Properties of waves

4.6.1.2 · Waves · revision notes

The quantities used to describe a wave (amplitude, wavelength, frequency, period and wave speed) and the wave equation v = f λ. Expect calculations, reading values from wave diagrams, and questions on the waves required practical, where you measure waves in a ripple tank and on a stretched string.

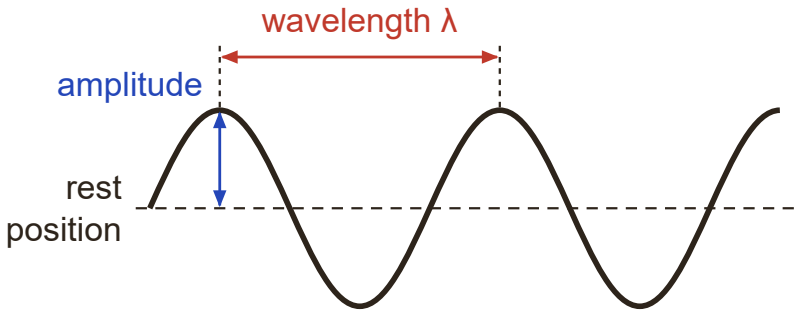
Key facts

- Amplitude = maximum displacement from the undisturbed position
- Frequency = number of waves passing a point each second (Hz)
- Wave speed = speed at which energy is transferred through the medium
- v in m/s, f in Hz, λ in m
- Sound entering a new medium: frequency stays the same; speed and wavelength change in proportion
- Wavelength = distance from a point on one wave to the equivalent point on the next wave
- Period: T = 1 ÷ f (T in s, f in Hz)
- wave speed = frequency × wavelength: v = f λ (on the equation sheet)
- 1 kHz = 10^3 Hz; 1 MHz = 10^6 Hz; 1 cm = 0.01 m

Notes

Describing a wave

- **Amplitude**: the maximum displacement of a point on a wave away from its undisturbed (rest) position. Measure from the middle line to a crest, **not** from crest to trough.
- **Wavelength** (λ): the distance from a point on one wave to the equivalent point on the next wave, e.g. crest to crest, or from the middle of one compression to the middle of the next.



Amplitude: rest position to crest. Wavelength: one crest to the next.

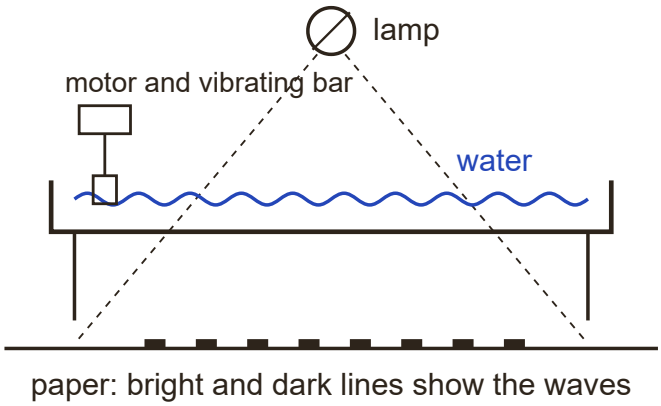
- **Frequency** (f): the number of waves passing a point each second, in hertz (Hz). 1 Hz = 1 wave per second.
- **Period** (T): the time for one complete wave to pass a point, in seconds. T = 1 ÷ f.
- **Wave speed** (v): the speed at which energy is transferred (or the wave moves) through the medium, in m/s.

The wave equation

- wave speed = frequency × wavelength, **v = f λ**. It is on the Physics Equations Sheet: pick it, rearrange it and use the units below.
- Units: v in m/s, f in Hz, λ in m. Convert first: 1 kHz = 1000 Hz, 1 MHz = 1 000 000 Hz, 1 cm = 0.01 m, 1 mm = 0.001 m.
- Rearranged: f = v ÷ λ and λ = v ÷ f.
- If the speed stays the same, doubling the frequency halves the wavelength.

Measuring wave speed (required practical)

- **Speed of sound in air**: two people stand a measured distance apart (at least 100 m). One makes a sound that can also be seen, such as banging two blocks together; the other starts a stopwatch on seeing it and stops it on hearing it. Speed = distance ÷ time. The long distance makes reaction time matter less; repeat and find a mean.
- **Ripple tank**: a lamp above the tank shows the waves as bright and dark lines on paper below. Measure the length of, say, 10 waves with a ruler and divide by 10 to get λ. Count the waves passing a point in 10 s and divide by 10 to get f. Then v = f λ. A photo with a ruler in view makes measuring easier.



Ripple tank: measure λ and count waves on the paper below.

- **Waves on a string**: a vibration generator shakes a string stretched over a pulley by hanging masses. Adjust the frequency on the signal generator until a steady wave pattern appears. Each loop is half a wavelength, so measure across as many loops as possible with a metre rule, keeping the masses the same. Read f from the signal generator, then v = f λ.

Sound passing into a different medium

- When sound passes from one medium into another, its **frequency does not change**: it is set by the source.
- Its **speed does change**. Sound travels faster in liquids than in gases, and usually faster still in solids.
- Since λ = v ÷ f and f stays the same, the wavelength changes in proportion to the speed. Sound going from air into water speeds up, so its wavelength gets longer.

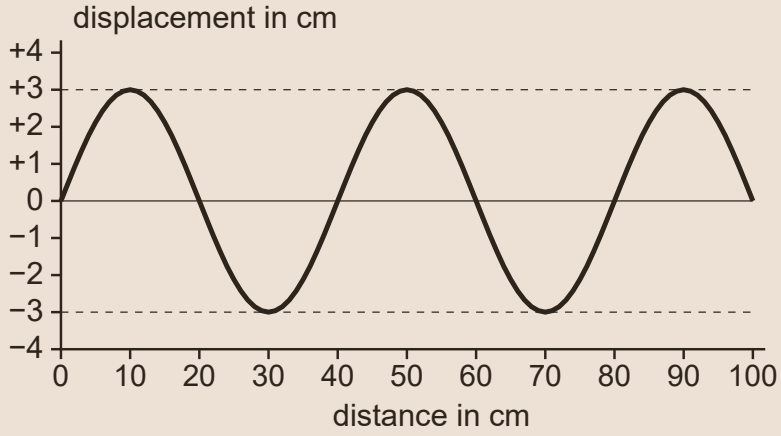
How to answer each type of question

Read the amplitude or wavelength from a diagram or graph

1 to 2 marks | Grade 3

1. Amplitude: measure from the middle (rest) line to the top of a crest.
2. Wavelength: measure one complete cycle, e.g. from one crest to the next.
3. Check the scale on each axis and give the unit.

Example. The graph shows the displacement of the water at different distances along a water wave at one instant.



(a) Give the amplitude of the wave.
(b) Give the wavelength of the wave.

Model answer.

(a) 3 cm (1)
(b) From one crest to the next: 50 − 10 = 40 cm (1)

Calculate wave speed, frequency or wavelength

2 to 3 marks | Grade 5

1. Write down $v = f \lambda$.
2. Convert to Hz and m.
3. Substitute, rearranging if needed ($f = v \div \lambda$, $\lambda = v \div f$).
4. Give the answer with its unit.

Example. A sound wave in air has a frequency of 1.7 kHz. The speed of sound in air is 340 m/s. Calculate the wavelength of the sound wave.

Model answer.

1.7 kHz = 1700 Hz (1)
$\lambda = v \div f = 340 \div 1700$ (1)
$\lambda = 0.20$ m (1)

Multi-step: find f and λ from measurements, then v

3 to 4 marks | Grade 6

1. Frequency = number of waves ÷ time taken.
2. Wavelength = total length ÷ number of wavelengths. Count the gaps between crests, not the crests.
3. Convert cm to m, then use v = f λ.

Example. In a ripple tank, 30 waves pass a point in 3.0 s. The distance from the first crest to the sixth crest is 10.0 cm.
Calculate the speed of the waves in m/s.

Model answer.

f = 30 ÷ 3.0 = 10 Hz	(1)
First to sixth crest is 5 wavelengths, so λ = 10.0 ÷ 5 = 2.0 cm = 0.020 m	(1)
v = f λ = 10 × 0.020	(1)
v = 0.20 m/s	(1)

Describe a method to measure the speed of waves

4 to 6 marks | Grade 5

1. Name the apparatus and say what each piece is for.
2. Say how you measure the wavelength (across several waves, then divide).
3. Say how you find the frequency.
4. Finish with v = f λ and how you improve accuracy (repeat, find a mean).

Example. Describe how a student could use a ripple tank to find the speed of water waves.

Model answer. Switch on the lamp above the tank so that the waves show as bright and dark lines on paper below the tank (1). Put a ruler on the paper and measure the length of several waves (e.g. 10), then divide by the number of waves to get the wavelength (1). Count the number of waves passing a point in a measured time (e.g. 10 s) and divide by the time to get the frequency (1). Calculate the speed using wave speed = frequency × wavelength (1).

Explain what happens to sound entering a new medium 3 marks **Grade 7**

1. State that the frequency does not change.
2. Calculate the wavelength in each medium with $\lambda = v \div f$.
3. Link the change in wavelength to the change in speed.

Example. A sound wave of frequency 500 Hz travels from air into water. The speed of sound is 340 m/s in air and 1500 m/s in water.
Explain what happens to the wavelength of the sound. Include calculations in your answer.

Model answer.

The frequency stays at 500 Hz (1).
In air $\lambda = 340 \div 500 = 0.68$ m; in water $\lambda = 1500 \div 500 = 3.0$ m (1).
The wavelength increases because the speed increases while the frequency stays the same (1).

Don’t lose marks

- Measuring the amplitude from crest to trough, which gives twice the amplitude.
- Forgetting to convert kHz to Hz, or cm to m, before using $v = f \lambda$.
- Counting crests instead of gaps when finding the wavelength from several waves.
- Saying frequency is 'how fast the wave travels'. Frequency is waves per second; speed is distance per second.
- In method questions, not saying how the measurements are made more accurate (measure many waves and divide, repeat and find a mean).

More tips

Memory tricks

- Formula triangle: v on top, f and λ underneath. Cover the quantity you want.
- Count the gaps, not the crests: from the 1st to the 6th crest is 5 wavelengths.
- T and f are opposites: $T = 1 \div f$ and $f = 1 \div T$. Remember 1 ms = 0.001 s.
- Calculator: enter 1.7 kHz as 1.7×10^3 using the $\times 10^x$ key, so you never miss a zero.
- Sense check: sound in air travels at about 340 m/s, while ripples in a ripple tank travel at tens of centimetres per second.

Exam technique

- Show the equation, the substitution and the answer with its unit: each is often a separate mark.
- Give answers to a sensible number of significant figures, usually the same as the data (often 2 or 3).
- In practical questions, name the equipment and say what you measure with it. A photograph or a stroboscope 'freezes' the ripples so they are easier to measure.
- If a question gives the time for one wave, that is the period: use $f = 1 \div T$ to get the frequency.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Label amplitude and wavelength on a diagram

Amplitude: from the undisturbed position to a crest (or trough). Wavelength: one complete wave, e.g. crest to crest.

Grade 4

Define frequency and period

Frequency is the number of waves passing a point each second (Hz); the period is the time for one wave (s).

Grade 4

Calculate wave speed using v = f λ

Multiply the frequency in Hz by the wavelength in m to get the wave speed in m/s.

Grade 5

Use T = 1/f

Find the period from the frequency, or the frequency from the period, e.g. f = 50 Hz gives T = 1 ÷ 50 = 0.02 s.

Grade 5

Describe the ripple tank and string practical

Measure across several wavelengths, find the frequency, use v = f λ, and explain why the apparatus suits each measurement.

Grade 6

Rearrange v = f λ with unit conversions

Convert kHz, MHz, cm or mm to Hz and m first, then rearrange to find f or λ.

Grade 6

Describe measuring the speed of sound in air

Time a sound over a long measured distance, then use speed = distance ÷ time.

Grade 7

Explain how sound changes in a new medium

The frequency stays the same, so if the speed increases the wavelength increases in proportion (λ = v ÷ f).

Free notes, Full packs, practice papers and mock exams at chhetriacademy.com. Written for this site; not taken from past papers. Stuck? 1-to-1 tutoring with a free 30-minute trial lesson.