Topic 3 · Waves

General wave properties, reflection and refraction, thin lenses, dispersion, the electromagnetic spectrum, and sound.

SUGGESTED TIME	TOTAL MARKS	QUESTIONS	MULTIPLE CHOICE
45 minutes	**38**	**10**	**6**

SECTION	**3 · Waves**
IN THE FORMAT OF	Papers 1 and 2 (multiple choice), Papers 3 and 4 (theory), Paper 6 (alternative to practical)
ROUTES	Core only — 6 questions, 13 marks. Core and Supp. — the whole paper, 10 questions, 38 marks. Every question is tagged in the left margin.
DEMAND	**Recall 3 · Routine 4 · Demanding 2 · Discriminating 1** *Pitched at the board's own level, not above it. Multiple choice is mostly one step, with a couple of two-step items and one that rewards the candidate who does not take the obvious route. Structured questions open on a 1-mark recall and close on an explanation or a suggestion worth two marks — the marks real candidates most often drop.*
SYLLABUS POINTS	3.1 · 3.2 · 3.3 · 3.4

INSTRUCTIONS

- Answer all questions in the spaces provided.
- Show your working. Method marks are awarded even where the final answer is wrong.
- Give your answers to a sensible number of significant figures, with a unit.
- The mark scheme for this paper follows the last question.

> *Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge IGCSE Physics 0625; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.*
>
> Cambridge IGCSE Physics 0625 syllabus — https://www.cambridgeinternational.org/Images/697209-2026-2028-syllabus.pdf

THE PAPER

Topic 3 · Waves

Answer all questions. 38 marks in 45 minutes.

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1 CORE

MULTIPLE CHOICE · RECALL · 3.1 **[1]**

Which statement describes a longitudinal wave?

A The particles vibrate at right angles to the direction of energy transfer.

B The particles vibrate along the direction of energy transfer.

C The particles travel with the wave from one place to another.

D The wave cannot travel through a solid.

Answer ☐

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2 CORE

MULTIPLE CHOICE · ROUTINE · 3.1 **[1]**

Water waves in a ripple tank have a wavelength of 2.5 cm. 12 complete waves pass a fixed point in 4.0 s. What is the speed of the waves?

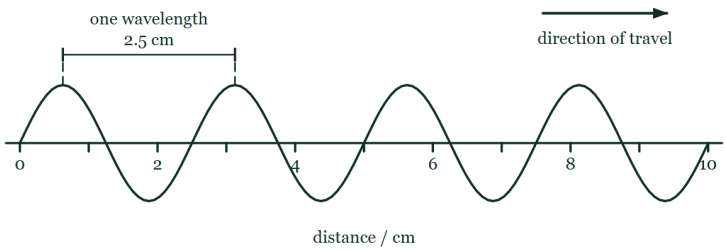

Fig. 2.1 *A snapshot of the water surface in the ripple tank at one instant, drawn as a side view. Four complete waves run left to right above a horizontal distance scale that is marked in centimetres from 0 to 10, the scale line itself being the undisturbed water level. A dimension line drawn between two neighbouring crests is labelled one wavelength, 2.5 cm, and a separate arrow above the wave shows the direction in which the waves are travelling.*

A 0.83 cm/s

B 7.5 cm/s

C 30 cm/s

D 120 cm/s

Answer ☐

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3 SUPP.

MULTIPLE CHOICE · ROUTINE · 3.2 **[1]**

A ray of light travels from air into a transparent block of refractive index 1.5. The angle of incidence in air is 40°. What is the angle of refraction in the block? (sin 40° = 0.643)

A 17°

B 25°

C 40°

D 74°

Answer ☐

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4 CORE

MULTIPLE CHOICE · RECALL · 3.3 **[1]**

Which list places these electromagnetic waves in order of increasing frequency?

A infrared, microwaves, ultraviolet, X-rays

B microwaves, infrared, ultraviolet, X-rays

C X-rays, ultraviolet, infrared, microwaves

D ultraviolet, X-rays, microwaves, infrared

Answer ☐

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5 CORE

MULTIPLE CHOICE · ROUTINE · 3.4 **[1]**

A student stands 165 m from a large wall and claps once. She hears the echo 1.0 s later. What is the speed of sound in air from her measurement?

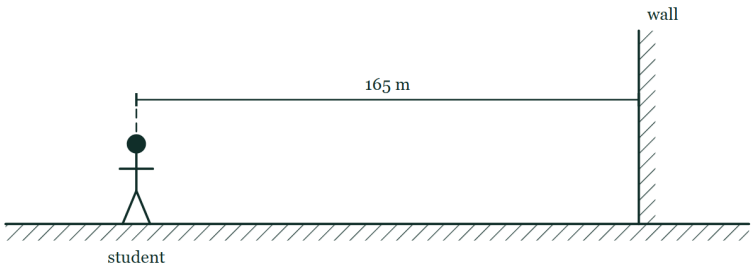

Fig. 5.1 *A side view of the arrangement. The student stands on level hatched ground on the left, facing a tall wall drawn as a hatched vertical slab standing on the same ground well to her right. A dimension line above her head runs horizontally from the student across to the face of the wall and is labelled 165 m. No sound path is drawn on the figure.*

A 165 m/s

B 247 m/s

C 330 m/s

D 660 m/s

Answer ☐

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6 CORE

MULTIPLE CHOICE · RECALL · 3.4 **[1]**

In which material does sound travel fastest?

A air

B a vacuum

C water

D steel

Answer

7 STRUCTURED · DEMANDING · 3.1 **[7]**

SUPP.

Straight water waves in a ripple tank travel from a deep region into a shallow region. The boundary between the regions is a straight line, and the wavefronts meet it at 30° to the boundary. In the deep region the waves have a wavelength of 1.8 cm and a frequency of 8.0 Hz. In the shallow region the wavelength is 1.2 cm.

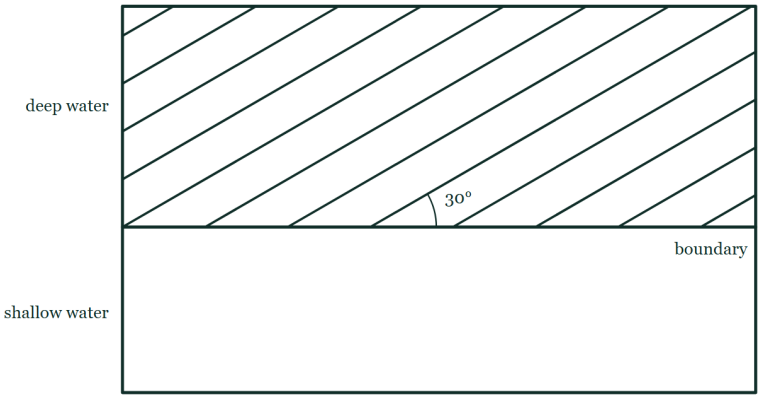

Fig. 7.1 *Plan view of the ripple tank, seen from above. A straight boundary runs right across the tank, dividing it into deep water in the upper part and shallow water in the lower part, each region labelled. Twelve straight parallel wavefronts, evenly spaced, fill the deep water and slope up to the right so that each one makes an angle of 30° with the boundary; that angle is marked with an arc where one front meets the boundary. The shallow region is drawn empty.*

(a) CALCULATE **[2]**

Calculate the speed of the waves in the deep region.

(b) DETERMINE **[2]**

Determine the speed of the waves in the shallow region.

(c) DESCRIBE **[3]**

The wavefronts meet the boundary at an angle. Describe and explain what happens to the direction in which the waves travel as they cross into the shallow region.

8 STRUCTURED · DISCRIMINATING · 3.2 **[9]**

SUPP.

An optical fibre has a glass core of refractive index 1.50. Light entering one end of the fibre travels along it by repeated total internal reflection at the core boundary, even where the fibre is gently curved.

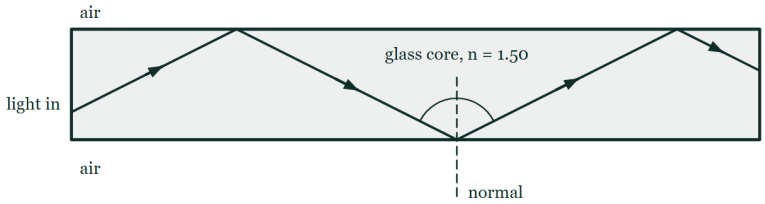

Fig. 8.1 *A straight length of optical fibre drawn in section as a long horizontal band with parallel walls, shaded to show glass and labelled glass core, n = 1.50, with air labelled outside it. Light entering the flat left-hand end travels up to the upper wall, reflects down to the lower wall, reflects again up to the upper wall and reaches the far end, giving a zig-zag path along the fibre. At one reflection a dashed normal is drawn perpendicular to the wall, and the angle on each side of it is marked with an arc; no angle is given a numerical value.*

(a) STATE **[2]**

State the two conditions necessary for total internal reflection to occur.

(b) CALCULATE **[3]**

Calculate the critical angle for the glass core.

(c) EXPLAIN **[3]**

A student suggests that bending the fibre very sharply would make no difference, because total internal reflection always happens. Explain why the student is wrong.

(d) GIVE **[1]**

Give one use of optical fibres other than in medicine.

9 CORE

STRUCTURED · ROUTINE · 3.3 **[8]**

The electromagnetic spectrum is a family of transverse waves that all travel at the same speed in a vacuum, 3.0×10^8 m/s.

(a) STATE **[1]**

State one property, other than their speed in a vacuum, that all electromagnetic waves share.

(b) IDENTIFY **[2]**

Identify the region of the electromagnetic spectrum used for each of the following, and give one different region for each: (i) cooking food in an oven that heats from the outside; (ii) sterilising medical equipment.

(c) CALCULATE **[3]**

A radio station broadcasts at a frequency of 95.8 MHz. Calculate the wavelength of the waves it emits.

(d) DESCRIBE **[2]**

Describe one harmful effect of excessive exposure to ultraviolet radiation, and state one way of reducing the risk.

10 SUPP.

PRACTICAL SKILLS · DEMANDING · 3.2 **[8]**

A student determines the refractive index of a glass block using optical pins. She places the block on a sheet of paper, draws round it, and shines a ray at the top face at an angle of incidence i, marking the ray in and the ray out with pins. She repeats this for several values of i and measures the angle of refraction r inside the block.

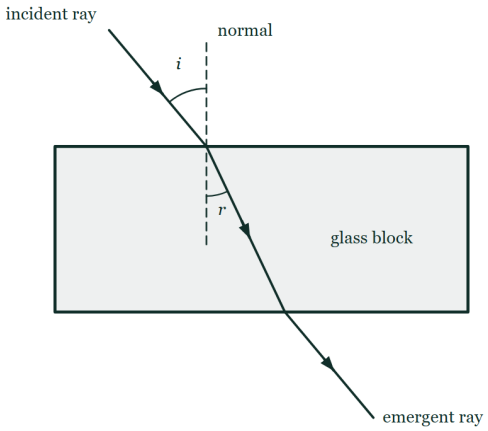

Fig. 10.1 *The rectangular glass block drawn on the paper, seen from above. A ray labelled incident ray comes down from the upper left and meets the top face of the block; a dashed normal is drawn perpendicular to that face at the point where the ray strikes it. The angle between the incident ray and the normal is labelled i, and the angle between the normal and the ray travelling inside the glass is labelled r. The ray crosses the block, leaves through the bottom face and continues as the emergent ray. The optical pins are not shown.*

The student's results

i / degrees	20	30	40	50	60
r / degrees	13.2	19.5	25.4	30.7	35.3
sin i	0.342	0.500	0.643	0.766	0.866
sin r	0.228	0.334	0.429	0.511	0.578

(a) DESCRIBE **[3]**

Describe how the student should place and use the optical pins so that the path of the ray is marked accurately.

(b) EXPLAIN **[3]**

Explain why plotting a graph of sin i against sin r gives a more reliable value for the refractive index than calculating sin i / sin r for a single pair of readings.

(c) DETERMINE **[2]**

Use the first and last results to determine a value for the refractive index of the glass.

MARK SCHEME

Topic 3 · Waves — mark scheme

One line per mark, as an examiner would award them. A note under a part is the error that part is set to catch.

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1 CORE

MULTIPLE CHOICE · RECALL · 3.1 **[1]**

Which statement describes a longitudinal wave?

KEY **B** **The particles vibrate along the direction of energy transfer.**

C is the misconception the whole topic is set against: a wave transfers energy without transferring matter. A describes a transverse wave.

A01

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2 CORE

MULTIPLE CHOICE · ROUTINE · 3.1 **[1]**

Water waves in a ripple tank have a wavelength of 2.5 cm. 12 complete waves pass a fixed point in 4.0 s. What is the speed of the waves?

KEY **B** **7.5 cm/s**

C multiplies by the number of waves instead of the frequency — the error of a candidate who never works out that f = 12 / 4.0 = 3.0 Hz.

A02

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3 SUPP.

MULTIPLE CHOICE · ROUTINE · 3.2 **[1]**

A ray of light travels from air into a transparent block of refractive index 1.5. The angle of incidence in air is 40°. What is the angle of refraction in the block? (sin 40° = 0.643)

KEY **B** **25°**

D applies the ratio the wrong way round. Light entering a denser medium bends towards the normal, so any answer larger than 40° can be rejected before a calculation is done.

A02

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4 CORE

MULTIPLE CHOICE · RECALL · 3.3 **[1]**

Which list places these electromagnetic waves in order of increasing frequency?

KEY **B** **microwaves, infrared, ultraviolet, X-rays**

A swaps the first pair, which is the pair candidates most often reverse. C is the correct order of decreasing frequency, offered for anyone who reads the question too quickly.

A01

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5 CORE

MULTIPLE CHOICE · ROUTINE · 3.4 **[1]**

A student stands 165 m from a large wall and claps once. She hears the echo 1.0 s later. What is the speed of sound in air from her measurement?

KEY **C** **330 m/s**

A is the trap and takes about half of all candidates: the sound travels to the wall and back, so the distance is 330 m, not 165 m.

A02

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6 CORE

MULTIPLE CHOICE · RECALL · 3.4 **[1]**

In which material does sound travel fastest?

KEY **D steel**

B is set for the candidate who confuses sound with light: sound needs a medium and does not travel through a vacuum at all.

AO1

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7 SUPP.

STRUCTURED · DEMANDING · 3.1 **[7]**

Straight water waves in a ripple tank travel from a deep region into a shallow region. The boundary between the regions is a straight line, and the wavefronts meet it at 30° to the boundary. In the deep region the waves have a wavelength of 1.8 cm and a frequency of 8.0 Hz. In the shallow region the wavelength is 1.2 cm.

(a) CALCULATE · AO2 **[2]**

Calculate the speed of the waves in the deep region.

1 $v = f\lambda = 8.0 \times 1.8$

2 $v = 14.4$ cm/s

(b) DETERMINE · AO2 **[2]**

Determine the speed of the waves in the shallow region.

1 the frequency is unchanged at 8.0 Hz as the waves cross the boundary

2 $v = 8.0 \times 1.2 = 9.6$ cm/s

The first marking point is the physics. Frequency is set by the source and does not change at a boundary; wavelength and speed do.

(c) DESCRIBE · AO2 **[3]**

The wavefronts meet the boundary at an angle. Describe and explain what happens to the direction in which the waves travel as they cross into the shallow region.

1 the direction of travel changes — the waves bend towards the normal to the boundary

2 because the part of each wavefront that reaches the shallow water first slows down before the rest of it does

3 so the wavefront pivots, and refraction has occurred

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8 SUPP.

STRUCTURED · DISCRIMINATING · 3.2 **[9]**

An optical fibre has a glass core of refractive index 1.50. Light entering one end of the fibre travels along it by repeated total internal reflection at the core boundary, even where the fibre is gently curved.

(a) STATE · AO1 **[2]**

State the two conditions necessary for total internal reflection to occur.

1 the light must be travelling in the optically denser medium, towards a boundary with a less dense medium

2 the angle of incidence at the boundary must be greater than the critical angle

(b) CALCULATE · AO2 **[3]**

Calculate the critical angle for the glass core.

1 sin c = 1 / n

2 sin c = 1 / 1.50 = 0.667

3 c = 41.8° (accept 42°)

(c) EXPLAIN · AO2 **[3]**

A student suggests that bending the fibre very sharply would make no difference, because total internal reflection always happens. Explain why the student is wrong.

1 bending the fibre sharply reduces the angle of incidence at the outer wall of the bend

2 if that angle falls below the critical angle of 41.8°, the light is no longer totally internally reflected

3 some light refracts out through the boundary and the signal is weakened or lost

The discriminating part of the paper. It requires the candidate to see that the angle of incidence is a property of the geometry, not a fixed feature of the fibre.

(d) GIVE · AO1 **[1]**

Give one use of optical fibres other than in medicine.

1 telephone / cable television / internet communication — any high-speed data transmission

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9 CORE

STRUCTURED · ROUTINE · 3.3 **[8]**

The electromagnetic spectrum is a family of transverse waves that all travel at the same speed in a vacuum, 3.0×10^8 m/s.

(a) STATE · AO1 **[1]**

State one property, other than their speed in a vacuum, that all electromagnetic waves share.

1 any one of: they are transverse; they transfer energy; they can travel through a vacuum; they can be reflected and refracted

(b) IDENTIFY · AO1 **[2]**

Identify the region of the electromagnetic spectrum used for each of the following, and give one different region for each: (i) cooking food in an oven that heats from the outside; (ii) sterilising medical equipment.

1 (i) infrared

2 (ii) gamma rays (accept ultraviolet for surface sterilisation)

(c) CALCULATE · AO2 **[3]**

A radio station broadcasts at a frequency of 95.8 MHz. Calculate the wavelength of the waves it emits.

1 $\lambda = v / f$

2 $\lambda = 3.0 \times 10^8 / 95.8 \times 10^6$

3 $\lambda = 3.1$ m

(d) DESCRIBE · AO1 **[2]**

Describe one harmful effect of excessive exposure to ultraviolet radiation, and state one way of reducing the risk.

1 damage to surface cells / skin ageing / skin cancer / eye damage such as cataracts

2 wear sunscreen, sunglasses or protective clothing; limit exposure at midday

10 SUPP. PRACTICAL SKILLS · DEMANDING · 3.2 **[8]**

A student determines the refractive index of a glass block using optical pins. She places the block on a sheet of paper, draws round it, and shines a ray at the top face at an angle of incidence i, marking the ray in and the ray out with pins. She repeats this for several values of i and measures the angle of refraction r inside the block.

(a) DESCRIBE · AO3 **[3]**

Describe how the student should place and use the optical pins so that the path of the ray is marked accurately.

1 place two pins in the incident ray, as far apart as possible

2 view from the far side of the block and place two more pins so that all four appear in line, one behind another

3 remove the block and draw a straight line through each pair to find the ray in and the ray out

"As far apart as possible" is a marking point in its own right: it reduces the effect of the uncertainty in each pin's position on the direction of the line.

(b) EXPLAIN · AO3 **[3]**

Explain why plotting a graph of sin i against sin r gives a more reliable value for the refractive index than calculating sin i / sin r for a single pair of readings.

1 n = sin i / sin r, so a graph of sin i against sin r should be a straight line through the origin of gradient n

2 the gradient uses all of the readings rather than one, so random errors in individual measurements average out

3 an anomalous result is visible as a point off the line and can be identified rather than silently included

(c) DETERMINE · AO2 **[2]**

Use the first and last results to determine a value for the refractive index of the glass.

1 gradient = (0.866 − 0.342) / (0.578 − 0.228) = 0.524 / 0.350

2 n = 1.50 (accept 1.5)

THE CHEAPEST MARKS ON ANY PAPER

What the command words are asking for

Every board publishes these and marks to them. A candidate who explains where the question said state has spent four minutes earning one mark; one who states where it said explain has earned none.

Calculate	Work out from given facts, figures or information.
Define	Give the precise meaning.
Describe	State the points of a topic; give characteristics and main features.
Determine	Establish an answer using the information available.
Estimate	Suggest an approximate value.
Explain	Set out purposes or reasons; make relationships evident; give why and/or how.
Give	Produce an answer from a given source or recall.
Identify	Name, select or recognise.
Show (that)	Provide structured evidence that leads to a given result.
State	Express in clear terms.
Suggest	Apply knowledge and understanding to situations where there is a range of valid responses in order to make proposals.

WHAT IS BEING TESTED

IGCSE assessment objectives

Every candidate sits two theory papers and one practical-skills paper. Core takes Papers 1 and 3 and is capped at grade C; Extended takes Papers 2 and 4 and reaches A*. Both then take either Paper 5 (practical test) or Paper 6 (alternative to practical), which carries 20% either way. Theory papers give you no formula sheet.

AO1
11 MARKS · 29%
QUALIFICATION 50%

Knowledge with understanding

Recall, describe, explain and use physics ideas, terminology, instruments and conventions.

AO2
21 MARKS · 55%
QUALIFICATION 30%

Handling information and problem-solving

Locate and interpret information, translate between forms, calculate, reason, and apply physics to unfamiliar situations.

AO3
6 MARKS · 16%
QUALIFICATION 20%

Experimental skills and investigations

Plan, use apparatus, record and present observations, analyse, evaluate, and suggest improvements.

> *Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge IGCSE Physics 0625; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.*
>
> Cambridge IGCSE Physics 0625 syllabus — https://www.cambridgeinternational.org/Images/697209-2026-2028-syllabus.pdf