Measuring waves

Answers, marking points and revision notes | AQA Combined Science 8464 and AQA GCSE Physics 8463

GCSE science required practicals

This practical online

Answers

1 Look at Aisha's experiment with the string.

a. Name the independent variable.

b. Name the dependent variable.

c. Give one control variable.

(3 marks)

a. The frequency of the vibration generator.
b. The wavelength of the wave (from the number of loops).
c. The tension in the string (the same hanging mass).

Marking points

- Independent: frequency
- Dependent: wavelength (or number of loops)
- Control: tension or hanging mass, vibrating length, type of string

2 In the ripple tank, Daniel measured the distance across ten waves and divided by ten, instead of measuring one wave. Explain why.

(2 marks)

One wavelength is only about 2 cm, so any reading error on the ruler is a big fraction of it. Measuring across ten waves makes the distance much larger, so the same reading error is a much smaller fraction, giving a more accurate wavelength.

Marking points

- A single wavelength is very small, so the measuring error is large compared with it
- Measuring several waves makes the error a smaller fraction, so the wavelength is more accurate

3 The ripples move too quickly for Daniel to measure them easily with a ruler. Suggest an improvement and explain why it helps.

(2 marks)

Take a photograph of the wave pattern with a ruler lying on the paper in the picture. The waves are frozen in the photo, so he can measure the distance across ten waves carefully, which makes the measurement more accurate.

Marking points

- Photograph the pattern with a ruler in shot (or use a strobe to freeze the waves)
- The waves appear still so the distance can be measured more accurately

4 Give one hazard when using the ripple tank and explain how to reduce the risk.

(2 marks)

Spilled water could reach the mains lamp or motor and cause an electric shock. Mop up any spills straight away and keep the plugs and sockets well away from the tank.

Marking points

- Hazard: water near mains electricity (risk of electric shock)
- Control: wipe up spills, keep electrics away from water, dry hands

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

5 Daniel measured 21.0 cm across ten waves. Calculate the wavelength in cm. (2 marks)

Wavelength = 21.0 ÷ 10 = 2.1 cm

wavelength = distance across ten waves ÷ 10

wavelength = 21.0 ÷ 10

wavelength = 2.1 cm

Marking points

- 21.0 ÷ 10
- 2.1 cm

6 Daniel counted 40 waves passing a mark on the paper in 5.0 s. Calculate the frequency of the waves. (2 marks)

Frequency = 40 ÷ 5.0 = 8.0 Hz

frequency = number of waves ÷ time

frequency = 40 ÷ 5.0

frequency = 8.0 Hz

Marking points

- 40 ÷ 5.0
- 8.0 Hz

7 The ripples have a frequency of 8.0 Hz and a wavelength of 2.1 cm. Calculate the speed of the ripples in m/s. Show your working. (3 marks)

Wavelength = 2.1 cm = 0.021 m. Wave speed = 8.0 × 0.021 = 0.168 m/s.

wavelength = 2.1 cm = 0.021 m

wave speed = frequency × wavelength

wave speed = 8.0 × 0.021

wave speed = 0.168 m/s

Marking points

- Wavelength converted to 0.021 m
- 8.0 × 0.021
- 0.168 m/s

8 Calculate the period of the ripples, which have a frequency of 8.0 Hz.

period = 1 ÷ frequency (2 marks)

Period = 1 ÷ 8.0 = 0.125 s

period = 1 ÷ frequency

period = 1 ÷ 8.0

period = 0.125 s

Marking points

- 1 ÷ 8.0
- 0.125 s

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

9 The vibrating length of Aisha's string is 1.20 m. Show that the wavelength is 0.80 m when there are 3 loops. (2 marks)

Each loop is half a wavelength, so 3 loops = 1.5 wavelengths. Wavelength = 1.20 ÷ 1.5 = 0.80 m.

one loop = half a wavelength

3 loops = 1.5 wavelengths

wavelength = 1.20 ÷ 1.5

wavelength = 0.80 m

Marking points

- Each loop is half a wavelength, so 3 loops = 1.5 wavelengths (or 2 × 1.20 ÷ 3)
- 1.20 ÷ 1.5 = 0.80 m

10 Identify the anomalous result in Aisha's table and say what she should do about it. (2 marks)

The 4 loop row, with a speed of 21.1 m/s, is anomalous because all the other speeds are about 24 m/s. She should leave it out of her mean and repeat that reading, checking the frequency gives a clear, steady pattern.

Marking points

- The 4 loops row (35.2 Hz, 21.1 m/s)
- Leave it out of the mean and repeat that reading

11 Calculate the mean wave speed on the string, leaving out the anomalous result. Give your answer to 3 significant figures. Show your working. (3 marks)

Mean = (24.2 + 23.8 + 24.3 + 24.1 + 23.8) ÷ 5 = 120.2 ÷ 5 = 24.04, so 24.0 m/s.

total = 24.2 + 23.8 + 24.3 + 24.1 + 23.8

total = 120.2 m/s

mean = 120.2 ÷ 5

mean = 24.04

mean = 24.0 m/s (3 s.f.)

Marking points

- Adds the five speeds without 21.1, total 120.2
- Divides by 5
- 24.0 m/s

12 **Higher tier**

Daniel keeps the water depth the same, so the ripples still travel at 0.168 m/s. He turns up the motor so the frequency is 12 Hz. Calculate the new wavelength in cm. Show your working. (3 marks)

Wavelength = wave speed ÷ frequency = 0.168 ÷ 12 = 0.014 m = 1.4 cm.

wave speed = frequency × wavelength, so wavelength = wave speed ÷ frequency

wavelength = 0.168 ÷ 12

wavelength = 0.014 m

wavelength = 1.4 cm

Marking points

- Rearranges to wavelength = wave speed ÷ frequency
- 0.168 ÷ 12 = 0.014 m
- 1.4 cm

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

13 **Higher tier**

Aisha's frequency went up by about six times, but the wave speed hardly changed. Explain this using the results. (2 marks)

The speed of a wave depends on the medium, here the string and its tension, which did not change. So when the frequency went up from 10.1 Hz to 59.6 Hz the wavelength went down by the same factor, from 2.40 m to 0.40 m, and frequency × wavelength stayed about 24 m/s.

Marking points

- Wave speed depends on the medium (string and tension), which stayed the same
- So wavelength decreased in proportion as frequency increased, for example 2.40 m to 0.40 m

14 Plan an investigation to find out how the depth of water in a ripple tank affects the speed of the ripples. (6 marks)

Level the ripple tank and pour in water to a depth of 5 mm, checking with a ruler at several points. Switch on the lamp above the tank and the dipper so straight ripples are projected onto white paper below. Keep the motor setting the same throughout so the frequency stays fixed. Count the number of waves passing a mark in 10 s and divide by 10 to find the frequency. Photograph the pattern with a ruler on the paper and measure across ten waves, then divide by ten for the wavelength. Work out speed = frequency × wavelength, with the wavelength in metres. Add water to make the depth 10 mm, then 15 mm, 20 mm and 25 mm, repeating the measurements each time. Repeat each depth three times and find a mean speed. Plot speed against depth and describe the pattern. The ripples should travel faster in deeper water. Keep the electrics away from the water and wipe up spills straight away.

Marking points (any 6, with the method in a logical order)

- Measure the water depth with a ruler and check the tank is level
- Change the depth in equal steps, at least five depths
- Keep the dipper frequency (motor setting) the same
- Find the frequency by counting waves passing a point in a measured time, or read it from the setting
- Find the wavelength by measuring across several waves (photograph with a ruler) and dividing
- Speed = frequency × wavelength in m/s
- Repeat each depth and find a mean
- Plot a graph of speed against depth to see the pattern
- Safety: keep mains electrics away from water and wipe spills

How it is marked

- 5-6 marks: a clear, logical plan that would work, changing and measuring depth, finding both frequency and wavelength properly and calculating speed, with control and repeats
- 3-4 marks: a workable plan that changes depth and measures some wave properties, but misses a key step such as how wavelength or frequency is found
- 1-2 marks: a few relevant ideas, such as changing the depth and timing waves, without a clear method

Revision notes: the method

Aim: To measure the frequency, wavelength and speed of waves in a ripple tank and of waves on a stretched string, and to decide which equipment suits each.

Equipment

- Ripple tank with a motor-driven wooden bar (dipper) and lamp above

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

- Sheet of white paper or card under the tank
- Metre ruler
- Stopwatch
- Signal generator and vibration generator
- Elastic string or thin cord
- Pulley clamped to the end of the bench
- Mass hanger and 100 g slotted masses
- Wooden bridge to support the string
- Camera or phone to photograph the wave pattern

Method

1. Ripple tank: fill the tank with water to a depth of about 5 mm and switch on the lamp so the waves cast a pattern on the paper below.
2. Lower the dipper so it just touches the water and switch on the motor to make straight ripples.
3. Place a metre ruler on the paper at right angles to the bright lines. Measure the distance across ten waves (from the first bright line to the eleventh) and divide by ten to find the wavelength.
4. Count how many waves pass a mark on the paper in 10 seconds and divide by 10 to find the frequency.
5. Work out the wave speed using wave speed = frequency × wavelength.
6. Waves on a string: tie the string to the vibration generator, run it over a wooden bridge and the pulley, and hang masses on the end to keep it tight.
7. Measure the length of string between the vibration generator and the bridge with a metre ruler.
8. Switch on the signal generator and slowly turn up the frequency until a clear, steady wave pattern of loops appears. Read the frequency from the signal generator.
9. Count the loops. Each loop is half a wavelength, so wavelength = 2 × length ÷ number of loops.
10. Increase the frequency to get more loops, recording the frequency and number of loops each time, then work out the speed for each.

Variables

- **Independent:** The frequency of the vibration generator (for the string)
- **Dependent:** The wavelength of the wave on the string, found from the vibrating length and the number of loops
- **Control:** The tension in the string, kept the same by hanging the same masses; The vibrating length of string between the generator and the bridge; The type and thickness of string, because these change the wave speed

Hazards

Hazard	What could happen	How to reduce the risk
Water near the mains-powered lamp and motor	Electric shock	Wipe up spills straight away, keep plugs and sockets away from the tank and do not touch switches with wet hands
Masses hanging from the string	The masses could fall on someone's foot if the string snaps	Keep feet clear and put a cushioned box under the masses
A tightly stretched string snapping	It could whip into someone's eye	Wear safety goggles and do not add more mass than needed

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.

Key points

- Measure across several waves and divide, which gives a more accurate wavelength than measuring one wave
- On a string, one loop is half a wavelength
- Wave speed = frequency × wavelength, with wavelength in metres to get m/s
- For a string at fixed tension, increasing the frequency makes the wavelength smaller but the speed stays about the same
- The ripple tank suits slow, small waves on water; the string with a vibration generator suits faster waves where the signal generator gives the frequency
- Water and mains electricity must be kept apart

Free for classroom and home use: print, photocopy and share. Not for resale or re-hosting.