PiXL KnowIT!

GCSE Physics

Edexcel Waves

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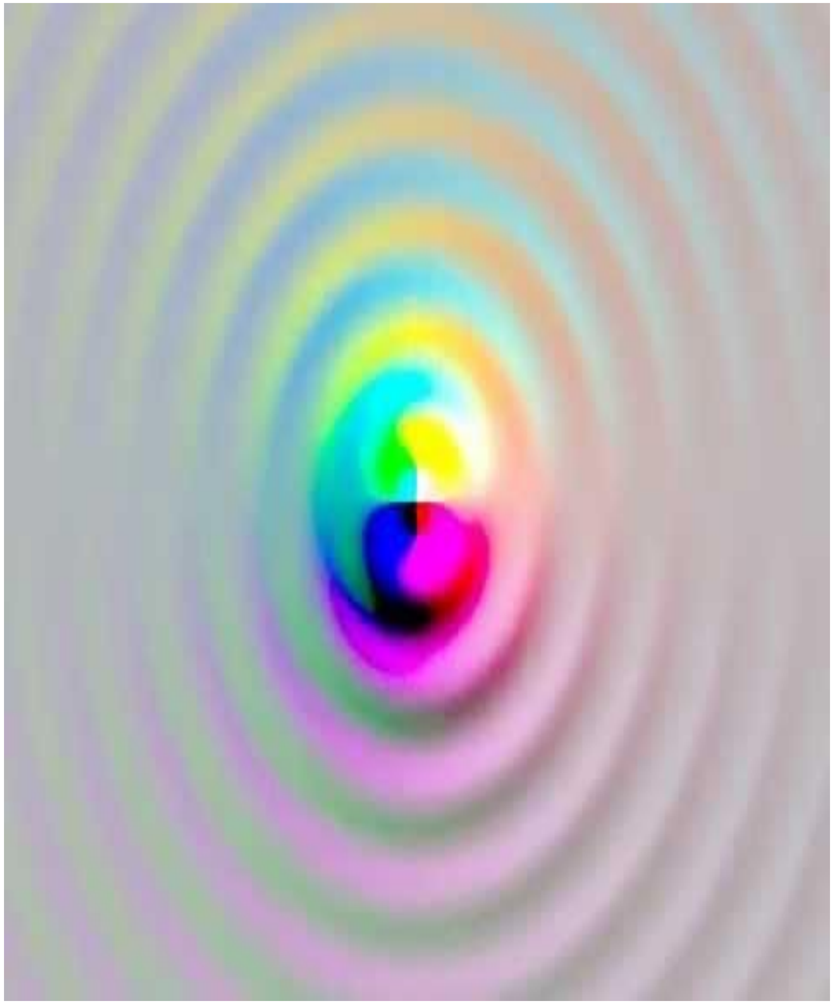
The PiXL Club Ltd, Company number 07321607

Overview
Edexcel Topic 4

Waves

- Wave basics
- Wave speed/velocity
- Effects of waves (physics only)



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LearnIT!
KnowIT!

Waves

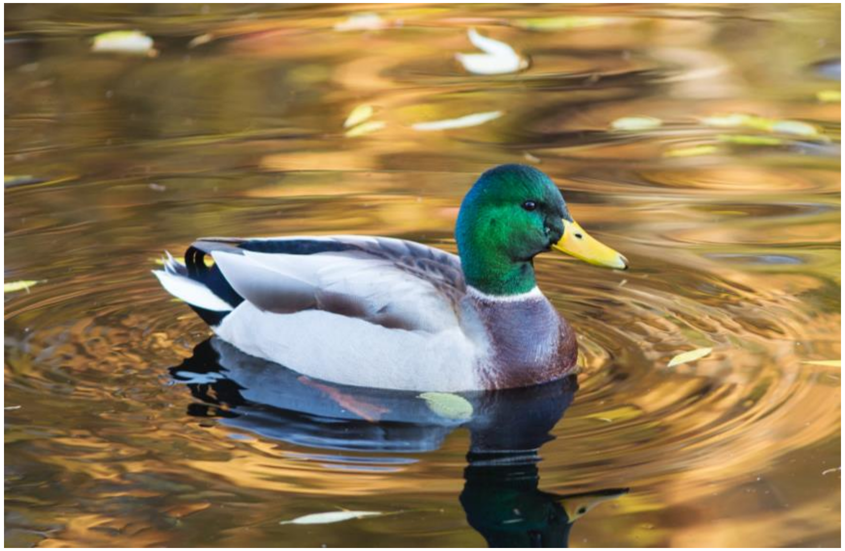
- Wave basics
- Wave speed/velocity
- Effects of waves (physics on

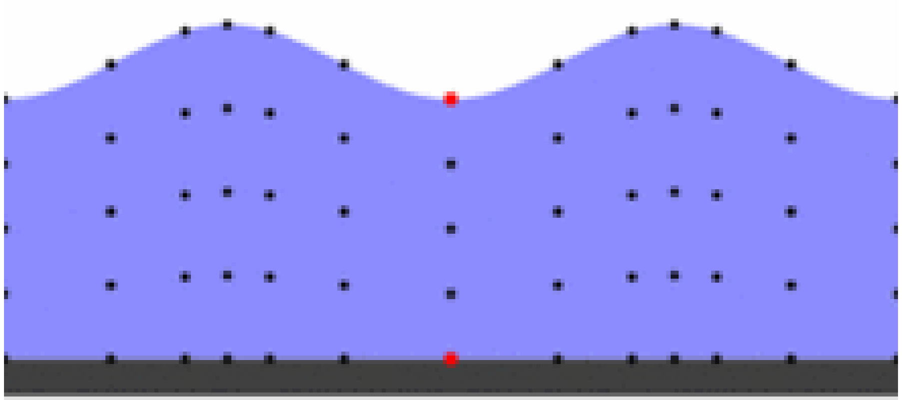
Wave basics

- Waves **transfer energy** and **information** in the direction of travel without transferring matter.
- Waves are often described as **vibrations** or **oscillations**.
- It is energy, **NOT the particles,** that move from one place to another!
- Evidence that it is the wave and not the water or air itself of this can be seen in **sound** waves and **water** waves.

Water Waves

- If you throw a small rock into a duck pond (obviously avoiding the ducks)
- You will see ripples form and move across the waters surface
- The **ripples** cause water particles to **vibrate up and down**
- The duck **does not** get carried to the edge of the pond it just bobs up and down



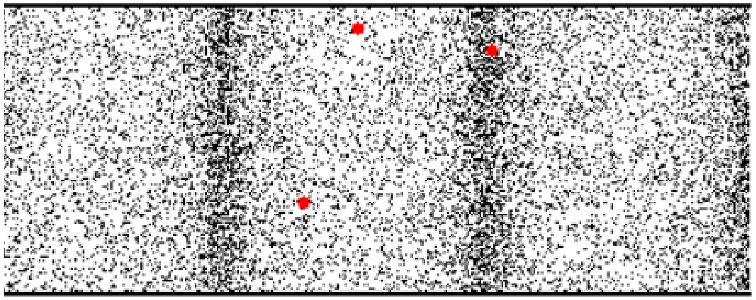


In this GIF the red dot represents the duck

Sound waves

- If you hit a drum you will create a **sound wave**
- The sound wave travels to your ear and you hear the drum sound
- Sound waves cause **air particles** to **vibrate back and forth**
- The air particles do not travel from the drum to your ear
- Only **energy** is transferred and **not** the particles

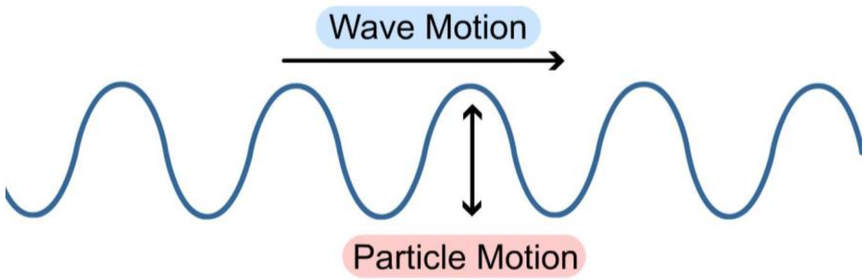
Sound wave



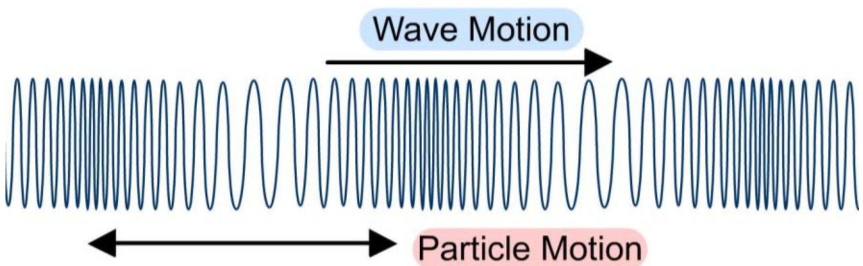
In this GIF the red dots represents air particles

Transverse and Longitudinal Waves

Transverse Wave



Longitudinal Wave

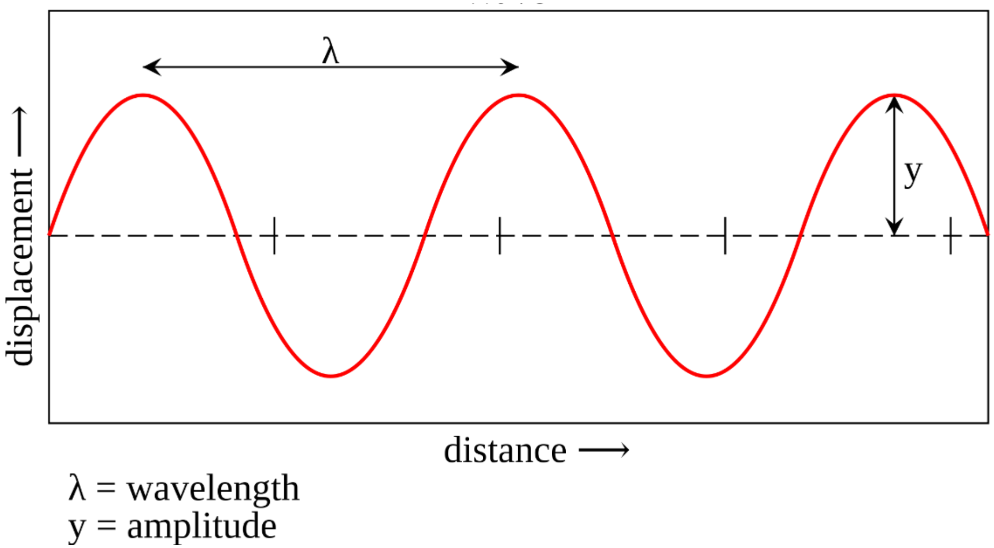


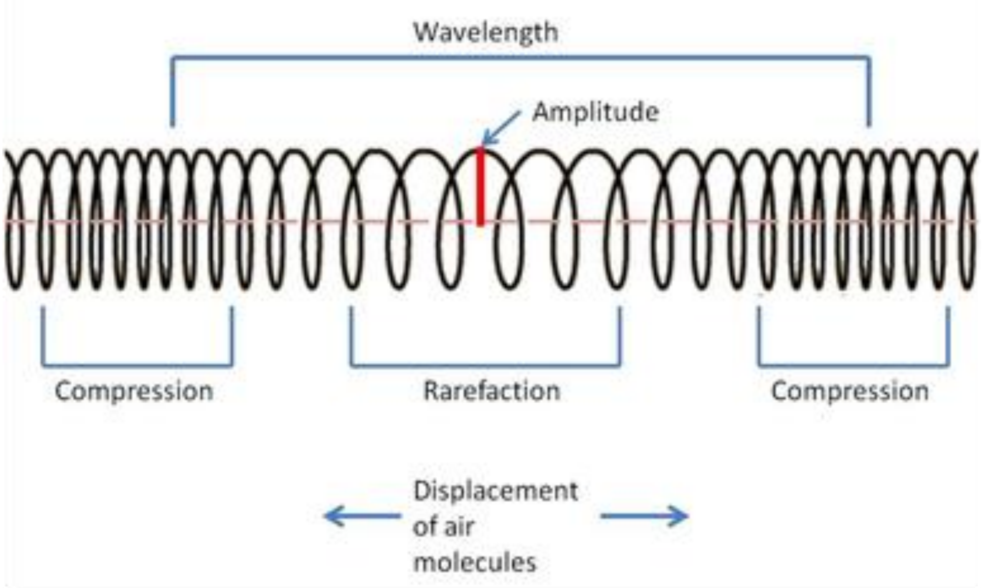
Remember, the particles in a wave move up and down or backwards and forwards only.
It is energy, NOT the particles, that move from one place to another!

In a **transverse wave** the particles within the wave move perpendicular (at 90°) to the direction the wave is travelling.
This is the wave produced in a rope when it is flicked **up and down**.
Examples of transverse waves are:
Water waves, electromagnetic (light) waves and guitar strings.

Longitudinal waves are compression (squash) waves where the particles are vibrating in the same direction as the wave movement.
This is the wave produced when a spring is **squashed** and released.
Examples of longitudinal waves are:
Sound waves and a type of seismic (P) wave.

Transverse and Longitudinal Waves





Wavelength (m) – the distance from one point on a wave to the same point on the next wave.
Amplitude (m) – the waves maximum displacement of a point on a wave from its undisturbed position.
Frequency (Hz) – the number of waves passing a point per second.
Period (s) - the time taken to produce one complete wave.

The displacement of a transverse wave is described as **peaks and troughs**. In a longitudinal wave these are described as **compressions and rarefactions**.

Recall and use both the equations below for all waves:

Wave speed is the speed at which energy is transferred by the wave (how quickly the wave moves) through the medium it is travelling in.

wave speed (m/s) = frequency (Hz) x wavelength (m)

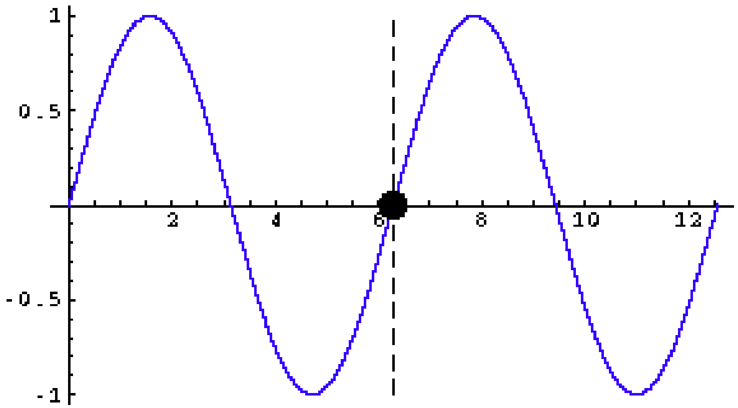
$$v = f\,\lambda$$

wave speed (m/s) = distance (m) ÷ time (s)

$$v = \frac{x}{t}$$

Recall and use both the equations below for all waves:

Example 1:
The wave below has a frequency of 0.5Hz and a wavelength of 6cm (0.06m).
Calculate the wave speed.



wave speed = frequency x wavelength

$$v = f\,\lambda$$

$$v = 0.5 \times 0.06$$

Click to reveal answer

Recall and use both the equations below for all waves:

Example 2:

A sound wave travels 1250 m in 0.82 s underwater.

Calculate the speed of this wave.

wave speed (m/s) = distance (m) ÷ time (s)

$$v = \frac{x}{t}$$

$$v = \frac{1250}{0.82}$$

Click to reveal answer

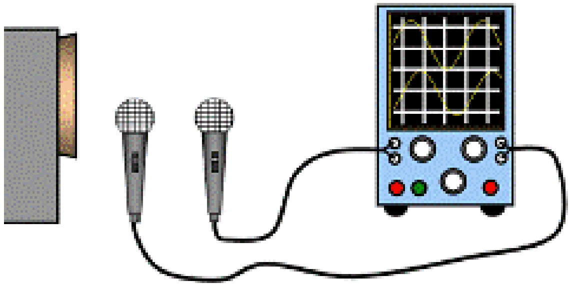
Method for measuring the speed of sound waves in air

100m

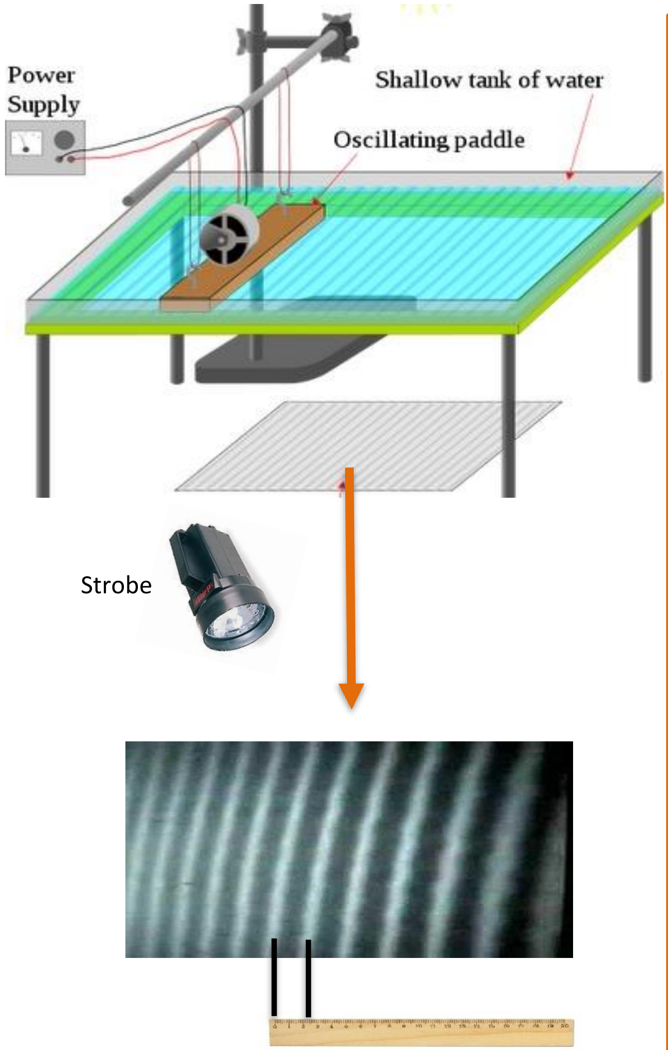
The cannon fires and the stopwatch is started (you can see a flash of light which takes almost zero time to travel 100m). When the sound reaches the observer the stopwatch is stopped. The time was **0.3s**
This will give the time for sound to travel **100m**.

Speed (m/s) = Distance (m) / Time (s)
Speed of sound = 100 / 0.3 = 333.3m/s

In the laboratory, a sound from a loudspeaker passes two microphones a set distance apart. The time recorded for the sound to travel this distance is measured and speed is calculated using the same formula as above.



Method for measuring the speed of ripples on a water surface



A ripple tank is used to make waves which are seen under the glass tank.
A strobe light has its frequency of flashes adjusted until the wave appears stationary – **this is the frequency of the water wave.**
Then, the **wavelength** of the water wave is measured by using a ruler to measure the distance from one peak to the next peak (white line to white line). This is converted to **metres**.

wave speed (m/s) = frequency (Hz) x wavelength (m)

If the frequency of the water wave is 5Hz and the wavelength is 0.6cm:

wave speed = 0.5 x 0.006 =

Click to reveal answer

Calculate depth or distance (Physics only Higher tier)

Example 1:

A man uses a dog whistle to call his dog, the whistle uses ultrasound.
The ultrasound takes 0.47 s to travel from the man to the dog.
The speed of sound in air is 330 m/s
How far away was the dog?

wave speed (m/s) = distance (m) ÷ time (s)

$$v = \frac{x}{t}$$

Click to reveal answer

Click to reveal answer

Click to reveal answer

Calculate depth or distance (Physics only Higher tier)

Example 2:

A pulse of ultrasound takes 0.75 s to travel from a fishing vessel to a shoal of shrimp in the sea.

The speed of sound in air is 1500 m/s

How deep in the sea is the shoal of shrimp?

wave speed (m/s) = distance (m) ÷ time (s)

$$v = \frac{x}{t}$$

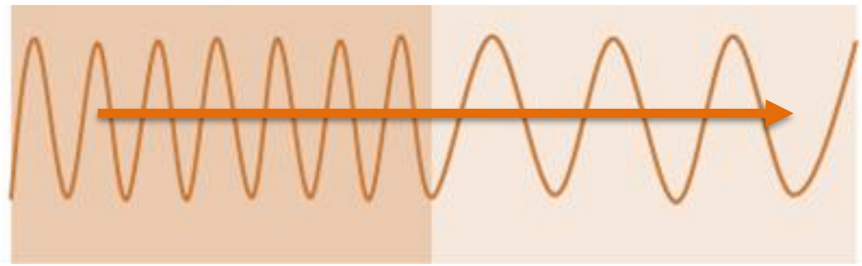
Click to reveal answer

Click to reveal answer

Click to reveal answer

Sound waves changing medium

When a **sound wave travels from one medium to another** e.g. air to water, **the frequency remains the same**. This is because frequency is a property of the object producing the sound, not the medium it travels through.



The sound wave will travel faster in water than air.

Remember, **wave speed (m/s) = frequency (Hz) x wavelength (m) or $f = v / \lambda$.**

So, if the **frequency remains the same**, as **velocity increases**, the **wavelength must also increase** proportionally.

If a sound wave has a frequency of 260Hz:

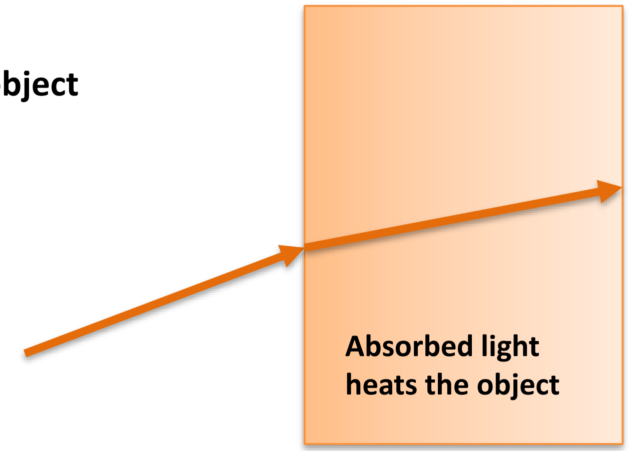
Speed of sound in air = **330m/s.** Speed of sound in water = **1500m/s.**

λ in air = 330 / 260 = **1.27m** λ in water = 1500 / 260 = **5.77m**

Reflection of waves (Physics only)

When light waves strike a boundary they can be **reflected, absorbed** or **transmitted** depending on the substance they strike.

Reflected light bounces off the object surface

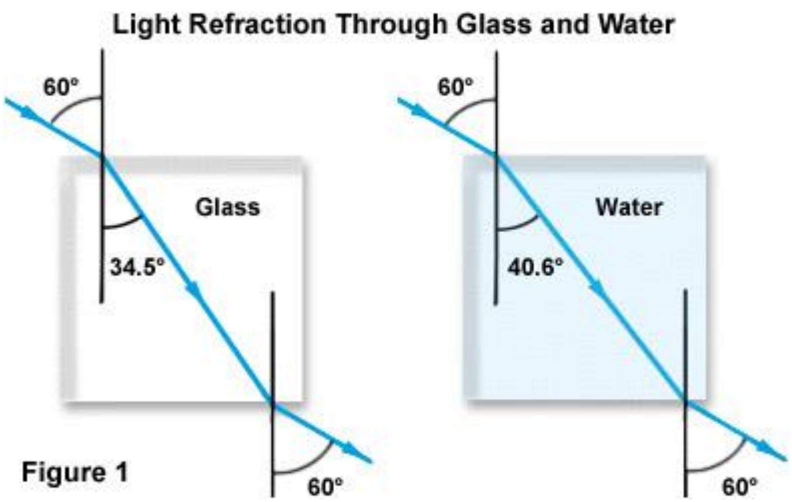


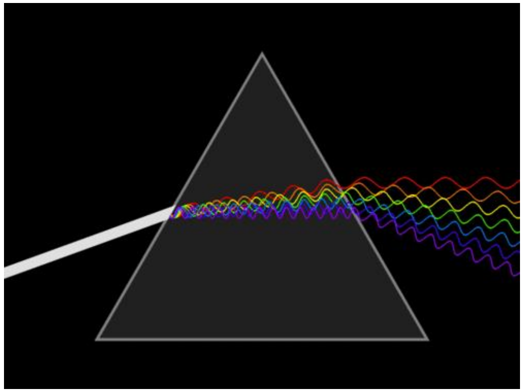
Transmitted light passes through the object

Refraction of waves (Physics only)

Refraction of different wavelengths of light in different materials

Refraction of electromagnetic waves occurs because the **wave changes speed** when it enters a substance of different **optical density**.
The light wave will only refract if one side of the wave strikes the new material before the other side.
The amount of refraction is different for materials of different optical density as seen in Figure 1 opposite.





Different wavelengths of light are **diffracted by different amounts**, resulting in a spectrum of colour being produced when white light is refracted (dispersed) by a prism.

QuestionIT!

Waves

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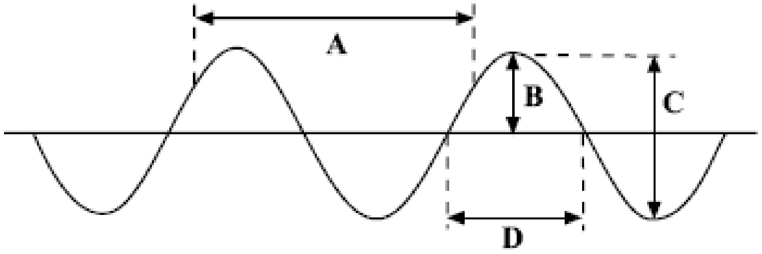
- Effects of waves (physics only)

1. What do waves transfer?



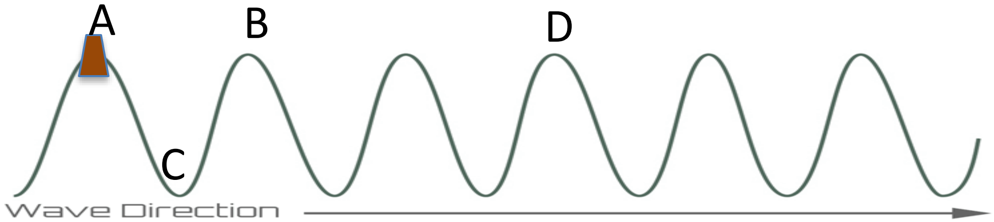
a. What type of wave is shown above?

b. Which letter represents the amplitude of the wave?

c. Which letter shows the wavelength?

2. Draw a longitudinal wave and label a compression, rarefaction and the wavelength.

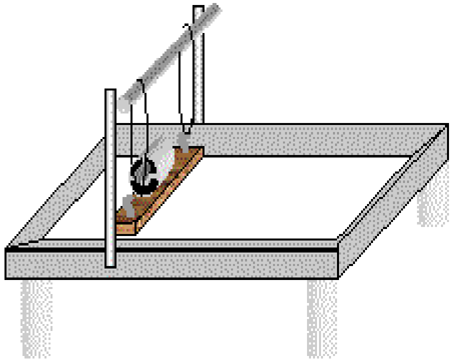
3. The diagram shows a cork floating on a water wave which has a frequency of 0.5 Hz. Which letter shows where the cork will be 2 seconds later?



4. What is meant by the period of a wave?

5. State the **two** equations that you can use to calculate wave speed.

6. A sound wave has a frequency of 240Hz and a wavelength of 1.38m. Calculate the velocity of this sound wave. Show clearly the formula you use for this calculation.



7. The diagram shows a ripple tank, used to generate waves in the laboratory.
Describe the measurements that must be made in order to calculate the velocity of water waves in the tank.

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AnswerIT!

Waves

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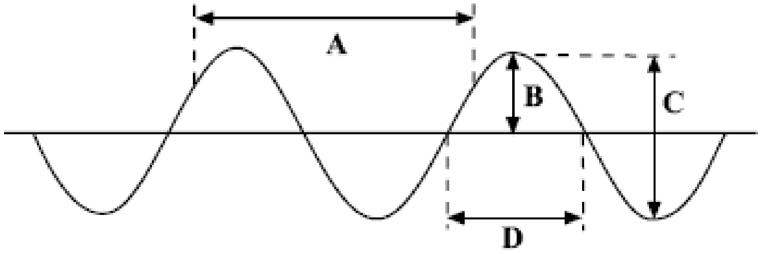
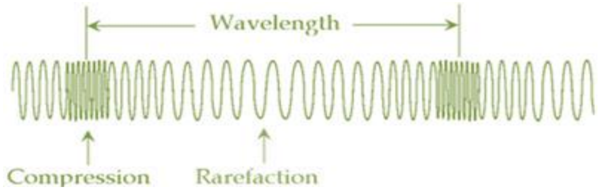
- Effects of waves (physics only)

1. What do waves transfer?
Energy

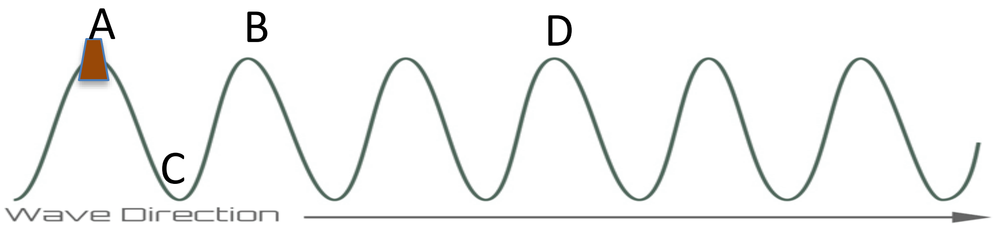


a. What type of wave is shown above? **Transverse**
b. Which letter represents the amplitude of the wave? **B**
c. Which letter shows the wavelength? **A**

2. Draw a longitudinal wave and label a compression, rarefaction and the wavelength.



3. The diagram shows a cork floating on a water wave which has a frequency of 0.5 Hz. Which letter shows where the cork will be 2 seconds later? **A**



4. What is meant by the period of a wave?

Time taken to complete 1 full wave.

5. State the **two** equations that you can use to calculate wave speed.

wave speed (m/s) = frequency (Hz) x wavelength (m)

$$v = f\lambda$$

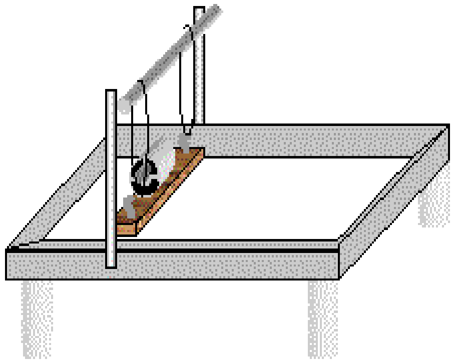
wave speed (m/s) = distance (m) ÷ time (s)

$$v = \frac{x}{t}$$

6. A sound wave has a frequency of 240Hz and a wavelength of 1.38m. Calculate the velocity of this sound wave. Show clearly the formula you use for this calculation.

$v = f\lambda$ $v = 240 \times 1.38$

Velocity of the wave = 331.3m/s



7. The diagram shows a ripple tank, used to generate waves in the laboratory. Describe the measurements that must be made in order to calculate the velocity of water waves in the tank.

Measure wave frequency with a strobe light and wavelength of a wave with a ruler then use $v = f\lambda$

or: measure time for a wave to travel a measured distance and use $v = \frac{x}{t}$