

GCSE Physics

Worksheet: EM waves: refraction and absorption

TIME 35 min	TOTAL 32 marks	CALCULATOR Allowed	DIFFICULTY Easy, Medium
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Topics: EM waves: refraction and absorption

NAME	CLASS	DATE
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- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Answer all questions in the spaces provided.
- In all calculations, show clearly how you work out your answer.
- The marks for questions are shown in brackets.

0 1

A student investigates how the angle of refraction in a glass block depends on the angle of incidence, using a ray box, a rectangular glass block and a protractor.

0 1 . 1 Write a hypothesis for this investigation.

.....

.....

[1 mark]

0 1 . 2 Identify the independent variable and the dependent variable, and state one variable that must be controlled.

.....

.....

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.....

.....

[3 marks]

0 1 . 3

Give one hazard in this investigation and a suitable control measure.

.....

.....

.....

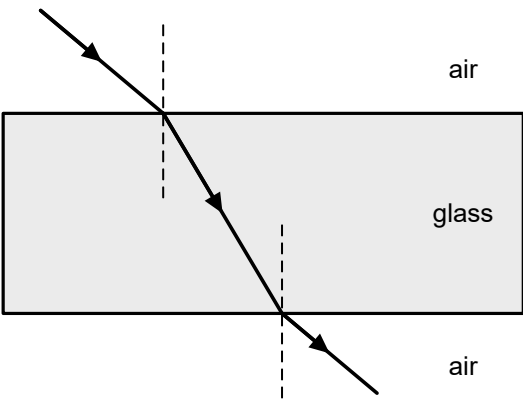
.....

[2 marks]

0 2

Figure 1 shows a ray of light passing through a rectangular glass block.

Figure 1



0 2 . 1

What name is given to the change in direction of the light at the surface of the glass?

.....

.....

.....

[1 mark]

0 2 . 2

What happens to the speed of the light as it passes from air into glass?

Tick (✓) **one** box.

It decreases.

It increases.

It stays the same.

☐

☐

☐

[1 mark]

0 2 . 3

As the light enters the glass, does it bend towards the normal or away from the normal?

[1 mark]

0 2 . 4

Compare the direction of the ray leaving the glass block with the direction of the ray entering the block.

[1 mark]

0 3

A ray of light travels from air into a glass block.

0 3 . 1

What happens to the speed and the wavelength of the light as it enters the glass?

Tick (✓) **one** box.

Both decrease

☐

Both increase

☐

Speed decreases, wavelength increases

☐

Speed increases, wavelength decreases

☐

[1 mark]

0 3 . 2

What happens to the frequency of the light as it enters the glass?

[1 mark]

0 3 . 3

The ray meets the glass surface along the normal (angle of incidence 0°). Does the ray change direction as it enters the glass?

[1 mark]

0 4

A student models the greenhouse effect using two identical open-topped clear plastic boxes placed in sunlight. Box A is empty apart from a thermometer. Box B is the same, but has a pane of glass fixed over the top. Most visible light passes through glass, but glass absorbs infrared radiation strongly.

0 4 . 1

Predict which box reaches the higher temperature. Give a reason for your answer.

.....

.....

.....

.....

[2 marks]

0 4 . 2

Give **one** variable that must be controlled for this to be a fair comparison.

.....

.....

[1 mark]

0 5

A student marks the path of a ray entering and leaving a glass block with pencil dots, removes the block, and joins the dots with a ruler to construct the refracted ray before measuring the angle of refraction with a protractor of resolution 1° . The student repeats the whole procedure three times for the same angle of incidence, obtaining 32° , 34° and 33° .

0 5 . 1

State the uncertainty in a single angle reading due to the resolution of the protractor.

.....

.....

.....

Uncertainty = $^\circ$

[1 mark]

0 5 . 2

Calculate the mean of the three repeat angles and the uncertainty in the mean, using the range of the readings.

.....

.....

.....

.....

.....

Mean angle of refraction = °

[3 marks]

0 5 . 3

Identify the more significant source of random error in this method: the protractor’s resolution, or marking the position of the ray with a pencil dot. Give a reason.

.....

.....

[1 mark]

0 6

A student draws around the glass block’s outline on paper before marking the ray positions with pencil dots. While marking the exit ray, the student accidentally nudges the block slightly out of its outline before finishing.

0 6 . 1

Explain why this would make the angle of refraction found from that reading invalid.

.....

.....

.....

.....

[2 marks]

0 6 . 2

State what the student should do about this particular reading.

[1 mark]

0 6 . 3

Suggest **two** ways the student could prevent the block moving, or make sure that a movement is noticed, in future repeats.

[2 marks]

0 7

A student used a Leslie cube to investigate how the type of surface affects the amount of infrared radiation emitted. A Leslie cube is a hollow metal cube with four different outside surfaces.

The student filled the cube with hot water. The student then placed an infrared detector 10 cm from each surface in turn. The larger the reading, the more infrared radiation the detector receives.

Table 1 shows the results.

Table 1

Surface	Infrared detector reading
Matt black	64
Matt white	58
Shiny black	49
Shiny silver	9

0 7 . 1

Which surface emitted the least infrared radiation?

.....

.....

.....

.....
[1 mark]

0 7 . 2

Explain why the detector was placed the same distance from each surface.

.....

.....

[1 mark]

0 7 . 3

The water cools down during the investigation.
Explain how this could affect the results, and suggest how the student could reduce this effect.

.....

.....

.....

.....

.....

.....

[3 marks]

0 7 . 4

Give **one** conclusion about shiny surfaces that can be made from the results.

.....

.....

[1 mark]

END OF QUESTIONS

Original practice questions written to match the specification. Not produced by, affiliated with or endorsed by AQA.

Mark scheme

GCSE Physics · Worksheet: EM waves: refraction and absorption · 32 marks

Question 1 (6 marks)

01.1 [1 mark]

Answer: As the angle of incidence increases, the angle of refraction also increases, but stays smaller than the angle of incidence, because light slows down on entering the glass and bends towards the normal.

- as angle of incidence increases, angle of refraction increases too, but remains smaller than the angle of incidence (light bends towards the normal entering the glass) (1)
-

01.2 [3 marks]

Answer: Independent: the angle of incidence. Dependent: the angle of refraction. Control: the same glass block (material) is used for every reading.

- independent variable: the angle of incidence (1)
 - dependent variable: the angle of refraction (1)
 - control variable: the glass block/material used (a different material would refract light by a different amount) (1)
-

01.3 [2 marks]

Answer: The ray box bulb can become hot; allow it to cool before handling, and switch it off between readings if it starts to overheat.

- a hazard, e.g. the ray box bulb becomes hot and could burn skin, or bright light could be uncomfortable/dazzling if looked at directly (1)
 - a control measure that matches the hazard, e.g. allow the bulb to cool before handling, switch off between readings, or avoid looking directly into the light source (1)
-

Question 2 (4 marks)

02.1 [1 mark]

Answer: Refraction

- refraction (1)
-

02.2 [1 mark]

Correct: It decreases.

02.3 [1 mark]

Answer: Towards the normal

- towards the normal (1)
-

02.4 [1 mark]

Answer: The ray leaving the block is parallel to the ray entering it.

- they are parallel / the ray leaves in the same direction as it entered (1)
-

Question 3 (3 marks)

03.1 [1 mark]

Correct: Both decrease

03.2 [1 mark]

Answer: It stays the same.

- it stays the same (does not change) (1)
-

03.3 [1 mark]

Answer: No, it continues in the same direction.

- no, it carries straight on (1)
-

Question 4 (3 marks)

04.1 [2 marks]

Answer: Box B: infrared re-emitted inside is absorbed by the glass rather than escaping, trapping more energy.

- box B (1)
- visible light passes through the glass and is absorbed inside, then re-emitted as infrared; this infrared is absorbed by the glass instead of escaping, so more energy stays inside box B (1)

Notes: The reason mark depends on choosing box B.

04.2 [1 mark]

Answer: The amount of direct sunlight each box receives (or the size/material of the boxes).

- the size/material of the boxes / the position of the thermometer / the amount of direct sunlight each box receives / the starting temperature (1)

Question 5 (5 marks)

05.1 [1 mark]

Answer: $\pm 0.5^\circ$

- $\pm 0.5^\circ$ (half the resolution of 1°) (1)

05.2 [3 marks]

Answer: 33° , uncertainty = $\pm 1^\circ$

- mean = $(32 + 34 + 33) \div 3 = 33^\circ$ (1)
- uncertainty = $\pm$ half the range = $\pm (34 - 32) \div 2$ (1)
- = $\pm 1^\circ$ (1)

05.3 [1 mark]

Answer: Marking the ray with a pencil dot, because the spread of the repeat readings ($\pm 1^\circ$) is bigger than the uncertainty from the protractor's resolution alone ($\pm 0.5^\circ$).

- marking the ray's position with a pencil dot (e.g. due to parallax, or the dot having a finite size), because the spread of the repeats ($\pm 1^\circ$) is bigger than the resolution uncertainty alone ($\pm 0.5^\circ$) (1)
-

Question 6 (5 marks)

06.1 [2 marks]

Answer: If the block has moved, its exit face is no longer where it was when the entry point and path inside the block were established, so a ray drawn between the (now mismatched) entry and exit marks would not correctly represent the true path of light through the block, giving an incorrect angle.

- if the block has moved, its exit face is no longer in the position used to establish the ray's path from the entry point (1)
- so the ray drawn between the (mismatched) entry and exit marks does not represent the true path of light through the block, giving an incorrect angle (1)

06.2 [1 mark]

Answer: Discard it (treat it as unusable/anomalous) and repeat the measurement with the block correctly repositioned in its outline.

- discard / ignore this reading and repeat it with the block correctly repositioned in its outline (1)

06.3 [2 marks]

Answer: Tape the paper to the desk so that it cannot slide, and hold the block down gently but firmly with one hand while marking the dots with the other.

- tape the paper to the desk so that the paper (and the drawn outline) cannot slide (1)
- hold / press the block down gently but firmly while marking the ray (1)
- place a small weight on top of the block (away from the ray's path) (1)
- check that the block is still exactly within its outline before removing it, and repeat the reading if it has moved (1)

Any 2 of the points above.

Question 7 (6 marks)

07.1 [1 mark]

Answer: Shiny silver

- shiny silver (1)
-

07.2 [1 mark]

Answer: The amount of radiation detected depends on the distance, so it must be kept the same for a fair test.

- the reading depends on the distance from the surface, so this makes it a fair test (1)
-

07.3 [3 marks]

Answer: The cube emits less infrared as it cools, so later readings are too low; take the readings quickly or at the same water temperature.

- the cube emits less infrared radiation as its temperature falls (1)
 - so surfaces measured later would give lower readings (not a fair comparison) (1)
 - take all the readings quickly / reheat or top up the water / measure the water temperature and take each reading at the same temperature (1)
-

07.4 [1 mark]

Answer: Shiny surfaces are poorer emitters than matt surfaces.

- shiny surfaces emit less infrared than matt surfaces of the same colour / shiny silver is the poorest emitter (1)
-