Measuring Waves

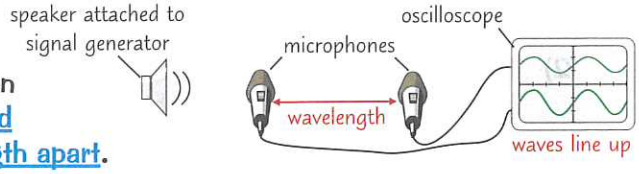
PRACTICAL

The speeds, frequencies and wavelengths of waves can vary by huge amounts. So you have to use suitable equipment to measure waves in different materials, to make sure you get accurate and precise results.

Use an Oscilloscope to Measure the Speed of Sound

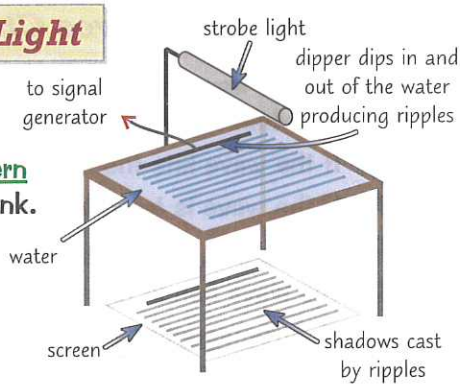
By attaching a signal generator to a speaker you can generate sounds with a specific frequency. You can use two microphones and an oscilloscope to find the wavelength of the sound waves generated.

1) Set up the oscilloscope so the detected waves at each microphone are shown as separate waves.
2) Start with both microphones next to the speaker, then slowly move one away until the two waves are aligned on the display, but have moved exactly one wavelength apart.
3) Measure the distance between the microphones to find one wavelength (λ).
4) You can then use the formula $v = f\lambda$ (p.164) to find the speed (v) of the sound waves passing through the air — the frequency (f) is whatever you set the signal generator to in the first place.



Measure the Speed of Water Ripples Using a Strobe Light

1) Using a signal generator attached to the dipper of a ripple tank you can create water waves at a set frequency.
2) Dim the lights and turn on the strobe light — you'll see a wave pattern made by the shadows of the wave crests on the screen below the tank.
3) Alter the frequency of the strobe light until the wave pattern on the screen appears to 'freeze' and stop moving. This happens when the frequency of the waves and the strobe light are equal — the waves appear not to move because they are being lit at the same point in their cycle each time.
4) The distance between each shadow line is equal to one wavelength. Measure the distance between lines that are 10 wavelengths apart, then find the average wavelength.
5) Use $v = f\lambda$ to calculate the speed of the waves.



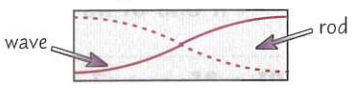
You can find the frequency by using a regular light, so you can see the waves moving. Count how many waves pass a mark on the screen in a given time, then divide this by the time in seconds to find the frequency.

Use Peak Frequency to find the Speed of Waves in Solids

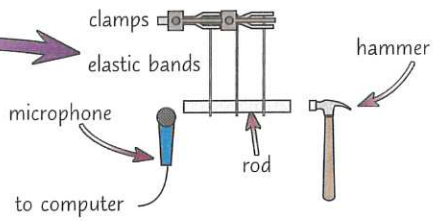
You can find the speed of waves in a solid by measuring the frequency of the sound waves produced when you hit the object, e.g. a rod, with a hammer. Hitting the rod causes waves to be produced along the rod. These waves make the rod vibrate and produce sound waves in the air around the rod (this is how a percussion triangle works). These sound waves have the same frequencies as the waves in the rod.

1) Measure and record the length of a metal rod, e.g. a brass rod.
2) Set up the apparatus shown in the diagram, making sure to secure the rod at its centre.
3) Tap the rod with the hammer. Write down the peak frequency displayed by the computer.
4) Repeat this three times to get an average peak frequency.
5) Calculate the speed of the wave using $v = f\lambda$, where λ is equal to twice the length of the rod.

Lots of waves at lots of different frequencies are created in the rod when it is hit. The peak (loudest) frequency is created by this wave in the rod:



rod length = half a wavelength



My wave speed depends on how tired my arm is...

The sound and water waves experiments are really common, so make sure they're firmly stuck in your head.

Q1 Describe an experiment to measure the wavelength of a water wave. [4 marks]

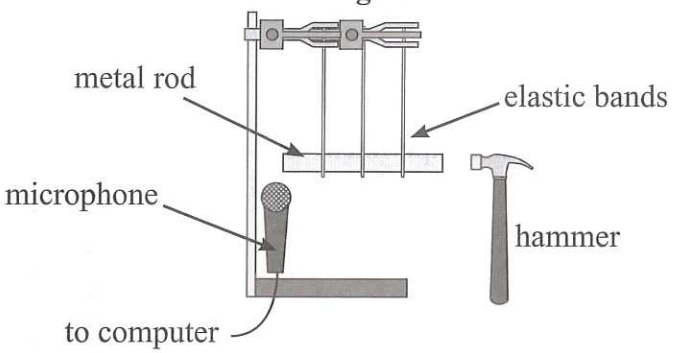
PRACTICAL

Measuring Waves

1 The wave speed in a solid can be found by hitting a metal rod with a hammer, shown in **Figure 1**. The sound waves produced when the rod is struck are recorded by the microphone and displayed by a computer.

Grade 6–7

Figure 1



A 20 cm metal rod is hit by the hammer. The peak frequency produced was 8500 Hz. Calculate the speed of the wave produced in the rod.

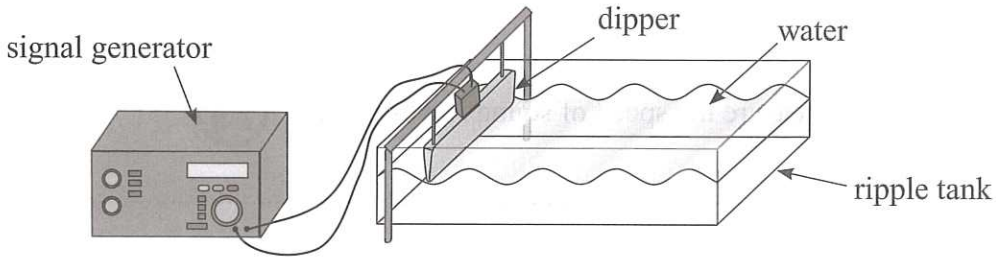
Speed = ... m/s

[Total 4 marks]

2 A student uses the equipment shown in **Figure 2** to investigate water waves in a ripple tank.

Grade 6–7

Figure 2



a) The student wants to measure the frequency of the ripples. She floats a cork in the ripple tank, and counts how many times it bobs up in 30 seconds. The student repeats her experiment five times. She does not adjust the signal generator between repeats.

State **two** other factors that should remain the same between repeats.

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[2]

Figure 3 shows the student's results. She recorded one of the results incorrectly.

Figure 3

trial	1	2	3	4	5
number of bobs in 30 seconds	12	11	21	11	14

b) i) Calculate the average number of times the cork bobbed up in 30 seconds, ignoring the anomalous result.

Average number of bobs = ...
[3]

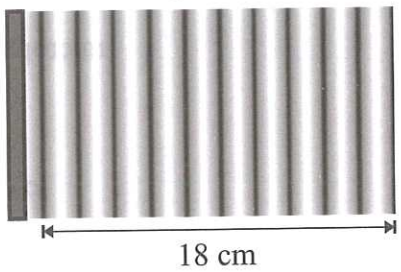
ii) Using your answer to part i), calculate the average frequency of the ripples.

Frequency = ... Hz
[2]

c) The student then decides to adjust her experiment to investigate the speed of the ripples. She sets the signal generator to 12 Hz. She then places a piece of paper underneath the ripple tank and uses a strobe light set to the same frequency as the signal generator so the waves appear to not move.

Figure 4 shows the wave pattern produced on the paper.

Figure 4



i) Write down the equation that links wave speed, frequency and wavelength.

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[1]

ii) Calculate the speed of the water ripples.
Give your answer to an appropriate number of significant figures.

Speed = ... m/s
[3]

[Total 11 marks]

3* Describe a method to measure the speed of sound waves in air. Grade 7-9

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[Total 6 marks]