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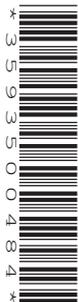
PHYSICS

0625/61

Paper 6 Alternative to Practical

May/June 2020

1 hour

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **12** pages. Blank pages are indicated.

1 A student investigates the balancing of a metre rule.
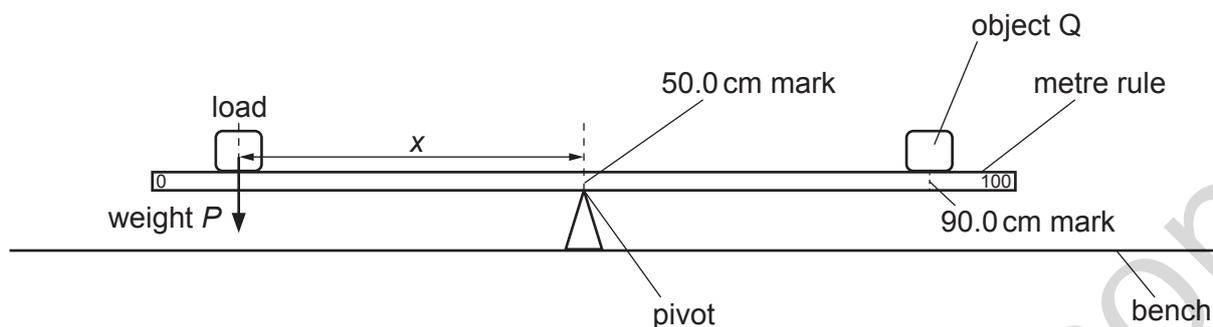
Fig. 1.1 shows the arrangement.

Fig. 1.1

(a) The student places the metre rule on the pivot at the 50.0 cm mark. He places an object Q on the metre rule with its centre at the 90.0 cm mark. He places a load of weight P = 2.0 N on the metre rule and adjusts the position of the load so that the metre rule is as near as possible to being balanced.

He measures the distance x from the centre of the load to the pivot.

He repeats the procedure using loads of weight P = 3.0 N, 4.0 N, 5.0 N and 6.0 N. All the values of P and x are recorded in Table 1.1.

Table 1.1

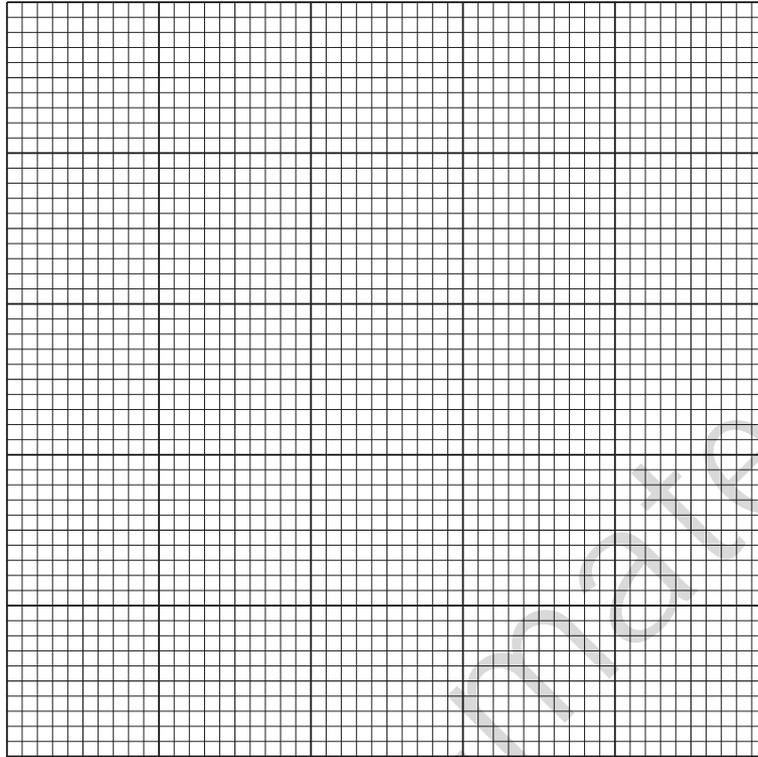| P/N	x/cm	$\dfrac{1}{x} / \dfrac{1}{cm}$
2.0	40.0	
3.0	27.0	
4.0	20.0	
5.0	15.9	
6.0	13.3	

Calculate, and record in Table 1.1, the values of $\dfrac{1}{x}$. [2]

(b) Plot a graph of P/N (*y*-axis) against $\dfrac{1}{x}\Big/\dfrac{1}{cm}$ (*x*-axis). Start both axes at the origin (0,0).

[4]

(c) In this experiment, x_{max}, the maximum possible value for x is 50.0 cm. Calculate $\dfrac{1}{x_{max}}$.

$$\frac{1}{x_{max}} = \text{...} \frac{1}{cm}$$

Use the graph to determine the minimum value of P required to balance the metre rule in this experiment. Show clearly on the graph how you determined this value.

minimum value of P = ... [2]

(d) In this experiment, the width of object Q is slightly greater than the width of the metre rule. Explain briefly how you would place the object Q as accurately as possible on the 90.0 cm mark of the metre rule. You may draw a diagram.

....

....

....

.... [1]

(e) In this experiment, it is difficult to determine the exact position of the load that will make the metre rule balance.

(i) Explain briefly why this is difficult.

....

....

.... [1]

(ii) Explain briefly how you would find the best position of the load that will make the metre rule balance.

....

....

.... [1]

[Total: 11]

Question no. 1

(a) Calculating and completing the 1/x column (in 1/cm)

We calculate **1/x** for each measured value of **x** (in cm). Keep **consistent significant figures** (here, **3 d.p.** is appropriate).

- For **x = 40.0 cm**: 1/x = 1 ÷ 40.0 = **0.025**
- For **x = 27.0 cm**: 1/x = 1 ÷ 27.0 = **0.037** (since 0.037037...)
- For **x = 20.0 cm**: 1/x = 1 ÷ 20.0 = **0.050**
- For **x = 15.9 cm**: 1/x = 1 ÷ 15.9 = **0.063** (since 0.062893...)
- For **x = 13.3 cm**: 1/x = 1 ÷ 13.3 = **0.075** (since 0.075188...)

So the completed column is:

0.025, 0.037, 0.050, 0.063, 0.075 (all in **1/cm**)

(b) Graph of P (y-axis) against 1/x (x-axis) starting at (0,0)

- x-axis label: **1/x / (1/cm)**
- y-axis label: **P / N**
- Start both axes at **(0,0)**
- Plot the points:
    - (0.025, 2.0)
    - (0.037, 3.0)
    - (0.050, 4.0)
    - (0.063, 5.0)
    - (0.075, 6.0)
- Draw a **thin, best-fit straight line** (good judgement, continuous)

Here is a correct plotted graph (with the required axes and best-fit line):

Graph of P against 1/x
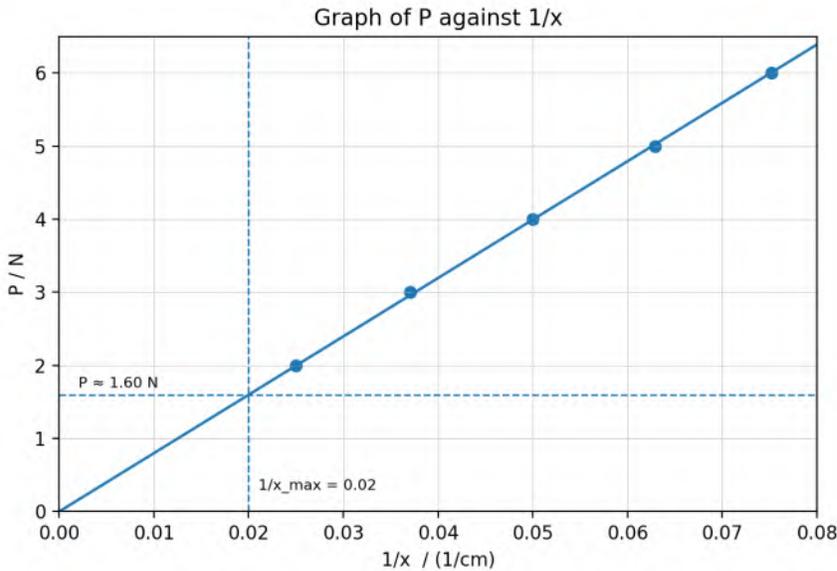
(c) Finding 1/x_max and the minimum P from the graph

Step 1: Calculate 1/x_max

Given **x_max = 50.0 cm**:

1/x_max = 1 ÷ 50.0 = **0.02 (1/cm)**

So,

1/x_max = 0.02 (1/cm)

Step 2: Use the graph to find the minimum P

- On the x-axis, locate **1/x = 0.02**
- Draw a **vertical line** up to the best-fit line
- From that intersection, draw a **horizontal line** to the y-axis to read **P**

From the line on the graph, the value is:

minimum value of P ≈ 1.6 N

(That construction is shown clearly on the provided graph.)

(d) Placing object Q accurately with its centre at the 90.0 cm mark

Because **Q is slightly wider than the metre rule**, the mark may be hard to see directly under it. The best method is:

- **Find the centre of Q** (e.g. measure its width and mark the midpoint, or use the symmetry of the object).
- Place Q so that this **centre line** is exactly above the **90.0 cm mark**.
- **View from directly above** the mark to avoid **parallax error**.

object Q

90.0 cm mark

(e)(i) Why it is difficult to find the exact balancing position

It is difficult because the metre rule is **very sensitive near balance**: a tiny movement of the load causes it to **tip to one side**, so it is hard to judge the **exact point where clockwise and anticlockwise moments are exactly equal**.

(e)(ii) How to find the best position of the load

A reliable method is to bracket the balance point:

- Slide the load until the rule **just tips one way**, note the position.
- Slide it back until it **just tips the other way**, note that position.
- Take the **midpoint (average)** of these two positions as the **best estimate** of the balancing position (and repeat to improve reliability).

2 A student determines the resistances of some filament lamps.
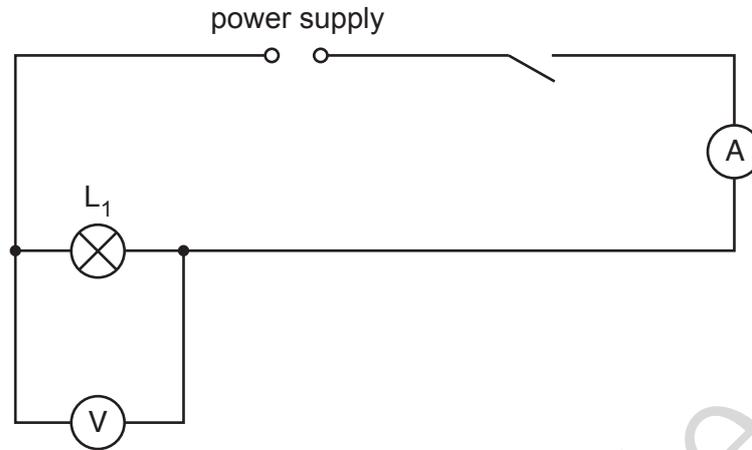
Fig. 2.1 shows the first circuit she uses.

Fig. 2.1

(a) (i) Record the potential difference V_1 across the lamp L_1, as shown on the voltmeter in Fig. 2.2.
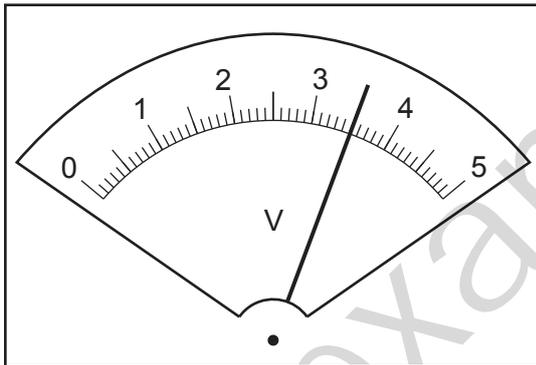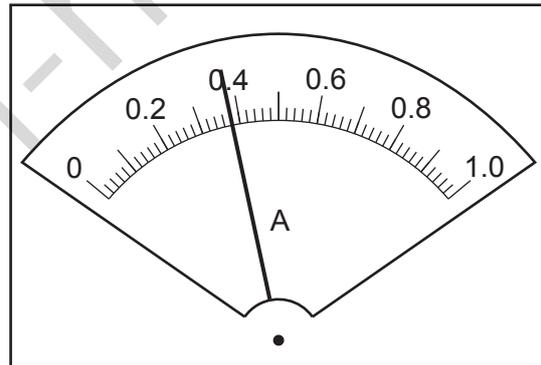
Fig. 2.2   **Fig. 2.3**

V_1 = ... V [1]

(ii) Record the current I_1 in the circuit, as shown in Fig. 2.3.

I_1 = ... A [1]

(iii) Calculate the resistance R_1 of the filament of lamp L_1. Use the equation $R_1 = \dfrac{V_1}{I_1}$. Include the unit.

R_1 = ... [2]

(b) The student disconnects the voltmeter. She connects lamp L_2 in series with lamp L_1. She connects the voltmeter across lamp L_2.

She measures the current I_2 in the circuit and the potential difference V_2 across lamp L_2.

$I_2 =$ .... 0.30 A

$V_2 =$ .... 1.7 V

Calculate the resistance R_2 of the filament of lamp L_2. Use the equation $R_2 = \dfrac{V_2}{I_2}$.

$R_2 =$ ....

The student disconnects the voltmeter. She connects lamp L_3 in series with lamps L_1 and L_2. She connects the voltmeter across lamp L_3.

She measures the current I_3 in the circuit and the potential difference V_3 across lamp L_3.

$I_3 =$ .... 0.26 A

$V_3 =$ .... 1.2 V

Calculate the resistance R_3 of the filament of lamp L_3. Use the equation $R_3 = \dfrac{V_3}{I_3}$.

$R_3 =$ ....
[1]

(c) Calculate $R_1 + R_2 + R_3$. Give your answer to a suitable number of significant figures for this experiment.

$R_1 + R_2 + R_3 =$ .... [1]

(d) Some students make suggestions about the results of the experiment.

Suggestion **A**: $R_1 + R_2 + R_3$ should be equal to $3 \times R_1$.

Suggestion **B**: $R_1 + R_2 + R_3$ should be less than $3 \times R_1$.

Suggestion **C**: $R_1 + R_2 + R_3$ should be greater than $3 \times R_1$.

State which suggestion **A**, **B** or **C** agrees with your results. Justify your answer by reference to your results.

statement ....

justification ....

....
[2]

(e) Draw a circuit diagram to show the circuit used in part **(b)** with all three lamps connected in series.

[3]

[Total: 11]

Question no. 2

(a)(i) Potential difference across lamp L_1

From the voltmeter shown in **Fig. 2.2**, the scale runs from **0 to 5 V**.
The pointer is halfway between **3 V and 4 V**, indicating a reading of:

V_1 = 3.5 V

(a)(ii) Current in the circuit

From the ammeter shown in **Fig. 2.3**, the scale runs from **0 to 1.0 A**.
The pointer is slightly below **0.4 A**, at approximately **0.38 A**.

I_1 = 0.38 A

(a)(iii) Resistance of lamp L_1

The resistance of a component is calculated using:

resistance = potential difference ÷ current

Substituting the measured values:

V_1 = 3.5 V
I_1 = 0.38 A

R_1 = 3.5 ÷ 0.38
R_1 = 9.21

Including the correct unit:

R_1 = 9.21 Ω

(b) Resistance of lamps L_2 and L_3

Lamp L$_2$

Given:

- I$_2$ = 0.30 A
- V$_2$ = 1.7 V

R$_2$ = V$_2$ ÷ I$_2$
R$_2$ = 1.7 ÷ 0.30
R$_2$ = 5.67

To a suitable number of significant figures:

R$_2$ = 5.7 Ω

Lamp L$_3$

Given:

- I$_3$ = 0.26 A
- V$_3$ = 1.2 V

R$_3$ = V$_3$ ÷ I$_3$
R$_3$ = 1.2 ÷ 0.26
R$_3$ = 4.62

To a suitable number of significant figures:

R$_3$ = 4.6 Ω

(c) Total resistance R$_1$ + R$_2$ + R$_3$

R$_1$ = 9.21 Ω
R$_2$ = 5.7 Ω
R$_3$ = 4.6 Ω

R$_1$ + R$_2$ + R$_3$ = 9.21 + 5.7 + 4.6
R$_1$ + R$_2$ + R$_3$ = 19.51

To a suitable number of significant figures for this experiment:

$R_1 + R_2 + R_3$ = 20 Ω

(d) Comparison with 3 × R_1

First calculate:

3 × R_1 = 3 × 9.21 = 27.6 Ω

From part (c):

$R_1 + R_2 + R_3$ = 20 Ω

Since:

20 Ω **is less than** 27.6 Ω

Statement

Suggestion B

Justification

The measured total resistance **$R_1 + R_2 + R_3$ = 20 Ω**, which is clearly **less than 3 × R_1 = 27.6 Ω**, so suggestion B agrees with the experimental results.

(e) Circuit diagram with three lamps in series

The diagram below shows:

- **Three lamps (L_1, L_2, L_3) connected in series**
- A **power supply**
- A **voltmeter connected across lamp L_3**
- Correct circuit symbols and continuous conducting path

L1 L2 L3

V
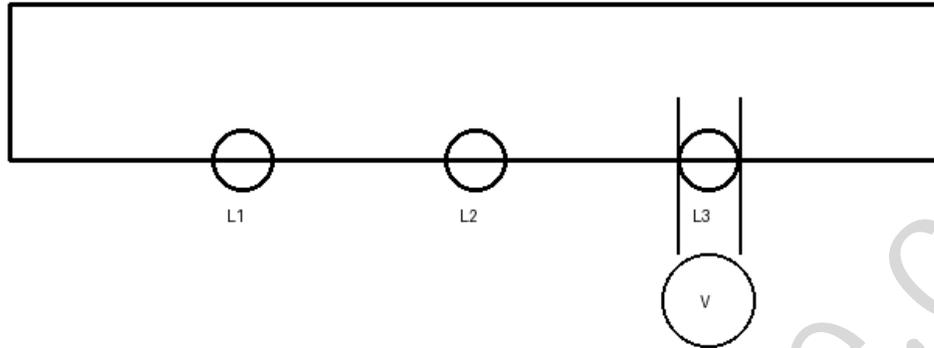
3   A student investigates the position of the image in a plane mirror.

   Fig. 3.1 shows the ray-trace sheet he uses.

Fig. 3.1

(a)

- The student draws the line **MR**.

- He draws a normal **NL** to this line that passes through the centre of **MR**.

- He labels the point at which **NL** crosses **MR** with the letter **B**.

- He draws a line from **B** at an angle of incidence $i = 30°$ to the normal below **MR** and to the left of the normal. He labels the end of this line **A**.

- He places a pin P_1 on line **AB**, as shown in Fig. 3.1. He places another pin P_2 on the line **AB**.

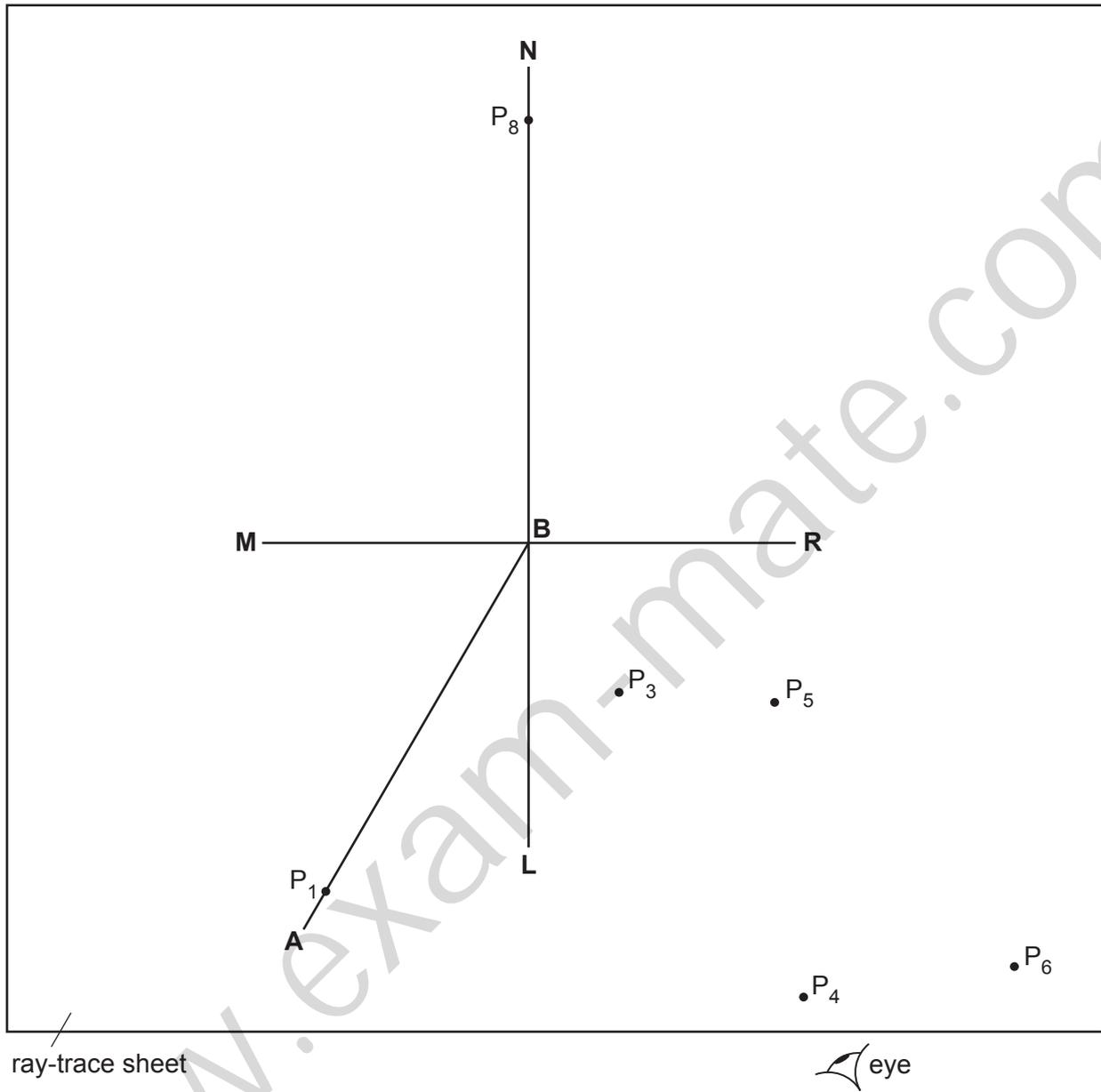- He places the reflecting face of the mirror vertically on the line **MR**.

- He views the images of pins P_1 and P_2 from the direction indicated by the eye in Fig. 3.1.

(i) On Fig. 3.1, mark with a cross a suitable position for pin P_2 in this experiment. [1]

- He places two pins P_3 and P_4 some distance apart so that pin P_3 and the images of P_2 and P_1 all appear exactly behind pin P_4. The positions of P_3 and P_4 are shown on Fig. 3.1.

(ii) Draw the line joining the positions of P_3 and P_4. Continue the line until it extends at least 7.0 cm beyond **MR**. [2]

(b)

- The student keeps pin P_1 in the same position but moves pin P_2 so that the angle of incidence $i = 40°$.

- The pin positions P_5 and P_6 for the reflected ray are marked on Fig. 3.1.

(i) Draw the line joining the positions of P_5 and P_6. Continue the line until it extends at least 7.0 cm beyond **MR**.

Label with the letter **Y** the point where the two lines cross beyond **MR**. [1]

(ii) Draw a line from P_1 to **MR** that meets **MR** at a right angle. Measure and record the length a of this line.

$a =$ .... [1]

(iii) Draw a line from the point labelled **Y** to **MR** that meets **MR** at a right angle. Measure and record the length b of this line.

$b =$ .... [1]

(c)
- The student removes all the pins. He places pin P_7 on the normal at a distance 6.0 cm from the front of the mirror.

- He views the image of P_7 in the mirror.

- He places pin P_8 on the normal behind the mirror.

- He adjusts the position of P_8 so that the image of the bottom of the pin P_7 and the top of pin P_8 seen over the mirror appear as one pin when viewed from all angles in front of the mirror.

(i) On Fig. 3.1, measure the distance x along the normal between P_8 and the mirror.

$x =$ .... [1]

(ii) Complete the diagram in Fig. 3.2 to show the appearance of the image of pin P_7 and pin P_8 as described in **(c)**.

mirror

Fig. 3.2

[1]

(d) The student expects the readings to show that the image formed in a plane mirror is the same distance behind the mirror as the object is in front of the mirror. Readings of $a = b$ and $x = 6.0$ cm will show this.

State whether your readings show that the image formed in a plane mirror is the same distance behind the mirror as the object is in front of the mirror. Justify your statement by reference to the readings.

statement ....

justification ....

....
[2]

(e) The student carries out this experiment with care. Suggest a practical reason why the results may not be accurate.

....

.... [1]

[Total: 11]

Question no. 3

(a)(i) Position of pin P_2

Pin P_2 must be placed **on the same straight line AB as P_1**, because both pins define the **incident ray**.

For the experiment to work accurately, **P_2 must be well separated from P_1** so that the direction of the ray can be judged precisely when viewed in the mirror.

A **suitable position** for P_2 is therefore:

- **On line AB**
- **At least 5.0 cm away from P_1**, further down the line towards A

This satisfies the experimental requirement and matches the ray shown in Fig. 3.1.

(a)(ii) Line joining P_3 and P_4

Pins P_3 and P_4 are positioned so that they line up with the **images of P_1 and P_2**. Therefore, the line joining P_3 and P_4 represents the **path of the reflected ray**.

To complete this part:

- A **straight line** is drawn joining **P_3 to P_4**
- This line is then **extended behind the mirror line MR**
- The extension must be **at least 7.0 cm beyond MR**

This extended line represents the **backward extension of the reflected ray**, which is used to locate the virtual image.

(b)(i) Line joining P_5 and P_6, and point Y

Pins P_5 and P_6 mark the reflected ray when the **angle of incidence is changed to 40°**.

Steps:

- Draw a **straight line joining P_5 and P_6**
- Extend this line **at least 7.0 cm beyond MR**

- The point where this line **crosses the previously drawn extended line (from part a)** is labelled **Y**

Point **Y** represents the **virtual image position** formed by the mirror for this second angle of incidence.

(b)(ii) Measurement of distance a

A perpendicular is drawn from **P$_1$ to the mirror line MR**.

- The line must meet MR at a **right angle**
- The length of this perpendicular is measured using a ruler
- This distance is recorded as **a**

A correct value of **a** must be measured **to within ± 2 mm**.

(b)(iii) Measurement of distance b

A perpendicular is drawn from point **Y** to the mirror line **MR**.

- The line meets MR at **90°**
- The distance is measured carefully
- This distance is recorded as **b**

Again, the measurement must be **within ± 2 mm** of the correct value.

(c)(i) Measurement of distance x

Pin **P$_7$** is placed **6.0 cm in front of the mirror on the normal**.
Pin **P$_8$** is adjusted **behind the mirror** so that the image of P$_7$ and the top of P$_8$ coincide when viewed.

The distance **x** is measured:

- **Along the normal**

- **Between P₈ and the mirror line**
- Recorded with the **correct unit (cm)**

Since the image in a plane mirror is formed the same distance behind the mirror as the object is in front, the measured value should be:

x = 6.0 cm (approximately)

(c)(ii) Diagram showing appearance of P₇ and P₈

In the completed diagram:

- The **image of pin P₇** appears **behind the mirror**
- The **top of pin P₈** aligns exactly with the **image of the bottom of P₇**
- The two appear as **one continuous pin** when viewed from the front

This shows correct understanding of **virtual image formation in a plane mirror**.

Formation of image of a point object in a plane mirror.
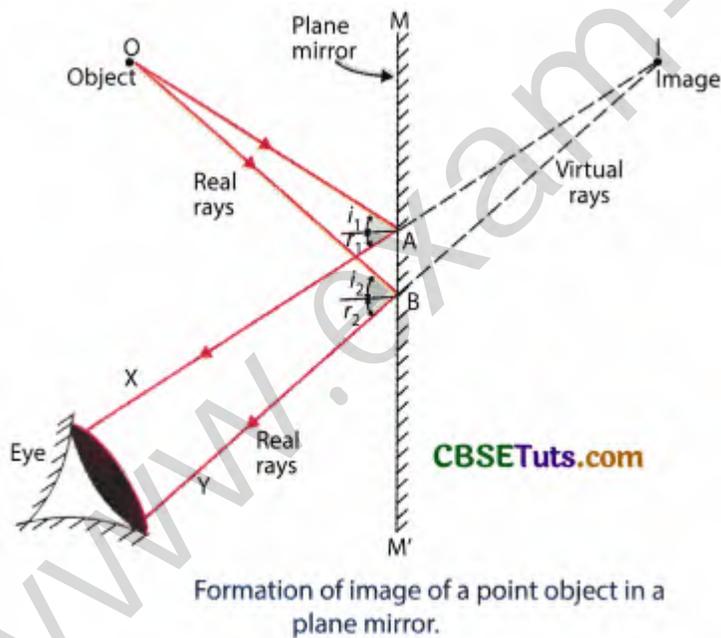
Image Formation by Plane Mirror
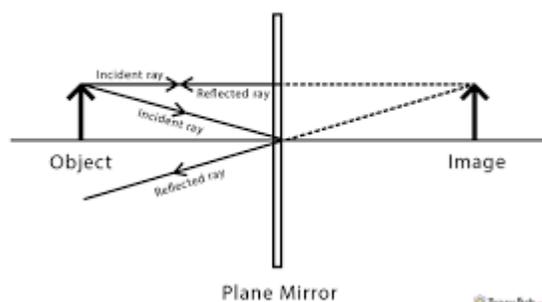
Plane Mirror

(d) Conclusion using readings

Statement:
The readings **do show** that the image formed in a plane mirror is the same distance behind the mirror as the object is in front.

Justification:
The measured distances show that:

- **a ≈ b**, meaning the object distance equals the image distance
- **x ≈ 6.0 cm**, which matches the original distance of P_7 from the mirror

These results agree with the known property of a **plane mirror**.

- Statement matches results
- Justification refers clearly to readings

(e) Practical reason for inaccuracy

One practical reason why the results may not be perfectly accurate is:

- **Difficulty in judging the exact alignment of pins and their images**

Small errors in eye position or pin placement make precise alignment difficult.

4 A student investigates the effect of the colour of the surface of a metal container on the rate of loss of heat from the container. She knows that black surfaces are better radiators of thermal energy than white surfaces and wants to investigate the effect of other colours.

The following apparatus is available:

metal containers each with the outer surface painted a different colour
a thermometer
a stop-watch
a supply of hot water.

She can also use other apparatus and materials that are usually available in a school laboratory.

Plan an experiment to investigate the effect of the colour of the surface of a metal container on the rate of loss of heat from the container.

You should:

* draw a diagram of the apparatus used

* explain briefly how you would carry out the investigation

* state the key variables to be kept constant

* draw a table, or tables, with column headings, to show how you would display your readings (you are **not** required to enter any readings in the table)

* explain how you would use your readings to reach a conclusion.

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.... [7]

[Total: 7]

Question no. 4

Diagram of the apparatus

The apparatus consists of a **metal container** filled with **hot water**, with a **thermometer** placed inside the water to measure its temperature. The **outer surface of the container is painted a specific colour** (for example black, white, red, blue). A **stop-watch** is used to measure time.

All containers are **identical in size, shape, and material**, differing **only in surface colour**. A **lid** may be placed on each container to reduce heat loss by convection and evaporation so that radiation is the main mechanism being compared.

Method (how the investigation is carried out)

First, hot water is poured into one of the metal containers until it reaches a fixed level. The thermometer is placed in the water and the **initial temperature is recorded immediately**. The stop-watch is started at the same time.

The temperature of the water is then **recorded at regular time intervals** (for example every 1 or 2 minutes) as the water cools. This is continued for a fixed total time, or until the temperature has fallen by a suitable amount.

The experiment is then **repeated using containers of different colours**, ensuring that **at least three different colours** are tested (for example black, white, and red). Each time, the same procedure is followed and temperatures are recorded in exactly the same way.

Key variables to be kept constant

To ensure a fair test, the following variables must be controlled:

- **Same starting temperature** of the hot water for each container
- **Same volume (mass) of water** in each container
- **Same room temperature** and surroundings
- **Same container material, shape, and surface area**
- **Same thickness of paint** on each container
- **Use of a lid (or no lid) for all containers**, consistently
- **Same time intervals** between temperature readings

The **independent variable** is the **colour of the container surface**.
The **dependent variable** is the **rate of temperature decrease of the water**.

Table to record results

Table: Temperature of water with time

Time / s	Temperature / °C (Black)	Temperature / °C (White)	Temperature / °C (Red)	Temperature / °C (Blue)

(Units are included in the column headings, and additional rows can be added if needed.)

Using the readings to reach a conclusion

For each colour, the **temperature drop over the same time interval** is calculated, or a **cooling curve (temperature against time)** is plotted.

The container that shows the **greatest decrease in temperature in a given time** has the **highest rate of heat loss**, meaning it is the **best radiator of thermal energy**.

By comparing the results for different colours, a conclusion can be drawn about **how surface colour affects thermal radiation**, confirming that **darker colours lose heat faster than lighter colours**, with black typically being the most effective radiator.