# Physics PAG 8: Interaction of waves

# Suggested Activity 1

# Combined Science PAG P4: Waves

# Suggested Activity 2

# Investigating the reflection of light off a plane mirror and the refraction of light through a rectangular prism

## Instructions and answers for teachers & technicians

These instructions cover the learner activity section which can be found on [page 9](#_Learner_Activity_1). This Practical activity supports OCR GCSE Physics.

**When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.**

|  |
| --- |
| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/) and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

**OCR recommendations:**

**Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

In this activity, learners will investigate the behaviour of light off a plane mirror and through a rectangular prism.

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Physics**](http://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Physics**](http://www.ocr.org.uk/Images/323482-gcse-physics-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

**4b** *[16b]*) Making observations of the effects of the interaction of electromagnetic waves with matter

**8**) Making observations of waves to identify the suitability of apparatus to measure the effects of interactions of waves with matter in: ii) solids

### Aims

To use suitable apparatus to measure the angle of incidence and the angle of reflection when light is reflected off a plane mirror.

Determine the relationship between the angle of incidence and the angle of reflection when light is reflected off a plane mirror.

To use suitable apparatus to measure the angle of incidence and the angle of refraction when light is passed through a rectangular prism

To relate this to the speed that light travels through different materials.

### Intended class time

50-60 minutes

### Links to Specifications:

### Gateway Science (Suite A) including Working Scientifically (WS)

P5.1g describe the effects of reflection, transmission, and absorption of waves at material interface

P5.3a recall that different substances may absorb, transmit, refract, or reflect electromagnetic waves in ways that vary with wavelength

P5.3b explain how some effects are related to differences in the velocity of electromagnetic waves in different substances

P5.3d construct two-dimensional ray diagrams to illustrate reflection and refraction (qualitative only)

WS1.2a, use scientific theories and explanations to develop hypotheses

WS1.2c, apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment

WS1.3f, presenting reasoned explanations

WS1.3h, identifying potential sources of random and systematic error

WS1.4a use scientific vocabulary, terminology and definitions

WS2a, carry out experiments

WS2d communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions

### Twenty First Century Science (Suite B) including Ideas about Science (IaS)

P1.3.8a describe the effects of reflection and refraction of waves at material interfaces

P1.3.8b describe how to measure the refraction of light through a prism

P1.3.8c describe how to investigate the reflection of light off a plane mirror

P1.3.9 recall that waves travel in different substances at different speeds and that these speeds may vary with wavelength

P1.3.10 explain how refraction is related to differences in the speed of the waves in different substances

P1.4.1 construct and interpret two-dimensional ray diagrams to illustrate specular reflection by mirrors (qualitative only)

P1.4.2 construct and interpret two-dimensional ray diagrams to illustrate refraction at a plan surface and dispersion by a prism (qualitative only)

IaS1.1 suggest appropriate apparatus, materials and techniques, justifying the choice with reference to the precision, accuracy and validity of the data that will be collected

IaS2.1 present observations and other data using appropriate formats

IaS2.9 in given context evaluate data in terms of accuracy, precision, repeatability and reproducibility, identify potential sources of random and systematic error, and discuss the decision to discard or retain an outlier

### Health and Safety

Use a low voltage power supply for the ray box so not to blow the bulb

Turn off switch between readings to ensure ray boxes don’t get too hot

Be aware that ray boxes can get very hot so do not touch the ray box until they are cooled down

Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.

### Method 1

Learners use a ray box and single slit to reflect a ray of light off of a plane mirror. They measure the angle of incidence and the angle of reflection to determine the relationship between the two angles.

### Method 2

Learners use a ray box and single slit to refract light through a Perspex/glass block. They measure the angle of incidence and the angle of refraction and relate these to the speed at which the light travels through different mediums.

### Notes

Teachers should trial this activity to be able to modify the learner sheet in the light of the equipment and lesson time available at the centre. These should include the appropriate voltage setting for use with the ray boxes available. Learners do not need to calculate refractive indices.

### Technicians notes

### For this practical the teacher will require:

* Ray boxes
* Low voltage power supplies
* Single slits
* Plane mirrors
* Holders for mirrors
* Protractors
* White paper
* Pencils
* Glass/Perspex blocks

### Answers for quiz questions

|  |  |  |
| --- | --- | --- |
| **1.** | A student shines a light from a ray box onto a mirror. The image below show the path of the ray as it leaves the ray box and hits the mirror. Draw on the reflected ray. **[2 marks]** |  |
|  | mirror  normal  Line reflected off the mirror with arrow head in correct direction ✓  Angle of reflection same as angle of incidence (judged by eye) ✓ |  |

|  |  |  |
| --- | --- | --- |
| **2.** | A periscope is used in a submarine to allow people to see above the water’s surface. A simple diagram of a periscope is shown below. Complete the diagram to show the path of the light and write down how the periscope allows the user to see above the water. **[4 marks]** |  |
|  | periscope  mirror  Straight line drawn from entrance to top mirror, reflected down to second mirror and into eye ✓  mirror  Arrow head on rays in correct direction ✓  Mirrors are at 45° angles ✓ so light is reflected off the first mirror onto the second and then into the observers eye ✓ |  |

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| --- | --- | --- |
| **3 (a)** | A student is investigating refraction of light. They shine a light through a rectangular glass block at an angle. The diagram below shows the ray as it hits the glass block. Complete the diagram to show the path of the ray and label the angle of incidence and angle of refraction. **[2 marks]** |  |
|  | refraction  Normal  Air  Line drawn so ray bends towards normal ✓  Glass  Both angles correctly labelled ✓ |  |

|  |  |  |
| --- | --- | --- |
| **(b)** | Fill in the gaps using words below: **[2 marks]**  smaller larger closer to further from |  |
|  | The light is now passed through a more dense material. This means the angle of refraction is now and therefore the normal.  smaller ✓ closer to ✓ |  |

|  |  |  |
| --- | --- | --- |
| **4** | A sound wave travels from water into air. Its wavelength in air is longer than in water.  Fill in the gaps to show how the frequency and speed of the wave in air compares with its value in water. **[2 marks]** |  |
|  | The frequency in air is as the frequency in water.  The speed in air is than the speed in water.  same ✓ faster ✓ |  |

### Document updates

v1 Published on the qualification pages

v1.1 January 2017 Consolidated labelling and formatting of activities

v1.2 February 2017 Added mapping to Combined Science

v1.3 June 2021 Updated to meet accessibility standards



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# Physics PAG 8: Interaction of waves

# Suggested Activity 1

# Combined Science PAG P4: Waves

# Suggested Activity 2

# Investigating the reflection of light off a plane mirror and the refraction of light through a rectangular prism

## Learner Activity

### Introduction

In this activity, learners will investigate the behaviour of light off a plane mirror and through a rectangular prism.

### Aims

To use suitable apparatus to measure the angle of incidence and the angle of reflection when light is reflected off a plane mirror.

Determine the relationship between the angle of incidence and the angle of reflection when light is reflected off a plane mirror.

To use suitable apparatus to measure the angle of incidence and the angle of refraction when light is passed through a rectangular prism

To relate this to the speed the light travels through different materials.

### Intended class time

50-60 minutes

### Equipment (per group)

* Ray box
* Low voltage power supply
* Single slit
* Plane mirror
* Holder for mirror
* Protractor
* White paper
* Pencil
* Glass/Perspex block

### Health and Safety

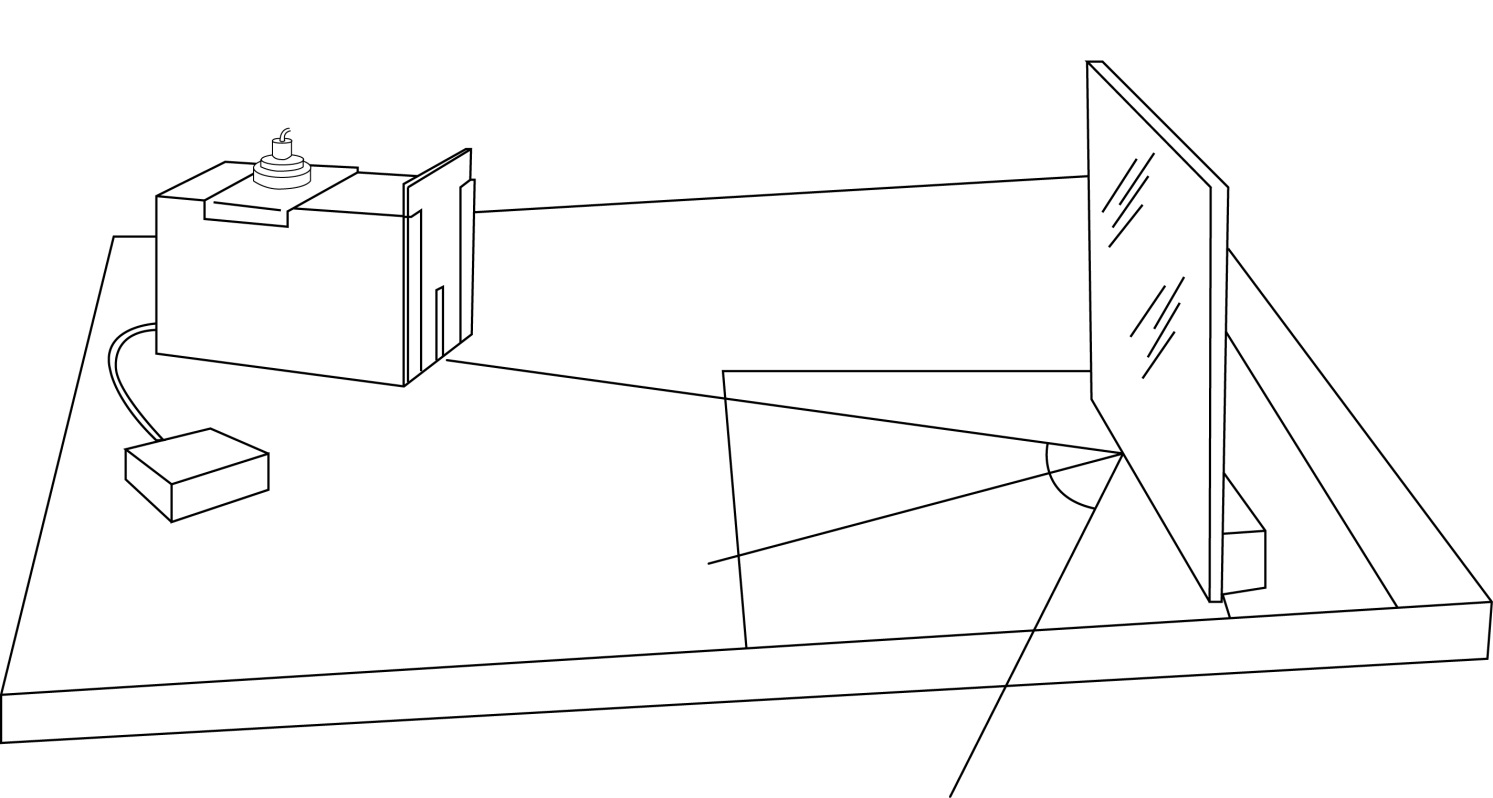
Use a low voltage power supply for the ray box so not to blow the bulb

Turn off switch between readings to ensure ray boxes don’t get too hot

Be aware that ray boxes can get very hot so do not touch the ray box until they are cooled down

### Method 1 – Reflection

1. Set up apparatus as shown below; do not turn on the power pack.



Power pack

Angle of incidence

Normal

Angle of reflection

2. Turn on the power pack at the voltage suggested by your teacher. Line up the ray of light so that it is at a 90° angle to the mirrors surface. At this angle the ray should reflect back on itself.

3. Use a pencil to draw a dashed line along the ray and a straight line to show the position of the mirror. Label the dashed line as the normal.

4. Move the ray box so that the ray of light now hits the mirror at the point where the normal meets the mirror but at an angle so the light is reflected off. Draw over the path of the light with a pencil.

5. Measure the angle of incidence (the angle at which the light hits the mirror from the normal) and the angle of reflection (the angle at which the light is reflected off the mirror from the normal). Record measurements in the table below.

6. Repeat steps 4 and 5 till you have measurements for a least 5 angles. Record all results in the table below.

### Results

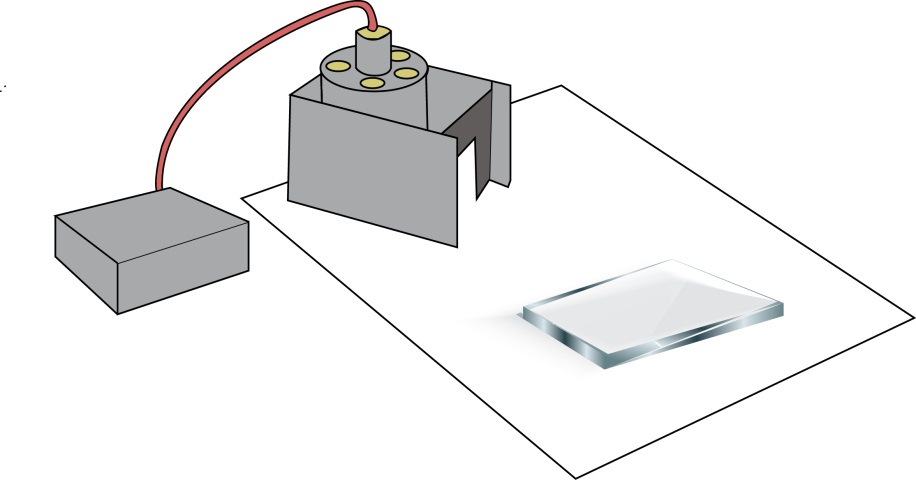
|  |  |
| --- | --- |
| **Angle of incidence (°)** | **Angle of reflection (°)** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

### Evaluation

|  |  |
| --- | --- |
| 1. Using your results, write down the relationship between the angle of incidence and the angle of reflection. |  |
|  |  |

### Method 2 – Refraction

1. Set up apparatus as shown below; do not turn on the power pack.



2. Turn on the power pack at the voltage suggested by your teacher. Draw around the block in pencil. Line up the ray of light so that it is at a 90° angle to the rectangular blocks surface. At this angle the ray should pass through the rectangular block without refracting.

3. Use a pencil to draw a dashed line along the ray. Label the dashed line as the normal.

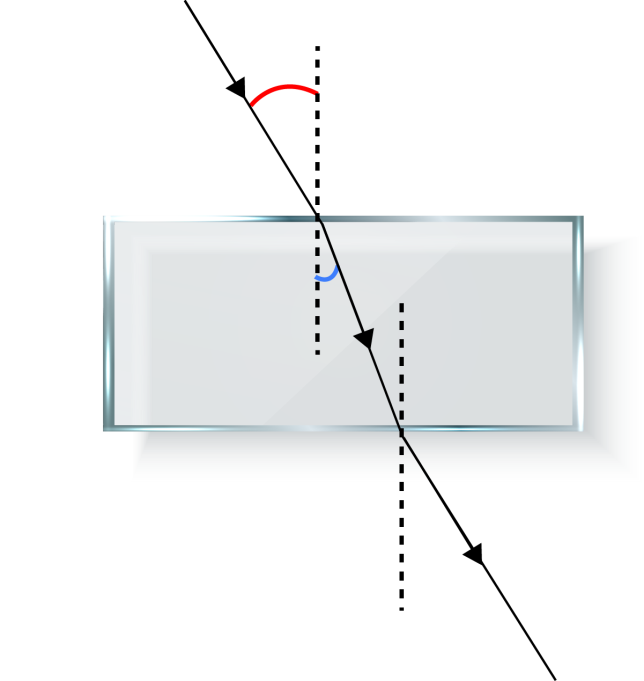
4. Move the ray box so that the ray of light now hits the block at the point where the normal meets the block but at an angle so the light is refracted through. Draw over the path of the light with a pencil.

5. Measure the angle of incidence (the angle at which the light hits the rectangular block from the normal) and the angle of refraction (the angle at which the light is refracted through the black from the normal). Record measurements in the table below.

Angle of incidence

Transparent block

normal



Angle of refraction

6. Repeat steps 4 and 5 till you have measurements for a least 5 angles. Record all results in the table below.

### Results

|  |  |
| --- | --- |
| **Angle of incidence (°)** | **Angle of refraction (°)** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

### Evaluation

|  |  |
| --- | --- |
| 1. In relation to the normal, in which way did the light bend when it entered the rectangular block? |  |
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|  |  |
| --- | --- |
| 1. Write down, using ideas about particle model, how the density of the glass block in compares to the density of air. |  |
|  |  |

|  |  |
| --- | --- |
| 1. How does the speed of the light change when it enters the glass block? |  |
|  |  |

|  |  |
| --- | --- |
| 1. Why does the speed of light change when travelling through the glass block? |  |
|  |  |

### Quiz - test your knowledge and understanding

|  |  |  |
| --- | --- | --- |
| **1.** | A student shines a light from a ray box onto a mirror. The image below show the path of the ray as it leaves the ray box and hits the mirror. Draw on the reflected ray. **[2 marks]** |  |
|  | mirror  normal |  |

|  |  |  |
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|  | periscope  mirror  mirror |  |

|  |  |  |
| --- | --- | --- |
| **3 (a)** | A student is investigating refraction of light. They shine a light through a rectangular glass block at an angle. The diagram below shows the ray as it hits the glass block. Complete the diagram to show the path of the ray and label the angle of incidence and angle of refraction. **[2 marks]** |  |
|  | refraction  Air  Normal  Glass |  |

|  |  |  |
| --- | --- | --- |
| **(b)** | Fill in the gaps using words below: **[2 marks]**  smaller larger closer to further from |  |
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|  |  |  |
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| **4** | A sound wave travels from water into air. Its wavelength in air is longer than in water.  Fill in the gaps to show how the frequency and speed of the wave in air compares with its value in water. **[2 marks]** |  |
|  | The frequency in air is as the frequency in water.  The speed in air is than the speed in water. |  |

### DfE Apparatus and Techniques covered

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| **Physics** | |  | ***Combined Science*** |
| --- | --- | --- | --- |
| 4b | 8−ii |  | *16b* |