5(c) Describe how a technician could obtain the wavelength and the frequency using the solid-cord apparatus in Figure 2. **[2 marks]**

Answer / mark points: Measure P to Q with a metre ruler and count the half-wave loop spans; divide the length by the number of full wavelengths (or use $\lambda = 2 \times \text{length} / \text{number of loops}$). [1]
 Read the frequency from the vibration generator's frequency setting/display, which drives the cord at that frequency. [1] The 25 Hz label represents that setting. A still image of the cord alone does not supply elapsed time.

5(d) An uncalibrated screen projection enlarges all crest spacings. A trainee repeats measurements on that same image and takes a mean. Explain why this does not remove the error and suggest a valid correction. **[2 marks]**

Answer / mark points: Averaging does not remove the systematic enlargement/calibration error; every measurement uses the same wrong length scale. [1]
 Use a scale calibrated for the actual water plane, or measure and correct the known projection magnification. [1] A better mean of the wrong scale is still not the true wavelength.

5(e) Suggest one precaution to reduce the electrical risk when using a ripple tank. **[1 mark]**

Answer / mark points: Keep powered equipment and electrical connections dry/away from spills, or use the specified low-voltage supply. [1] Accept a specific suitable electrical precaution, not "be careful".



6 Writing instructions for a new technician

The technician must determine the wave speed in a second ripple tank. Available equipment: a low-voltage wave generator and straight bar, water tray, metre ruler and phone camera with real recording timestamps. The waves are too fast to count reliably by eye. Use the short planning steps, then write a complete method.

6(a) To obtain frequency, choose a single still photograph or a video with real timestamps. Give the reason for your choice. **[1 mark]**

Answer / mark points: Video with real timestamps: it supplies elapsed time as well as a count of complete oscillations/waves. [1 for choice with reason] A still photograph alone gives no time interval.

6(b) State two conditions to keep the same while repeating measurements for one chosen ripple-tank setting. **[2 marks]**

Answer / mark points: Keep water depth the same. [1]
Keep the wave-generator frequency/driver setting the same. [1] Accept other justified controls, e.g. the same tank/water and unchanged bar amplitude; repeats at a new setting must be analysed separately.

6(c) Describe a complete method to determine wave speed in the second ripple tank. Explain how to obtain wavelength and frequency, how to calculate speed, and how to reduce measurement errors. Include one safety precaution. **[6 marks]**

Answer / mark points: Use best-fit levels, not one mark for every bullet. Level 3 (5–6): a logically ordered method measures BOTH wavelength and frequency validly, links them to $v = f\lambda$, and explains an error-reduction step. For 6 marks, also includes a suitable safety precaution and sufficiently clear operational details. Level 2 (3–4): a useful method but one measurement, link or practical detail is incomplete. Level 1 (1–2): isolated relevant ideas, not a complete usable method. No relevant physics: 0.

Example: Set a shallow, measured water depth. Use the low-voltage vibrating bar just touching the water to produce steady straight waves. Keep the setting fixed while measuring. Film directly from above with a ruler/calibrated length in the water-surface plane. In a clear frame, measure a distance perpendicular to crests spanning several COMPLETE crest-to-crest intervals; $\lambda = \text{distance} / \text{number of intervals}$, converting cm to m.

At one fixed point, count several complete oscillations/crests passing during a measured REAL recording time, using timestamps or a clock recorded with the video. Calculate $f = \text{count} / \text{real time}$. Use $v = f\lambda$ with consistent SI units. Repeat readings at the same setting and take a mean to reduce random variation; a longer timing interval reduces the relative effect of timing error. Keep electrics dry and use the low-voltage supply.

Accept a calibrated projected-image method if magnification is properly accounted for. Do not accept uncalibrated screen spacing, five crests treated as five wavelengths, or slowed playback time treated as real elapsed time. Section 6(a–b) is scaffolding; assess the complete method written here on its own.

Review and improve

Insist on complete intervals, real recording time, and the chain: measured distance $\rightarrow$ wavelength; oscillations and time $\rightarrow$ frequency; then $v = f\lambda$. Particles oscillate; they do not travel with the wave. Timing is estimated and untrials. This paper follow-up does not replace practical work.

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