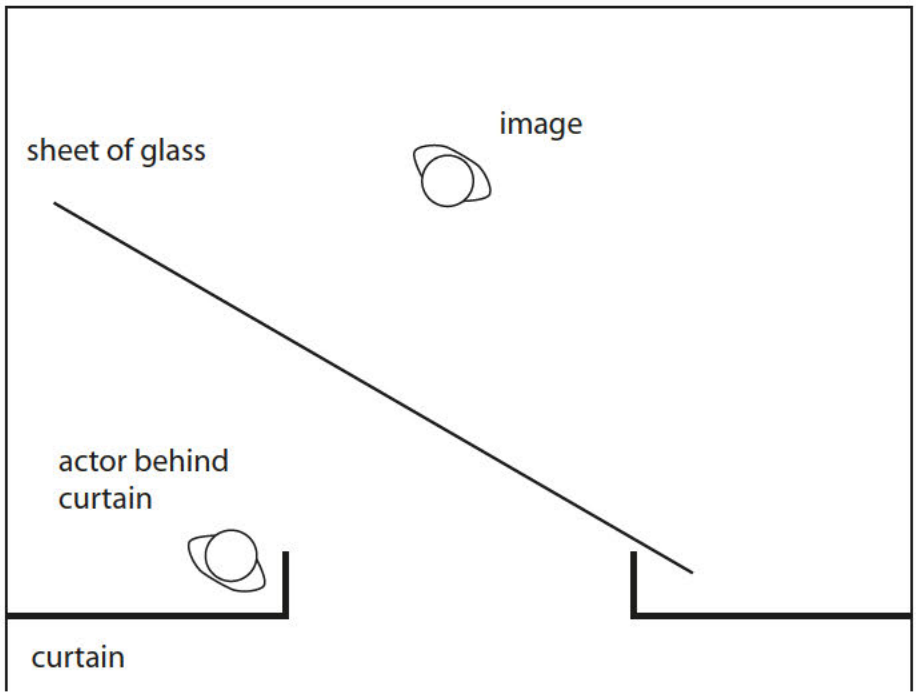
**1** Pepper's Ghost is a theatre effect used to make it appear that there is an image on stage.

The diagram shows a theatre viewed from above.

A sheet of glass is placed on the stage. A brightly lit actor stands behind a curtain at the side of the stage.

The audience sees the reflection of this actor in the glass.




(a) Add a ray diagram to show how light from the actor appears to come from the image.

**(3)**

(b) The image formed by the glass is a virtual image.

State what is meant by the term **virtual image**.

**(1)**

.....

.....

(c) Light travels as a transverse wave.

Some waves travel as longitudinal waves.

(i) Give an example of a wave that travels as a longitudinal wave.

**(1)**

.....

(ii) Describe the difference between transverse waves and longitudinal waves.

You may draw diagrams to help your answer.

**(3)**

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**(Total for Question 1 = 8 marks)**

**2** Echo sounding is used to detect fish in the sea.

Sound waves are emitted from a fishing boat. Some of the sound waves are reflected by fish and detected back at the boat.

(a) The shortest time between the sound waves being emitted and detected is 0.26 s.

The speed of sound in water is 1.5 km/s.

Calculate the distance between the boat and the nearest fish.

**(4)**

distance = ..... m

(b) Each sound wave is emitted for a very short time.

The reflected sound wave received at the boat lasts for a longer time.

Suggest a reason for this difference in time.

**(2)**

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**(Total for Question 2 = 6 marks)**

**3** This question is about the reflection of light.

(a) Light reflects from a plane mirror.

(i) Use words from the box to complete the sentence below.

(1)

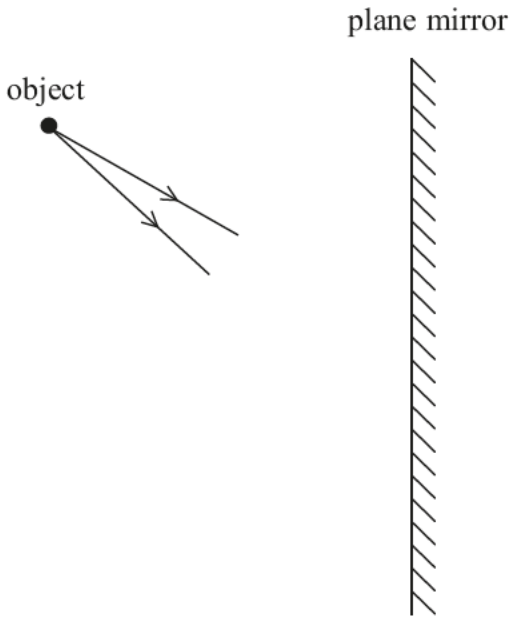
| less than | eq | to | eater than |
|---|---|---|---|

When light reflects from the surface of a plane mirror, the angle of incidence is ..... the angle of reflection.

(ii) The diagram shows two rays of light coming from an object.

Continue the two rays and add further lines to the diagram to show how an image is formed by a plane mirror.

(2)




(iii) The image in a plane mirror is a **virtual image**.

How can you tell this from your diagram?

(1)

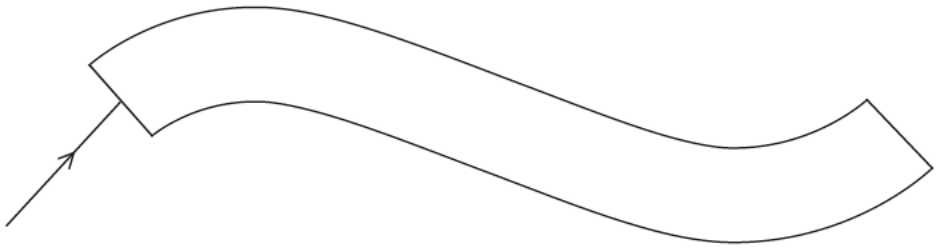
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(b) Light can also reflect along optical fibres by total internal reflection.

(i) Complete the diagram to show the path of the ray of light as it enters and passes through the optical fibre.

**(2)**



(ii) State **two** conditions required for total internal reflection to happen.

**(2)**

1 .....

.....

2 .....

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(iii) Telephone signals can be sent along optical fibres using light. In earlier systems the signals were sent using electric currents in copper wires.

Suggest **one** advantage of sending signals using optical fibres.

**(1)**

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**(Total for Question 3 9 marks)**

**4** A student is investigating refraction of light.

(a) What is **refraction**?

**(1)**

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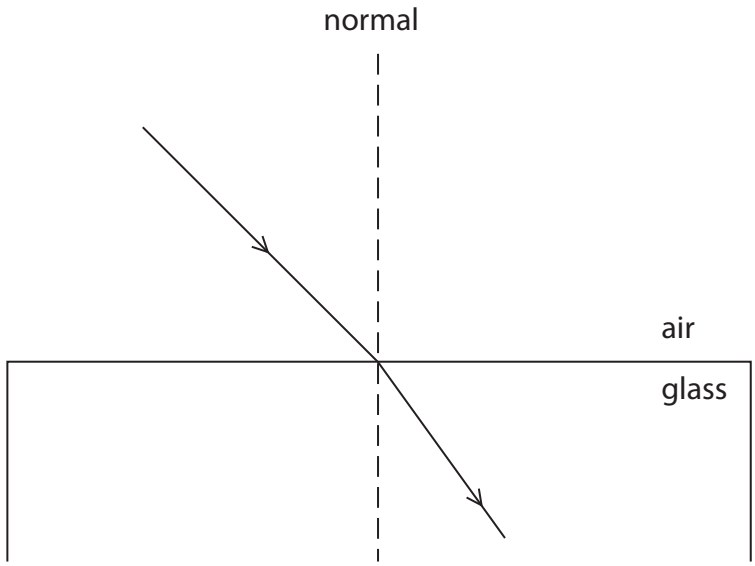
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(b) The diagram shows a ray of light travelling from air to glass.

Add labels to show the angle of incidence, *i*, and the angle of refraction, *r*.

**(2)**

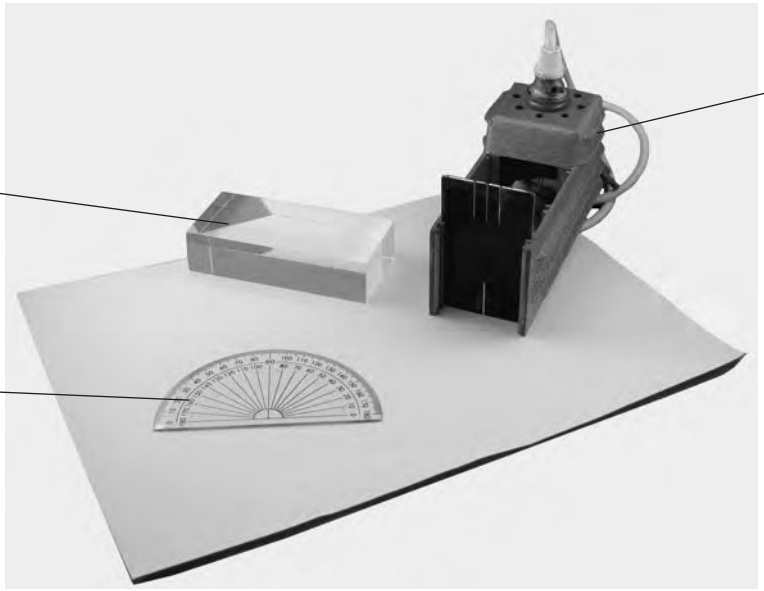



(c) The student wants to find the refractive index of the glass.

(i) State the equation linking refractive index, angle of incidence and angle of refraction.

**(1)**

(ii) The photograph shows the apparatus the student has available.




Describe how the student should carry out the experiment.

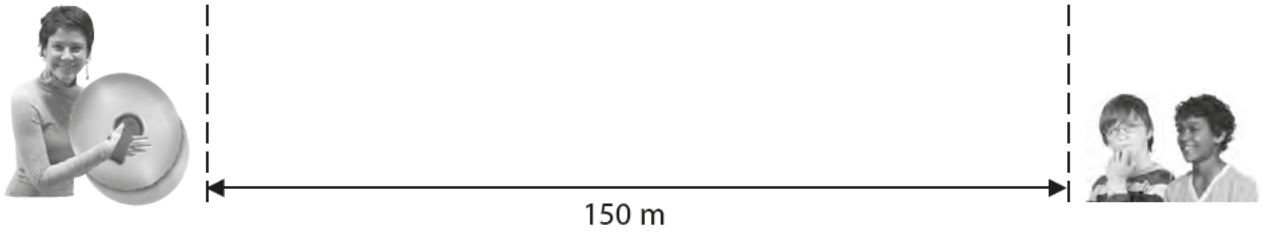
You should include:

- what the student should measure
- how the measurements should be made
- how the student should use a graph to find the refractive index.

**(6)**

**(Total for Question 4 = 10 marks)**

**5** A teacher and two students are measuring the speed of sound.




The teacher makes a loud sound by hitting two cymbals together.

Each student starts a stopwatch when they see the teacher hit the cymbals. They each stop their stopwatch when they hear the sound.

(a) Describe how a sound wave moves through the air.

**(3)**

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(b) The students repeat the experiment and record their readings in a table.

| Student | Time in s |
|---|---|
| Andrew | 0.44, 0.46, 0.44, 0.48, 0.43 |
| Kefe | 0.5, 0.6, 0.4, 0.4, 0.6 |

(i) State the precision of Andrew's readings.

**(1)**

.....

(ii) State the equation linking speed, distance travelled and time taken.

**(1)**

(iii) The teacher was standing 150 m from the students.

Use the experimental data recorded by each student to complete the table below.

Give your answers to an appropriate number of significant figures.

**(3)**

| Student | Mean (average) time in s | Speed of sound in m/s |
|---|---|---|
| Andrew | | |
| Kefe | | |

(c) The students look in a data book and find that the speed of sound in air is given as 341 m/s.

The students discuss their results.



Andrew

My experiment was more accurate because my answer was closest to 341 m/s.

No, you didn't allow for reaction time. My result is the best that you can get with this method.

No, reaction time didn't matter because I had to react twice and it cancelled out.



Kefe

Evaluate these conclusions.

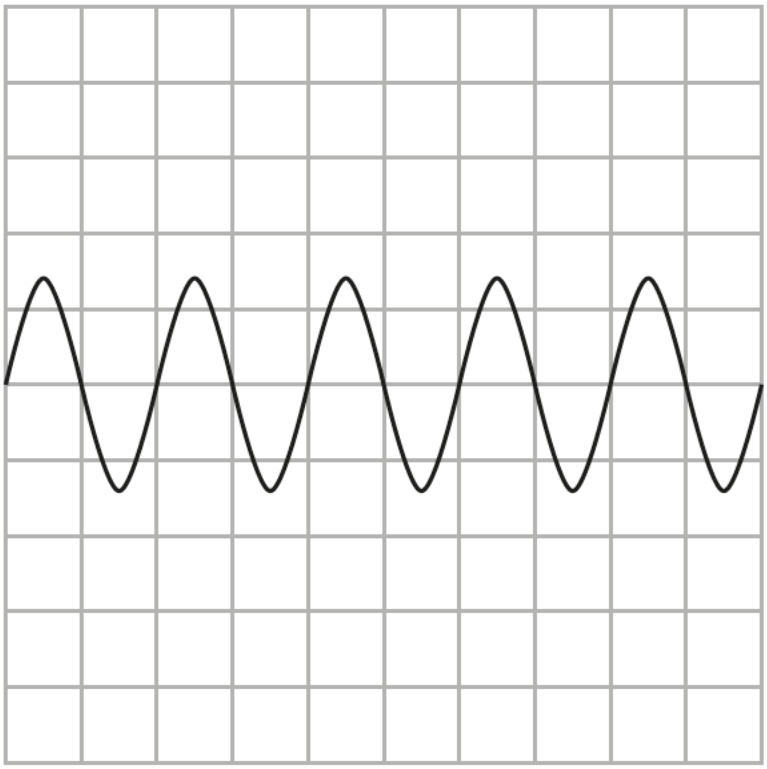
**(5)**

**(Total for Question 5 = 13 marks)**

**6** Waves can travel on water, through air or in a vacuum.

(a) The diagram shows the side-view of a wave on the surface of water.

Each square on the grid represents 1 cm x 1 cm.



(i) State the wavelength of the wave shown.

**(1)**

wavelength = ..... cm

(ii) On the grid sketch the trace of a wave travelling at the same speed, but with a larger amplitude and a lower frequency.

**(2)**

(b) Two students investigate the speed of sound waves in air.

They use a stopwatch that shows times to the nearest 0.1 s.

They use an outdoor running track as their measure of distance.

The track is straight and 100 m long.

Describe what else they must do to obtain a value for the speed of sound.

**(5)**

(c) (i) State the equation linking wave speed, frequency and wavelength.

**(1)**

(ii) The speed of radio waves is 300 000 000 m/s.

A radio wave has a frequency of 31 MHz.

Calculate the wavelength of this radio wave.

**(3)**

wavelength = ..... m

(d) A sound wave and a radio wave have the same wavelength.

State why they have different frequencies.

**(1)**

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**(Total for Question 6 = 13 marks)**