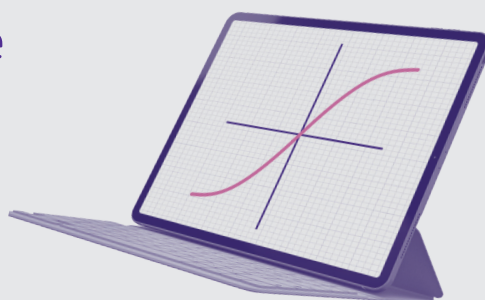
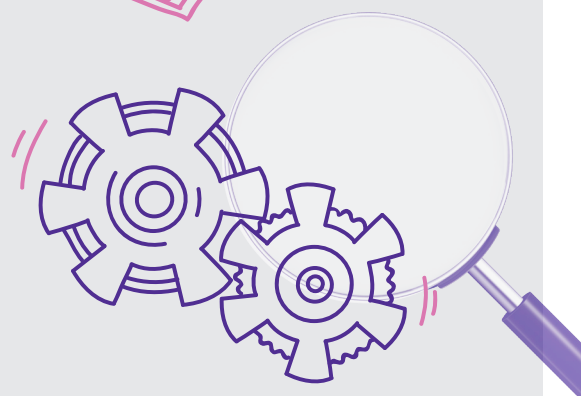


# Focus on success: GCSE science

A03

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## Contents

Contents	Page
Introduction	4
ISAs linked to the required practicals	6
Further ISAs linked to areas of subject content	35

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## Introduction

In this booklet you will find information from the legacy ISAs which you can use in class with students to develop their AO3 skills. As you look at the materials you will see that they are also relevant for developing many aspects of AO2, particularly if you are looking for practicals set in a different context from what the students have properly experienced in class.

Not all of the legacy ISAs are relevant to use with the new specification, so we have listed only those that have links either to the required practicals or to areas of the subject content where the information could be useful in teaching. The full range of legacy ISA materials are available on [e-AQA](#).

The information we have given for each ISA depends on whether it has a link to the current required practicals.

### ISAs linked to the required practicals (RPs)

For these ISAs we have supplied the following materials

- Title
- Context: Brief overview explaining the purpose of the investigation and possible context the teacher could use to set the investigation in.
- Method sheet outlining how you could carry out the practical. If you are carrying out one of the **required practicals** you might find the method sheets in the [practical handbook](#) more useful. Detailed guidance can be found for all the required practicals in the free practical handbooks which include technician and teachers notes plus student worksheets.
- The ISA Section 2 questions relates both to the practical carried out and the case study for the ISA.
- Section 2 Question 1

All parts of Question 1 in Section 2 are the same for each set of ISAs and refer to the method used. The focus of these questions is the same, regardless of the ISA and ISA set (A, B, etc), so we have selected the most common ones to present here (page 7). They can be applied to all the methods. If you would like to see the original questions for each practical these can be found with the full ISA resources on SKM.

If you are using these questions with the practical lessons from the required practicals students have to carry out, then you will be able to use the students' own data. If you are using them for revision then results for each RP is provided in the technician section of the practical handbook.
- Case studies

These will be very useful because, firstly they set the investigation in a different context which reinforces to students that, on the exam paper, questions will be set in unfamiliar context. Secondly they provide data sets that are the appropriate size and complexity to use with students to practice many of the skills needed in the new papers. These include graphing skills, a number of the maths skills and all the AO3 skills discussed in the previous activity. Teachers will be able to amend the data sets to match the ability of their students, for example, altering the numbers to include decimals raises the level of demand.
- Section 2 Question 2

The second series of questions in section 2 refer to the data on the **secondary data sheet** which are the **case studies**. These questions are AO3 type questions and are very useful as the context for each case study will be unfamiliar. These questions could be used for

---

homework or to stimulate a discussion during intervention lessons. This is another opportunity to ensure students understand the command words and really do write explanations rather than descriptions.

### ISAs linked to areas of subject content

Some of the ISAs do not have a direct links to a required practical but do contain information that is covered in the specification so could be used in teaching these particular areas of the subject content. For each of these ISAs we have given the following:

- ISA title
- context
- case studies.

**When you carry out any practical it is the schools responsibility to carry out a risk assessment and any preparatory work to ensure the practical works.**

---

# ISAs linked to the required practicals

ISA title	Brief summary of experiment	Link to RPA? (Biology/Trilogy/Synergy)
PU2.2 Stretching	Factor affecting extension of a rubber band	Physics 6/Trilogy 18/ Synergy 13
PU2.7 Springs	Factor affecting extension of a spring	Physics 6/Trilogy 18/ Synergy 13
PU1.3 Reflection	Angle of reflection depends on angle of incidence	Physics 9
PU2.3 Resistance	Factor affecting resistance of a filament bulb	Physics 4/Trilogy 16/ Synergy 15
PU2.4 Thermistors	Factor affecting resistance of a thermistor	Physics 4/Trilogy 16/ Synergy 15
PU2.5 Light-dependent resistors	Factor affecting resistance of an LDR	Physics 4/Trilogy 16/ Synergy 15
PU3.5a Refraction	Factor affecting angle of refraction	Physics 9

---

## Section 2 question 1:

### Possible questions to use with the method sheet

- 1 (a) (i)** Do your results support the hypothesis that you investigated?

You should use any pattern that you can see in your results to support your answer.

You should include examples from your results.

- 1 (a) (ii)** Did you get any anomalous results?

Explain your answer.

Your explanation should include examples from your results.

- 1 (b)** Describe in detail how you could use repeated readings to obtain more accurate results.

- 1 (c)** What was the independent variable in the investigation that you did?

.....

What was the range of the independent variable?

The range was from ..... to .....

Explain why this was or was not a suitable range.

What was the dependent variable ? .....

One control variable was? .....

- 1 (d)** Most investigations contain errors or uncertainties.

What do you think was the cause of the largest error or uncertainty in your investigation?

.....

.....

What could you do to reduce the size of this error or uncertainty if you were to repeat the investigation?

Explain your answer.

---

## PU2.2 Stretching

### Context:

Investigating factors affecting the extension of an elastic object. The extension of an elastic object is directly proportional to the force applied, provided that the limit of proportionality is not exceeded. Students could develop their own hypothesis and identify which variables to control, what the dependent variables are, etc. An example of a suitable context could be luggage scales.

There are two ISAs covering this aspect of the specification: PU2.2 and PU2.7. The method below is from PU2.2 and investigates how the extension of a rubber band varies with the force applied, but the topic could also be investigated using a spring or springs in different configurations (as in PU2.7). The case studies and section 2 questions for PU2.7 have been included here.

**This method could be used to investigate the following hypothesis:**

*'The extension of a rubber band depends on the force applied'*

### Equipment:

Rubber band

Half metre rule

Laboratory stand, boss and clamp

G-clamp

Slotted weights and hanger

### Method:

1. Use the G-clamp to secure the laboratory stand to the bench.
2. Hang the rubber band from the stand and measure its length.
3. Add the weight hanger and measure the new length of the rubber band.
4. Add further weights, each time measuring the new length of the rubber band.



---

## Case studies

### Case Study 1

Some students tested a rubber band by hanging weights from it and measuring the extension. Their results are shown in the table.

Weight added to rubber band in newtons	Extension of rubber band in mm
1	5
2	10
3	17
4	20
5	24

### Case Study 2

Some other students tested a different rubber band in the same way as in Case study 1.

Their results are shown below.

Weight added to rubber band in newtons	Length of rubber band in mm			
	Trial 1	Trial 2	Trial 3	Mean
0	80	80	80	80
2	90	92	91	91
4	101	101	103	102
6	109	113	111	111
8	117	118	117	117
10	121	119	120	120

### Case Study 3

A scientist tested different rubber bands to find out how much each type stretched when a force of 10 newtons was applied.

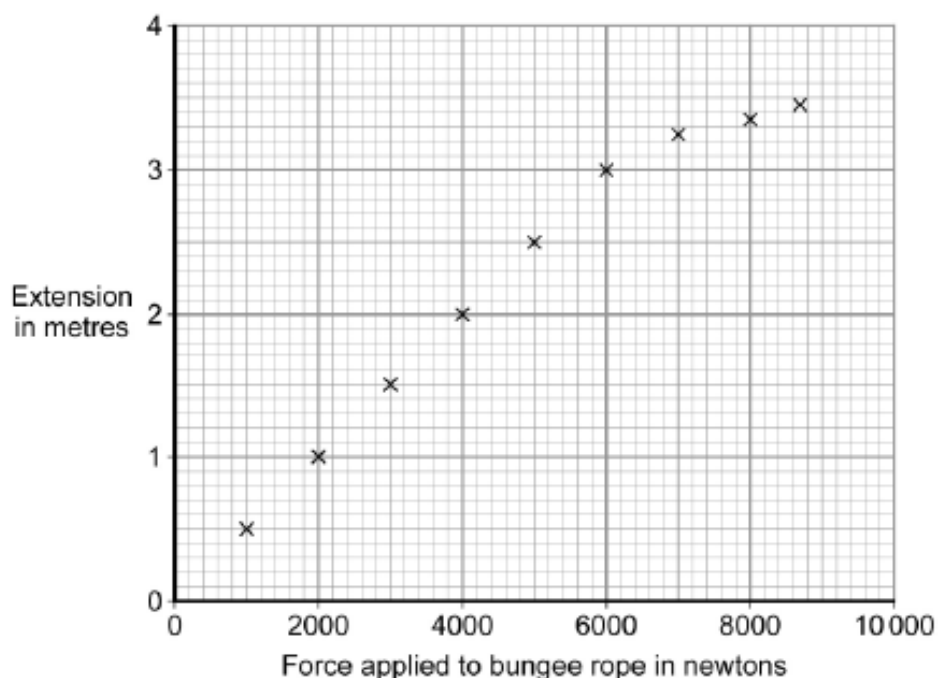
The results are shown below.

Type of band	Extension of band in mm
30 mm x 3 mm x 2 mm	10
50 mm x 3 mm x 2 mm	20
80 mm x 5 mm x 2 mm	30
100 mm x 5 mm x 2 mm	40
150 mm x 5 mm x 2 mm	50

### Case Study 4

A manufacturer of bungee ropes has been testing one of the bungee ropes.

The results are shown on the graph below.

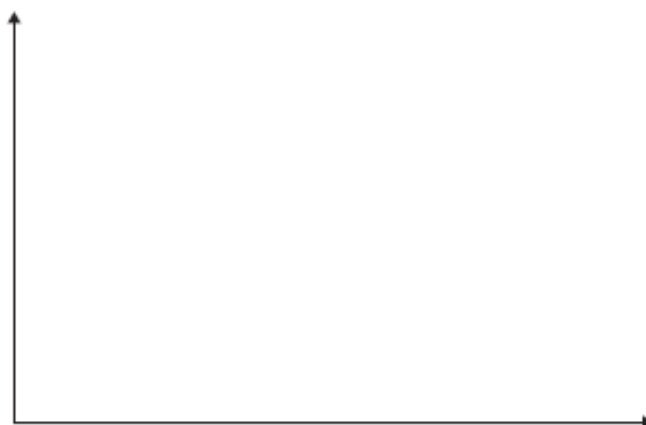


## Section 2 questions

- 2 You have been given a Secondary Data Sheet that provides results from similar investigations.

- 2 (a) Draw a sketch graph of the results in Case Study 1.

The graph should show how the extension of the rubber band varies with the weight added to it.



(2 marks)

- 2 (b) Bungee jumpers jump off tall objects, such as bridges or cliffs, attached to a bungee rope.

A bungee rope behaves in a similar way to a rubber band.

A manufacturer of bungee ropes makes this hypothesis:

**'The extension of the bungee rope is directly proportional to the force applied.'**

Look at Case Studies 1, 2 and 3.

Explain whether or not the results in Case Studies 1, 2 and 3 support this hypothesis.

To gain full marks, your explanation should include appropriate examples from the results in Case Studies 1, 2 and 3.

- 2 (c) Look at Case Study 4.
- 2 (c) (i) Do the results support the manufacturer's hypothesis?

Explain your answer.

2 (c) (ii) Estimate what the extension would be if the force applied was 10 000 newtons.

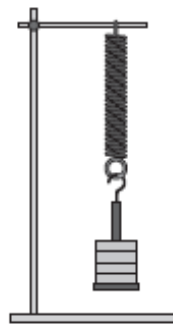
Give one reason why you cannot be sure that your estimate will be correct.

Ideas from your own investigation may help you to answer this question.

## PU2.7 Springs

### Case Study 1

A group of students investigated how the extension of a spring varied with the force applied. They did this by hanging different weights from the end of the spring.



Here are their results.

Weight added to spring in newtons	Extension of spring in cm
0	0
2	3
4	6
6	9
8	12

### Case Study 2

A second group of students did a similar investigation using the same method as the students in Case Study 1. They used three different springs.

These are their results.

Weight added to spring in newtons	Extension of spring in cm		
	Spring 1	Spring 2	Spring 3
2	2.0	4.0	1.0
3	3.0	6.0	1.5
4	4.0	8.1	2.0
5	5.0	10.0	2.0
6	6.0	12.1	2.0

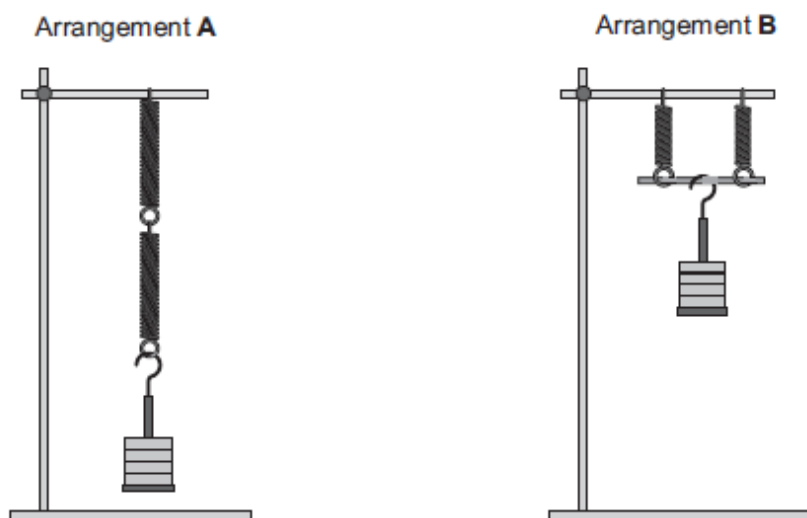
### Case Study 3

A third group of students did an investigation using a similar method to the students in Case Study 1. These are their results.

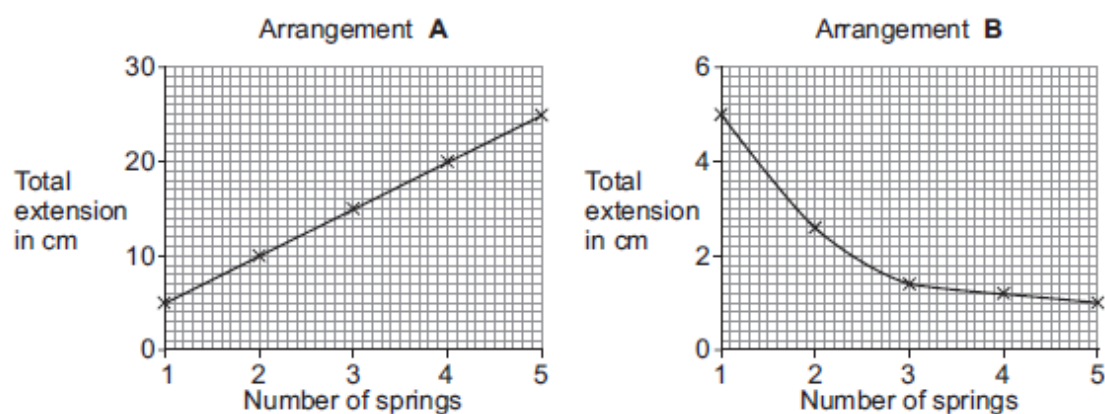
Weight added to spring in newtons	Extension of spring in cm			
	Trial 1	Trial 2	Trial 3	Mean
2	3.0	3.1	1.2	3.1
4	6.0	5.9	2.0	6.0
6	9.1	8.9	6.0	9.0
8	12.0	11.9	8.6	12.0
10	15.0	15.1	13.1	15.1

### Case Study 4

A different group of students investigated extending springs arranged in different ways. They used the same weight each time. In Arrangement A they started with one spring and then hung further springs from the bottom of the first spring. In Arrangement B they started with one spring and then added further springs side by side.



They plotted a graph of total extension against the number of springs for each arrangement.



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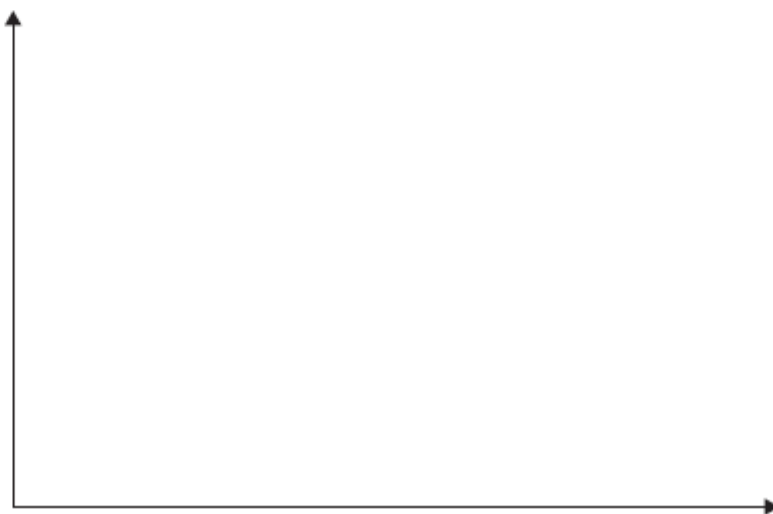
## Section 2 questions

**2** You have been given a Secondary Data Sheet with results from similar investigations.

**2 (a)** Draw a sketch graph of the results in Case Study 1.

The graph should show how the extension of the spring varies with the weight added to the spring.

[2 marks]



**2 (b)** A student found the following hypothesis in a textbook:

**‘The extension of a spring is directly proportional to the force applied to the spring.’**

Look at Case Studies 1, 2 and 3.

Explain whether or not the results in Case Studies 1, 2 and 3 support this hypothesis.

**2 (c)** Suggest reasons why the results in Case Study 3 are likely to be more accurate than the results in Case Study 1.

---

## PU1.3 Reflection

### Context:

The angle of incidence is equal to the angle of reflection. An example of a suitable context could be rear view mirrors in cars, or periscopes.

This method could be used to investigate the following hypothesis:

**'The angle of reflection depends upon the angle of incidence'.**

### Equipment

Plane mirror  
Drawing board  
White paper  
Pencil  
Ruler  
Protractor  
Ray box

### Method

1. Lay the drawing board flat on the bench and put a sheet of white paper on the drawing board.
2. Stand the plane mirror upright on the white paper.
3. Using a pencil, draw a line along the back edge of the mirror.
4. Put the ray box on the board and shine a ray of light towards the centre of the mirror.
5. Using a pencil put two crosses on the incident ray and two crosses on the reflected ray.
6. Remove the mirror. Using a pencil and ruler, and using the crosses you have made as a guide, draw in the incident ray and the reflected ray.
7. Draw a line at  $90^\circ$  to the mirror at the point where the light was reflected.
8. Measure and record the angle of incidence,  $i$ , and the angle of reflection,  $r$ .
9. Repeat steps 4 to 8 for different angles of incidence.

---

## Case studies

### Case Study 1

A group of students did an investigation similar to the one you did. These are the students' results.

Angle of incidence, in degrees	Angle of reflection, in degrees
10	11
20	19
30	30
40	41
50	50

### Case Study 2

A second group of students did an investigation similar to the one you did.

They did the investigation three times. These are the students' results.

Angle of incidence, in degrees	Angle of reflection, in degrees			
	Trial 1	Trial 2	Trial 3	Mean
20	21	20	22	21
40	40	41	39	40
60	61	68	60	63
80	82	80	81	81

### Case Study 3

A company manufactures mirrors. The company wanted to see if the brightness of the reflected ray changed with the angle of incidence. These are the manufacturer's results.

Angle of incidence, in degrees	Brightness of reflected ray, as a % of incident brightness
10	80
20	75
30	77
40	78
50	81
60	79

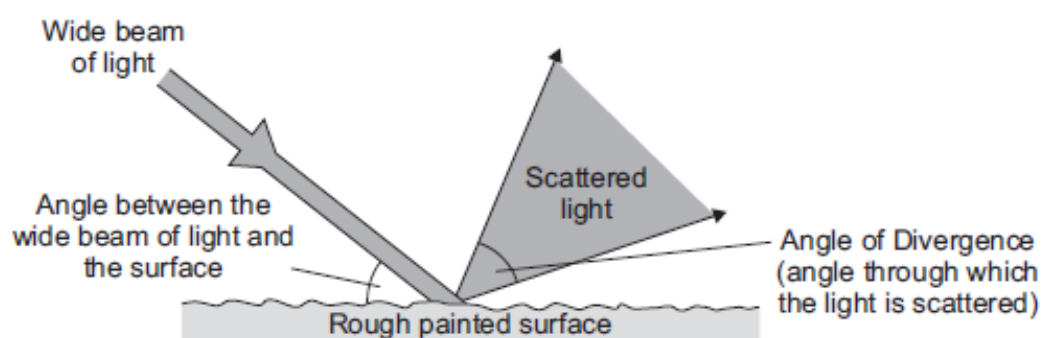


#### Case Study 4

Some surfaces are rough. These surfaces scatter light at different angles.

A paint manufacturer is testing different types of paint.

The manufacturer wants to find out how the angle of divergence of the scattered light depends on the angle at which a wide beam of light strikes the rough painted surface.



These are the manufacturer's results.

Paint surface being tested	Angle between the wide beam of light and the surface, in degrees	Angle of divergence, in degrees
A	10	70
	20	50
	40	25
	60	15
B	10	40
	20	20
	40	10
	60	5
C	10	5
	20	3
	40	1
	60	0

---

**2** You have been given a Secondary Data Sheet. The Data Sheet gives results from similar investigations.

**2 (a) (i)** Draw a sketch graph of the results in Case Study 1.

The graph should show how the angle of reflection varies with the angle of incidence.



**2 (a) (ii)** Use Case Study 1 to answer this question.

Do you think the results of your investigation are reproducible?

Explain your answer.

**2 (b)** Look at Case Studies 1, 2 and 3.

Explain whether or not the results in Case Studies 1, 2 and 3 support the hypothesis you were given.

To get full marks your explanation should include appropriate examples from the results in Case Studies 1, 2 and 3.

**2 (c)** Use Case Study 4 to answer this question.

Which of the three types of paint surface, **A**, **B**, or **C**, scatters the light most?

.....

Describe the relationship between the angle at which the wide beam of light strikes the rough painted surface and the angle of divergence of the scattered light.

## PU2.3 Resistance

### Context:

The resistance of electrical components such as lamps, diodes, thermistors and LDRs is not constant: it changes with the current through the component. The resistance of a filament lamp (bulb) increases as the temperature of the filament increases. Examples of suitable contexts could include filament lamps in homes, car headlamps or torch bulbs.

This method could be used to investigate the following hypothesis:

**'The resistance of a filament bulb depends on the current in the bulb'.**

### Equipment

12 volt filament bulb, eg 12V 6W SBC lamp Philip Harris Item Code B8A56807

Bulb holder

Connecting wires

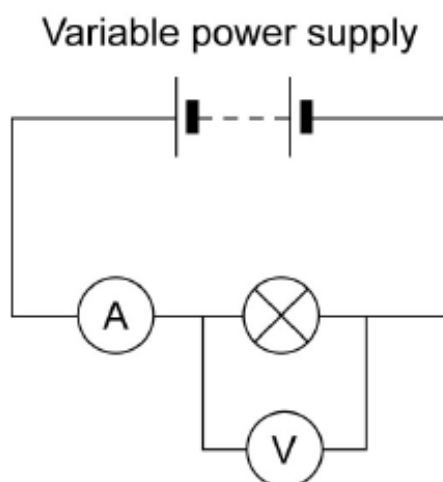
Variable power supply

Ammeter

Voltmeter

### Method:

1. Connect the circuit as shown.



2. Switch on the variable power supply and record the readings on the two meters.
3. Use your readings and the equation  $R = V/I$  to calculate the resistance of the bulb.
4. Change the setting on the power supply to alter the current in the bulb, and again record the readings on the meters.
5. Repeat for different settings on the variable power supply.

## Case studies

### Case Study 1

Some students tested a filament bulb.

Their results are shown in the table.

Current through bulb, in amps	Resistance of bulb, in ohms
0.2	1.0
0.4	1.8
0.6	2.5
0.8	3.2
1.0	4.0

### Case Study 2

Some scientists tested a different filament bulb. Their results are shown below.

Current through bulb, in amps	Resistance of bulb, in ohms			
	Trial 1	Trial 2	Trial 3	Mean
2	90	92	91	91
4	101	101	103	102
6	109	107	108	108
8	110	122	114	112
10	114	112	116	114

### Case Study 3

A manufacturer tested different filament bulbs to find out the resistance of each bulb when fully lit.

The results are shown below.

Type of bulb	Resistance of bulb, in ohms
12 volt, 6 watt	24
12 volt, 24 watt	6
230 volt, 25 watt	2110
230 volt, 40 watt	1320
230 volt, 60 watt	880

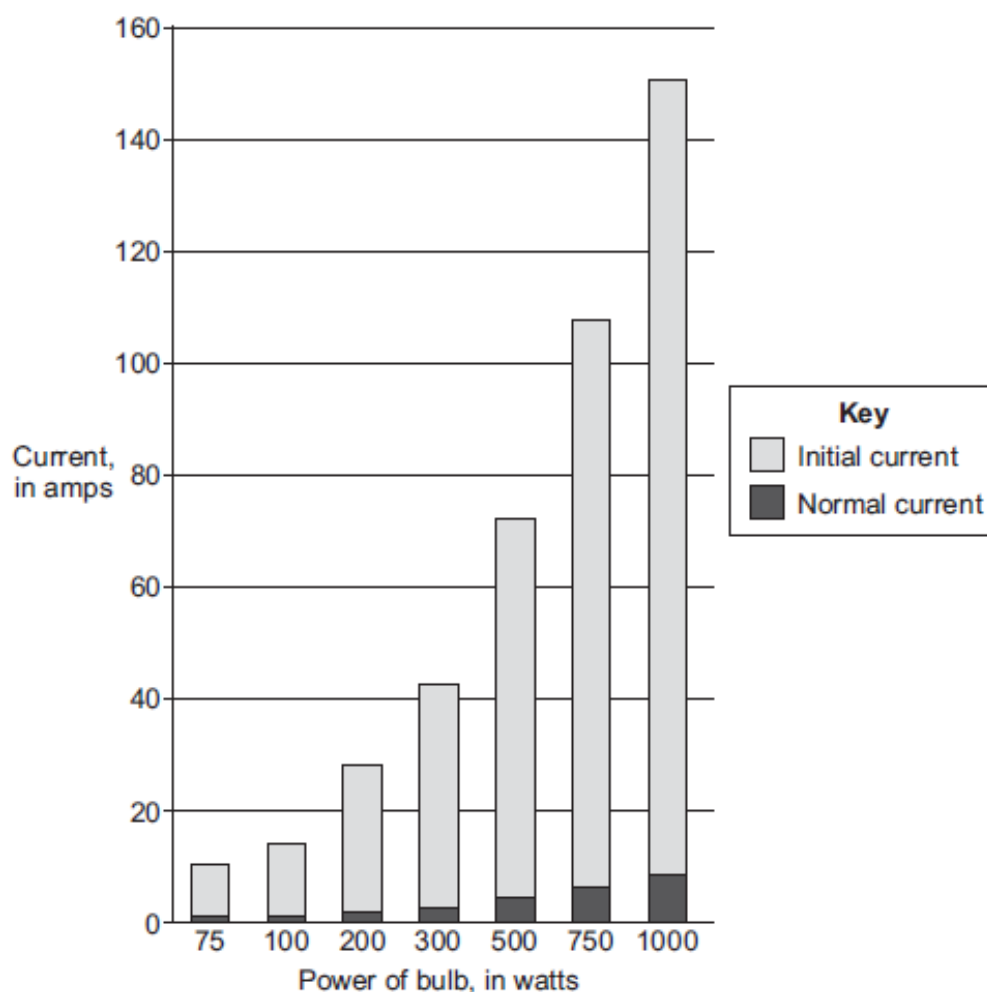
#### Case Study 4

Very large filament bulbs are used in theatre spotlights. When the bulb is first switched on there is a high initial current. The current then decreases to its normal value.

Power of bulb, in watts	Time for current to reach high initial value, in milliseconds	Time for current to decrease to normal value, in milliseconds
75	0.4	70
100	0.7	100
200	0.8	100
300	1.1	130
500	1.4	150
750	2.1	170
1000	3.1	230

1 millisecond = 1/1000 second

The chart shows the current for bulbs of different powers.



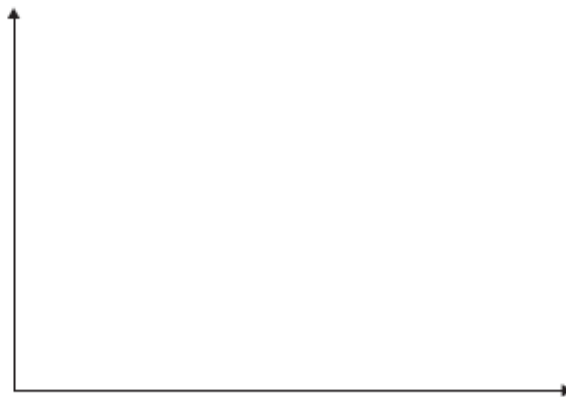
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## Sections 2 questions

**2** You have been given a Secondary Data Sheet. The Data Sheet gives results from similar investigations.

**2 (a)** Draw a sketch graph of the results in Case Study 1.

The graph should show how the resistance of the bulb varies with the current through the bulb.



(2 marks)

**2 (b)** A student makes the following hypothesis:

**'The resistance of a bulb increases as the current in the bulb increases.'**

Look at Case Studies 1, 2 and 3.

Explain whether or not the results in Case Studies 1, 2 and 3 support this hypothesis.

To get full marks, your explanation should include appropriate examples from Case Studies 1, 2 and 3.

**2 (c)** Look at Case Study 2.

One of the results seems to be anomalous.

State the anomalous result.

.....

Explain how you can tell that this result is anomalous.

Would this anomalous result affect any conclusion that you could make from this data?

## PU2.4 Thermistors

### Context:

The resistance of electrical components such as lamps, diodes, thermistors and LDRs is not constant: it changes with the current through the component. The resistance of a thermistor decreases as the temperature increases. Examples of suitable contexts could include the use of thermistors as thermostats or for safety cut-outs to avoid overheating.

This method could be used to investigate the following hypothesis:

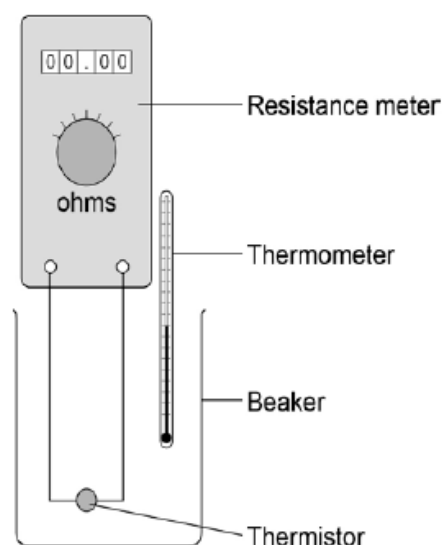
**'The resistance of a thermistor depends on its temperature.'**

### Equipment

Connecting wires with crocodile clips  
Thermometer  
Thermistor  
250 cm<sup>3</sup> beaker  
Kettle  
Digital multimeter switched to the ohms range  
Heat-proof mat  
Stirring rod

### Method

- 1 Set up the equipment as shown.



- 2 Pour boiling water into the beaker and take readings of the resistance of the thermistor as the temperature falls. Record the results.

---

## Case studies

### Case Study 1

A group of students investigated how the resistance of a thermistor varied with temperature. These are their results.

Temperature in °C	Resistance in kΩ
0	50
20	20
40	8
60	4
80	2

### Case Study 2

A second group of students did an investigation similar to the investigation in Case Study 1.

This group did the investigation three times.

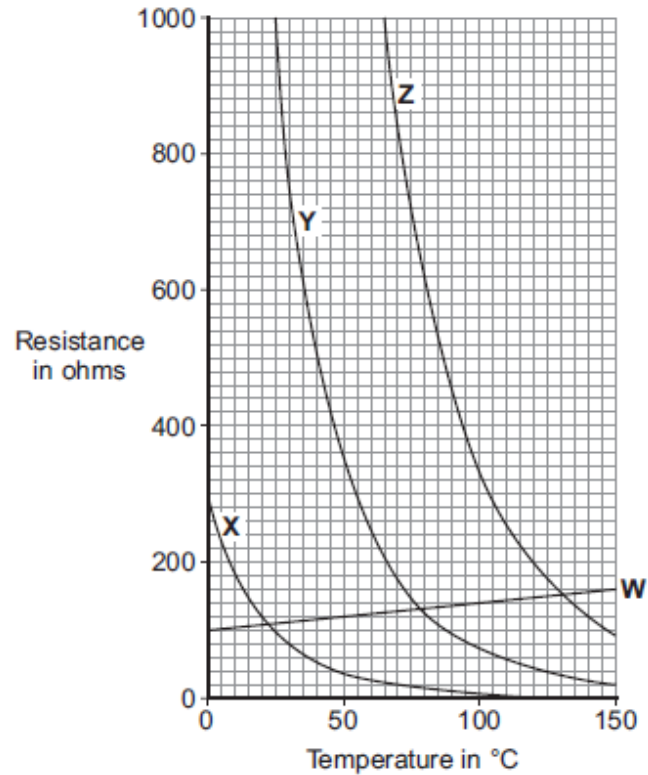
The table shows the results.

Temperature in °C	Resistance in kΩ			
	Trial 1	Trial 2	Trial 3	Mean
0	47	49	46	47.3
10	30	23	33	31.5
20	19	20	21	20.0
30	12	10	11	11.0
40	8	8	9	8.3



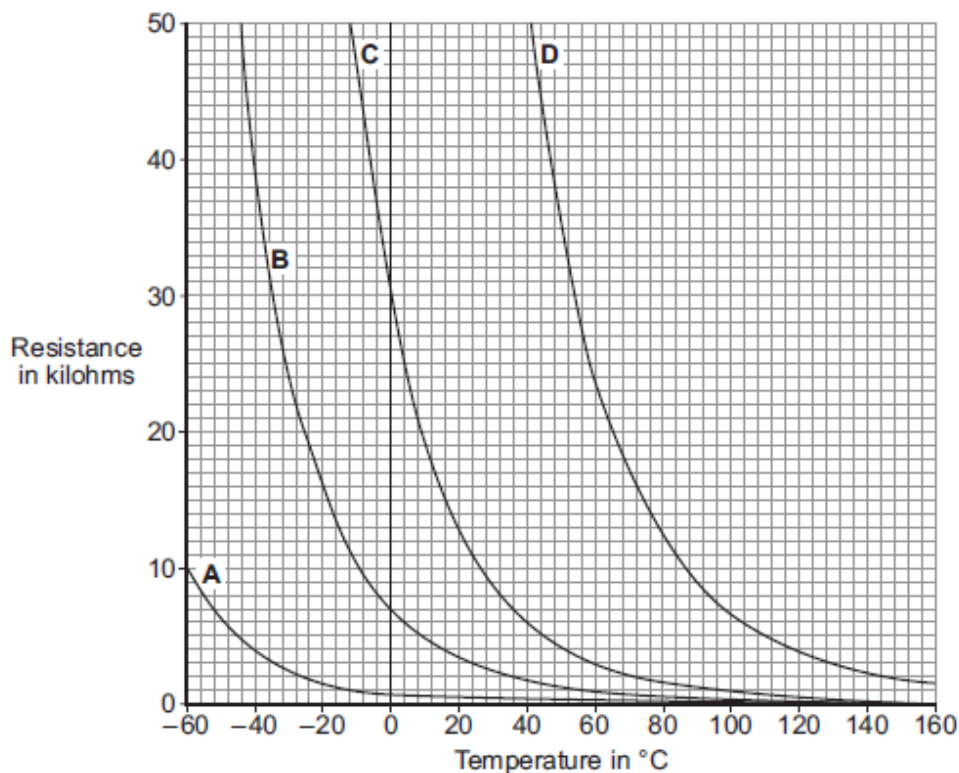
### Case Study 3

A company tested four different types of thermistor, W, X, Y and Z. Here are their results.



### Case Study 4

A manufacturer uses thermistors as thermostats to control the temperature of a room. The manufacturer tested several different types of thermistor to find out which would be the best to use in a house where the room temperature is about 20 °C. The results are shown on the graph.



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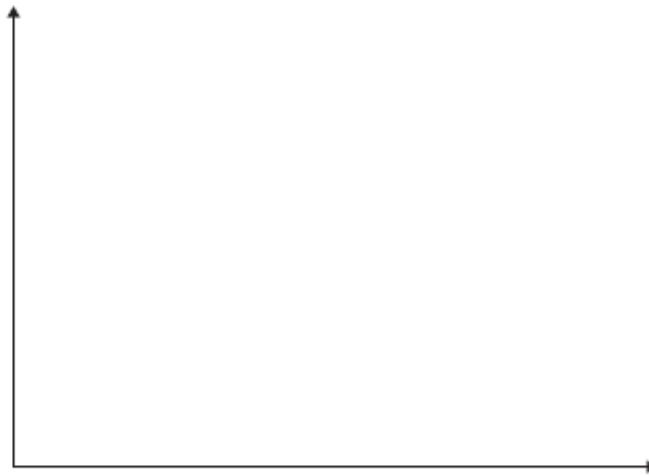
## Section 2 questions

**2** You have been given a Secondary Data Sheet with results from similar investigations.

**2 (a)** Draw a sketch graph of the results in Case Study 1.

The graph should show how the resistance varies with the temperature.

**[2 marks]**



**2 (b)** A student made this hypothesis:

**‘The resistance of a thermistor decreases as the temperature increases.’**

Look at Case Studies 1, 2 and 3.

Explain whether or not the results in Case Studies 1, 2 and 3 support this hypothesis.

To gain full marks, your explanation should include appropriate examples from the results in Case Studies 1, 2 and 3.

**2 (c)** Look at Case Study 2.

One of the results seems to be anomalous.

Which result is this?

.....

Why did you choose this result?

.....

.....

How can you tell that the scientists who obtained the results also noticed this anomalous result?

## PU2.5 Light-dependent resistors

### Context:

The current through a component depends on its resistance. The greater the resistance the smaller the current for a given potential difference across the component. The resistance of a light-dependent resistor (LDR) decreases as light intensity increases. Examples of suitable contexts could include smoke detection, automatic lighting control, batch counting and burglar alarm systems.

This method could be used to investigate the following hypothesis:

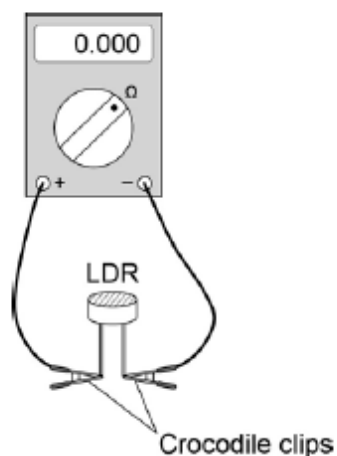
**'The resistance of a light-dependent resistor decreases with increasing light intensity.'**

### Equipment

- 2 leads with crocodile clips
- Bench lamp
- Light-dependent resistor (LDR)
- Multimeter set to measure resistance

### Method

- 1 Connect the circuit as shown.



- 2 Place the bench lamp 50 cm from the LDR and record the resistance shown on the meter.
- 3 Repeat for different distances of the lamp.

---

## Case studies

### Case Study 1

A group of students investigated how the resistance of a light-dependent resistor (LDR) varies with the intensity of the light source.

As the distance from the light source to the LDR decreases, the light intensity increases.

These are their results.

Distance from the light source to the LDR in cm	Resistance in ohms
10	50
30	70
50	80
70	85
90	87

### Case Study 2

A second group of students did an investigation to find out how the resistance of an LDR varies with the current through it.

They kept the light intensity the same throughout the investigation.

These are their results.

Potential difference in volts	Current in milliamps	Resistance in ohms
1.1	3.9	280
1.3	5.1	250
1.5	7.1	210
1.7	8.7	200
1.9	10.3	180

### Case Study 3

A third group of students did an investigation to find out how the resistance of an LDR varies with the light intensity.

These are their results.

Lux are units of light intensity

Light intensity in lux	Resistance in k $\Omega$			
	Trial 1	Trial 2	Trial 3	Mean
10	102	105	95	101
20	56	58	59	58
30	39	40	38	39
40	29	61	30	40
50	23	24	20	22
60	20	19	18	19

### Case Study 4

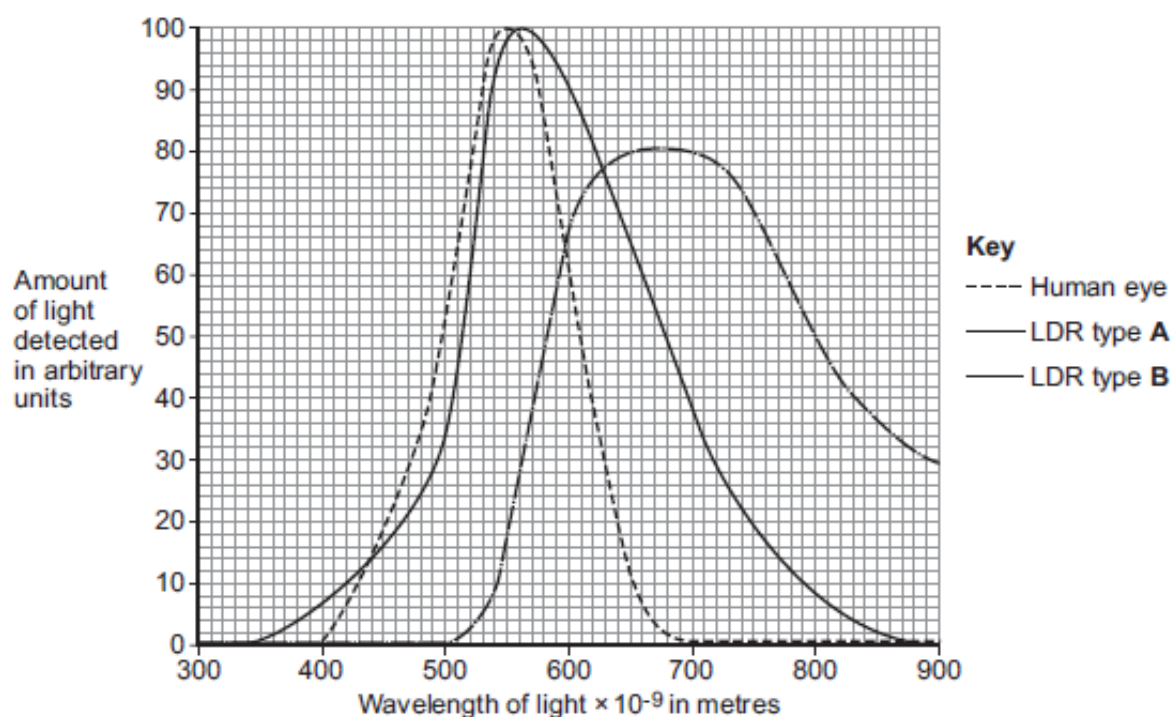
The resistance of an LDR varies with the intensity of the light that falls on it.

This means that the LDR can be connected in a circuit and used to detect light.

A manufacturer of LDRs measured how much light could be detected by two different LDRs, A and B, for different wavelengths of light.

The manufacturer also measured how much light could be detected by the human eye for different wavelengths of light.

The results are shown on the graph.



---

## Section 2 questions

**2** You have been given a Secondary Data Sheet with results from similar investigations.

**2 (a)** Draw a sketch graph of the results in Case Study 1.

The graph should show how the resistance varies with the distance from the light source to the light-dependent resistor (LDR).

**[2 marks]**



**2 (b)** A scientist made this hypothesis:

**‘The resistance of a light-dependent resistor increases as the light intensity decreases.’**

Look at Case Studies 1, 2 and 3.

Explain whether or not the results in Case Studies 1, 2 and 3 support this hypothesis.

To gain full marks, your explanation should include appropriate examples from the results in Case Studies 1, 2 and 3.

**2 (c)** Look at Case Study 1.

The teacher of the students who did this investigation said that they should have taken more readings.

State **two** ways in which taking more readings would have improved the investigation, and explain why **one** of these ways would lead to an improvement.

## PU3.5a Refraction

### Context:

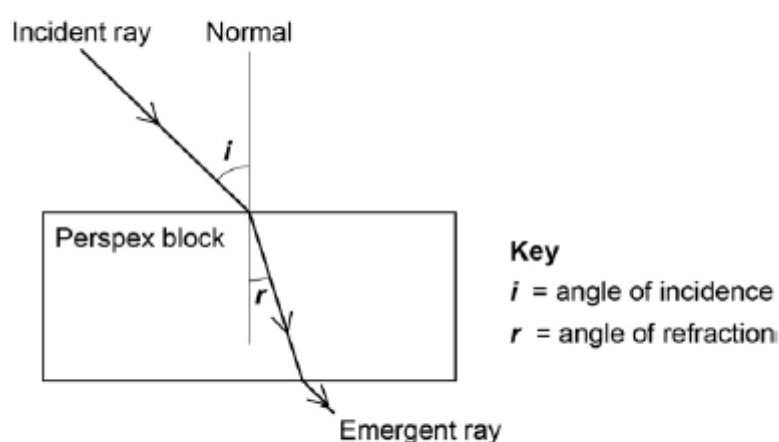
Refraction is the change of direction of light as it passes from one medium to another. Light is refracted to different extents by different materials. Examples of suitable contexts could include lenses for spectacles, cameras, telescopes, magnifying glasses, etc.

This method could be used to investigate the following hypothesis:

**'The angle of refraction increases with the angle of incidence.'**

### Equipment

Rectangular Perspex block  
Ray box + power supply  
Protractor  
Pencil  
Ruler



### Method

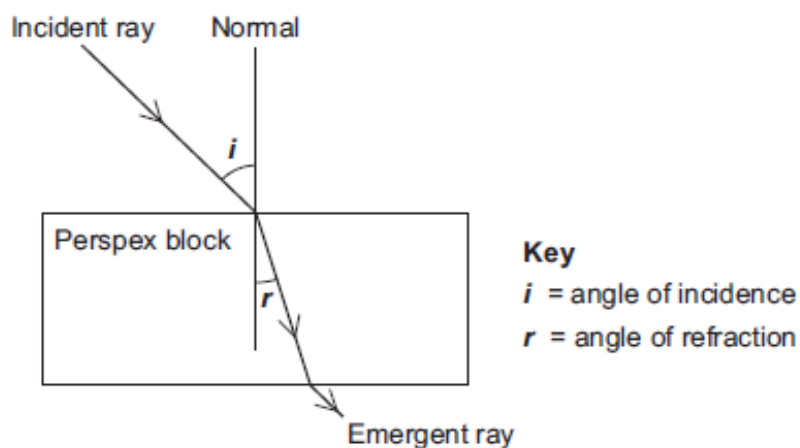
- 1 Place the Perspex block on a sheet of white paper and draw around the edge of the block with a pencil.
- 2 Shine a ray of light towards one of the long faces of the block.
- 3 Draw two pencil crosses on the paper to mark the position of the incident ray.
- 4 Draw two pencil crosses on the paper to mark the position of the ray that emerges from the other side of the block.
- 5 Remove the block and, using a ruler and pencil, join the incident ray to the emergent ray.
- 6 Draw the normal at the point where the incident ray enters the block.
- 7 Measure and record the angle of incidence and the angle of refraction.
- 8 Repeat this procedure for different angles of incidence.

## Case studies

### Case Study 1

A group of students investigated refraction.

The students shone a ray of light through a Perspex block.



The students measured the angle of incidence and the angle of refraction. These are their results.

Angle of incidence in degrees	Angle of refraction in degrees
10	7
20	13
30	19
40	25
50	31

### Case Study 2

A second group of students did an investigation using the same method as shown in Case Study 1. These are their results.

Angle of incidence in degrees	Angle of refraction in degrees			
	Trial 1	Trial 2	Trial 3	Mean
20	15	17	17	16.3
25	17	22	21	20
30	22	12	25	19.6666
35	24	29	27	26.7
40	32	31	28	30.3



### Case Study 3

A third group of students did an investigation using the same method as shown in Case Study 1.

The students used blocks of different materials.

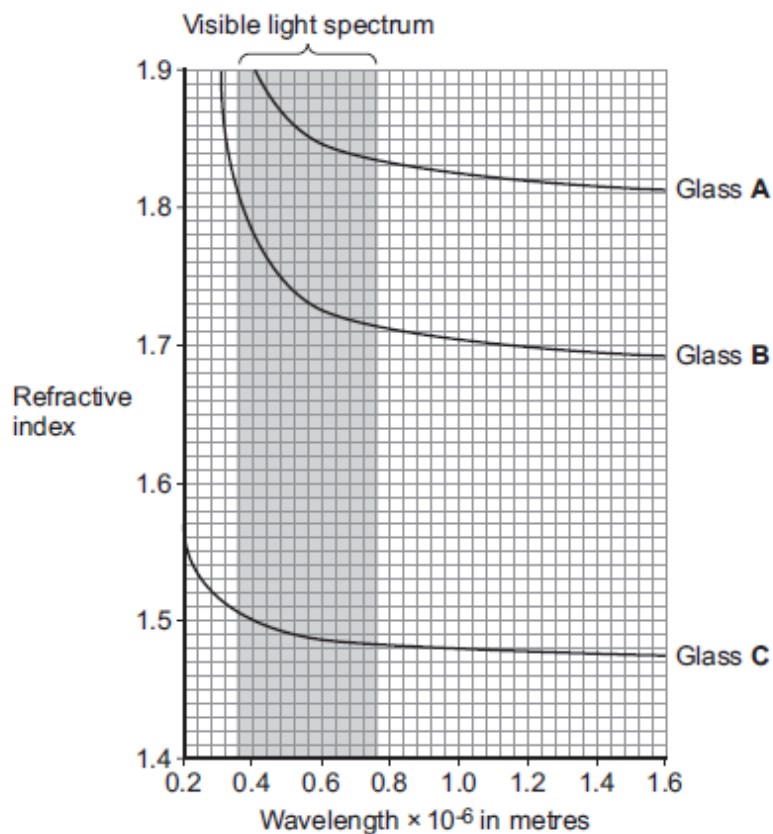
Type of material	Angle of incidence in degrees	Angle of refraction in degrees
acrylic	30	19.7
acrylic	50	31.2
acrylic	80	41.7
glass	30	19.5
glass	50	30.7
glass	80	41.0
polycarbonate	30	18.2
polycarbonate	50	28.6
polycarbonate	80	38.0

### Case Study 4

A lens works by changing the direction of rays of light by refraction.

A lens manufacturer has been investigating how the refractive index of different types of glass varies with the wavelength of light shone through it.

The results are shown below.



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## Section 2 questions

**2** You have been given a Secondary Data Sheet with results from similar investigations.

**2 (a)** Draw a sketch graph of the results in Case Study 1.

The graph should show how the angle of refraction varies with the angle of incidence.

**[2 marks]**



**2 (b)** Look at Case Studies 1, 2 and 3.

The students who did these three investigations were investigating the following hypothesis:

**‘The angle of refraction increases with the angle of incidence.’**

Explain whether or not the results in Case Studies 1, 2 and 3 support this hypothesis.

To gain full marks, your explanation should include appropriate examples from the results in Case Studies 1, 2 and 3.

**2 (c)** Look at Case Study 2.

The students have recorded the mean values of the angle of refraction.

Their teacher said they had not done this in the best way.

What mistakes have the students made in calculating and recording the mean values?

Explain your answer.

**2 (d)** Look at Case Study 4.

The manufacturer wanted to find the best type of glass for making the lenses for a pair of spectacles.

Describe the differences between the three different types of glass shown in the graph.

Suggest why this data might be useful to a manufacturer of spectacle lenses.

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# Further ISAs linked to areas of subject content

Context and case studies given

ISA title	Brief summary of experiment
PU1.1 Solar cells	Output voltage depends on area
PU1.2 Surface area and cooling	Rate of cooling of water depends on surface area exposed
PU3.2b Cantilevers	Factor affecting deflection of a cantilever
PU1.5 Wind turbines	Output voltage depends on number of blades

## PU1.1 Solar cells

### Context:

The main energy resources available for use on Earth include non-renewable and renewable resources. A renewable resource is one that can be replenished as it is used. Solar cells use the Sun's radiation to produce electricity. Students investigated how the surface area of a solar cell exposed to light affected the amount of electricity produced by the cell.

The AQA method sheet investigated the hypothesis that the output voltage of a solar cell depends on the area of the solar cell exposed to the light. To do this, students used a bench lamp shining on a solar cell, the exposed surface area of which was controlled with black card.

### Case studies

#### Case study 1

A group of students did an investigation to find out whether the output voltage of a solar cell depends on the area of the solar cell exposed to light.

The students did the investigation three times and calculated a mean. The students used the same solar cell and lamp each time.

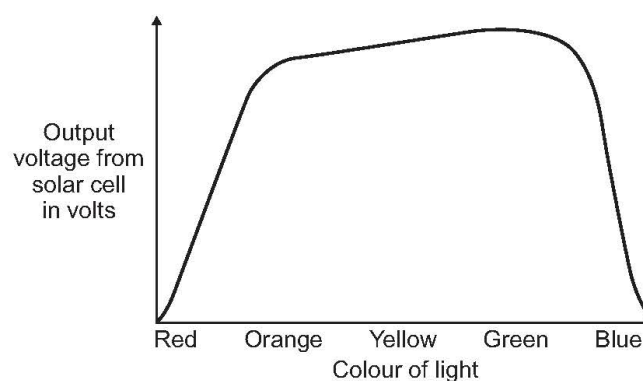
These are the students' results.

Area of solar cell exposed to light in cm <sup>2</sup>	Mean output voltage in millivolts
10	80
15	110
20	150
25	200
30	230
35	270

#### Case study 2

A second group of students did an investigation to find out if the colour of light affected the output voltage from the solar cell.

The students recorded their results on a graph.



### Case study 3

Students in a laboratory did tests to find out if the output voltage from a solar cell depended upon the area of the cell exposed to light.

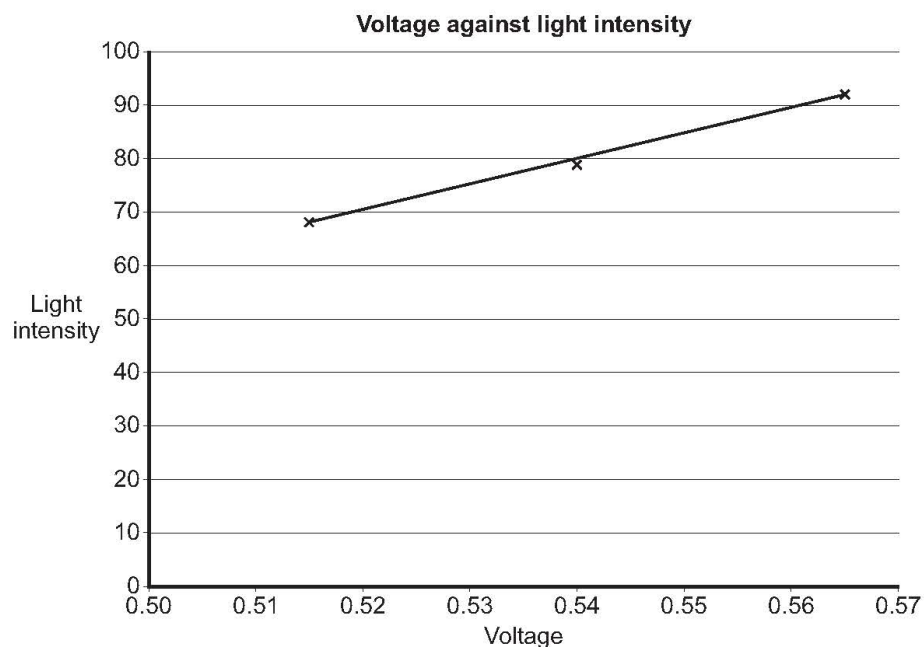
The students measured the output voltage twice for each area of the cell, and then calculated a mean.

These are the students' results.

Area of solar cell in cm <sup>2</sup>	Output voltage in millivolts		
	Test 1	Test 2	Mean
20	21	16	19
40	30	24	27
60	40	37	39
80	70	65	68
100	160	160	160

### Case study 4

A group of students has been investigating the effect of altering the light intensity falling on a solar cell. The students used three different light intensities and then plotted the graph below.



## PU1.2 Surface area and cooling

### Context:

The amount of infrared radiation radiated by a surface depends on the nature of that surface. Students investigated how the rate of infrared radiation by water depends on surface area and volume. The AQA method investigated how the rate of cooling of water is affected by the surface area of the water that is exposed. To do this, students measured the temperature of a known volume of hot water every minute for 10 minutes, using a selection of beakers of different top area.

### Case studies

#### Case Study 1

Some students took some beakers of different sizes. Each beaker had a different diameter.

They put the same volume of boiling water in each beaker and measured the temperature drop after 10 minutes.

Their results are shown in the table.

Surface area of water in cm <sup>2</sup>	Temperature drop after 10 minutes in °C
50	35
100	40
150	45
200	50
250	55

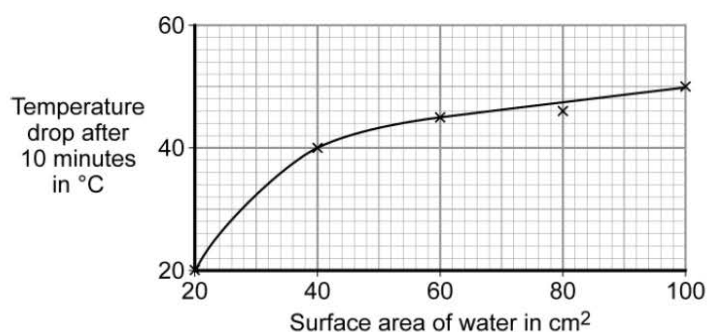
#### Case Study 2

A manufacturer of paper cups wanted to find out which size of cup would keep tea hotter for longer.

Scientists at the company tested 5 different sizes of cup.

They put the same volume of tea at 80 °C into each cup and measured the temperature drop after 10 minutes.

Their results are shown on the graph below.



### Case Study 3

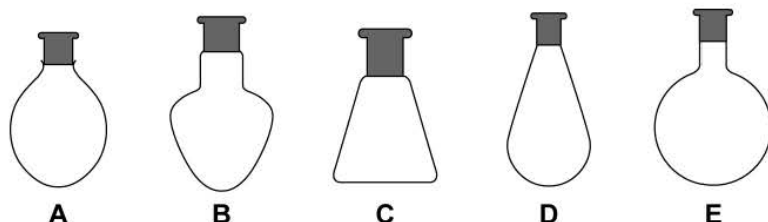
Some students took a number of beakers of different volumes. They filled each one to within 1cm of the top with hot water. They recorded the temperature of the water at the start and 10 minutes later. Here are their results.

Volume of beaker in cm <sup>3</sup>	Temperature drop after 10 minutes in °C
100	24
250	22
400	28
600	23
1000	32

### Case Study 4

A company that makes glass flasks wants to find the best shape for keeping liquids hot for as long as possible.

Scientists at the company tested the five different shapes shown below. Each flask has the same volume but has a different surface area of glass.



They filled each flask with boiling water, put in a stopper, and measured the temperature drop after 30 minutes.

The results of the scientists' investigations are shown below.

Flask	Surface area in cm <sup>2</sup>	Temperature drop after 30 minutes in °C			
		Trial 1	Trial 2	Trial 3	Mean
A	45	25	26	36	26
B	44	26	28	29	28
C	43	22	29	21	24
D	42	21	25	22	23
E	41	21	23	22	22

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## PU3.2b Cantilevers

### Context:

The turning effect of a force is called the moment of the force. The size of the moment is defined by the equation

Moment of a force = force  $\times$  distance [ $M = F d$ ]

Students should be able to calculate the size of a force, or its distance from a pivot, acting on an object that is balanced. A simple lever can be used to transmit the rotational effects of forces. The AQA method investigated the effect of force applied on the deflection of a cantilever. To do this they used a metre ruler fixed to a bench and measured the distance the ruler was deflected from the horizontal with different weights added.



## Case studies

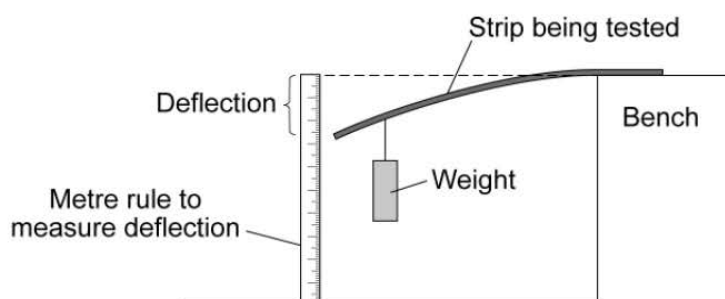
### Case Study 1

Some scientists tested a new material for a swimming pool springboard.

They cut some of the new material into strips, 1 metre long and 2 cm wide.

They clamped one end of a strip to the edge of the bench.

They tested the strips by placing a weight at different distances from the free end of the strip.



Here are their results.

Distance of weight from free end of strip in cm	Deflection from horizontal in mm
20	15
30	10
40	6
50	3
60	1

### Case Study 2

Some other scientists did a similar investigation.

They measured the distance from the edge of the bench to the position of the weight.

Here are their results.

Distance of weight from the end of the bench in cm	Deflection from horizontal in mm			
	Trial 1	Trial 2	Trial 3	Mean
20	2	3	4	3
30	5	9	6	7
40	18	10	11	13
50	13	13	14	13
60	19	21	20	20

### Case Study 3

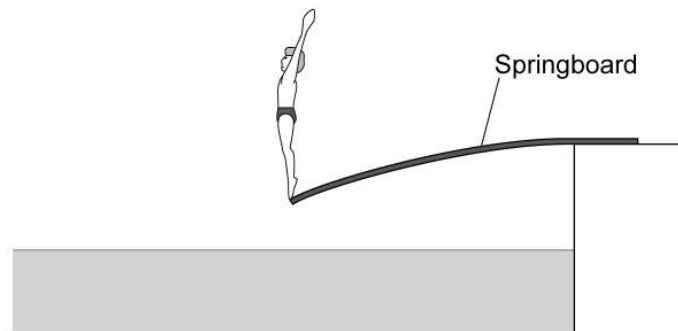
A third group of scientists carried out a similar experiment by hanging different weights from the same place on the strip.

Here are their results.

Weight added in newtons	Deflection from horizontal in mm
2	3
4	7
6	11
8	15
10	20

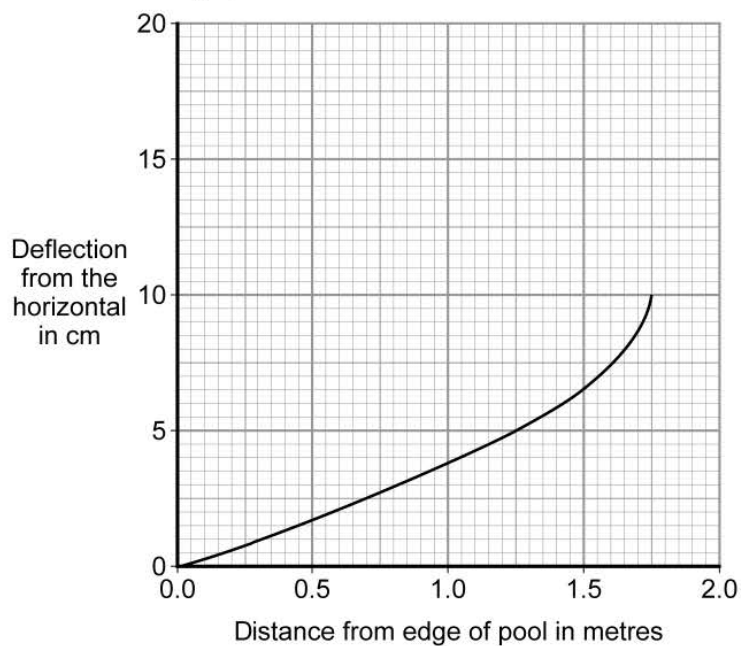
### Case Study 4

The scientists then tested a full-sized springboard made from the new material.



The scientists added a 70 kg mass at different distances along the springboard and then measured the deflection from the horizontal.

They plotted the results on a graph.



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## PU1.5 Wind turbines

### Context:

Electricity can be generated by using the wind to turn the blades of a turbine. A number of factors will affect the amount of electricity generated, such as the number of blades of the turbine, or the speed of the wind. Students investigated how the number of blades on a turbine affects the output. The AQA method sheet used turbines with different numbers of blades created using cork and cardboard and measured how the number of blades affected the voltage output of a small dc motor used as a generator when air was blown across the blades from a hairdryer.

### Case studies

#### Case Study 1

A student investigated how the output voltage of a wind turbine varies with the number of blades on the turbine.

These are the results.

Number of blades on the turbine	Output voltage in volts
2	1.7
3	2.3
4	2.9
5	3.5
6	4.1

#### Case Study 2

A company wanted to find out how the efficiency of a wind turbine varies with the number of blades on the turbine.

The company scientists put turbines with different numbers of blades into a wind tunnel and calculated the efficiency of each turbine.

The results are shown in the table.

Number of blades on the turbine	Percentage (%) efficiency			
	Trial 1	Trial 2	Trial 3	Mean
2	35	37	36	36
3	45	48	42	45
4	47	51	54	51
5	29	31	43	34
6	15	17	19	17

### Case Study 3

A student wanted to find out how the output voltage of a wind turbine varies with the number of blades on the turbine.

The results are shown in the table.

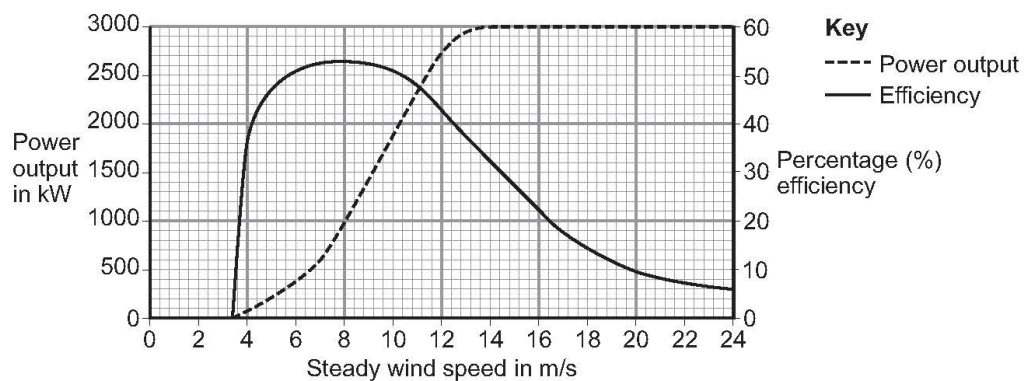
Number of blades on the turbine	Output voltage in volts			
	Trial 1	Trial 2	Trial 3	Mean
2	1.4	1.5	1.6	1.5
3	1.7	1.9	1.7	1.76666
4	2.6	2.4	2.8	2.6
5	2.0	3.1	2.1	2.4
6	1.6	1.7	1.9	1.73333

### Case Study 4

A manufacturer of commercial wind turbines has been testing one particular type of turbine.

The company scientists investigated how the power output and the efficiency of the turbine vary with the wind speed.

The scientists plotted the results on a graph.



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## Notes

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## Notes



## Contact us

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