REDSPOT New Solutions . New Minds

About O Level

PHYSICS
ALTERNATIVE TO PRACTICAL
(PAPER 4) (YEARLY)

About Thinking Process

When solving problems, we first analyse the questions and then gather relevant information until we are able to determine the answers. But for presentation reason, we need to organise, rearrange and then present ONLY the required workings and solutions.

Thinking process reveals the extra but relevant information which is not required as part of the solutions.

period	**2010 to 2024**
contents	**June & November, Paper 4, Worked Solutions**
form	**Yearly**
compiled for	**O Levels**
special features	**Thinking Process**

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E-Mail: info@redspot.com.pk
Website: www.redspot.pk
Address: P.O. Box 5041, Model Town, Lahore, Pakistan.

CONTENTS

JUNE 2023 **PAPER** 4

Answer **all** questions.

Question 1

A student measures the capacity of a drinks cup by three different methods.
The capacity of a cup is the maximum volume of liquid that it can hold.

(a) method 1

The student measures:

- the height h of the cup
- the diameter D of the top of the cup
- the diameter d of the bottom of the cup.

Fig. 1.1 shows a full-size diagram of the cup.

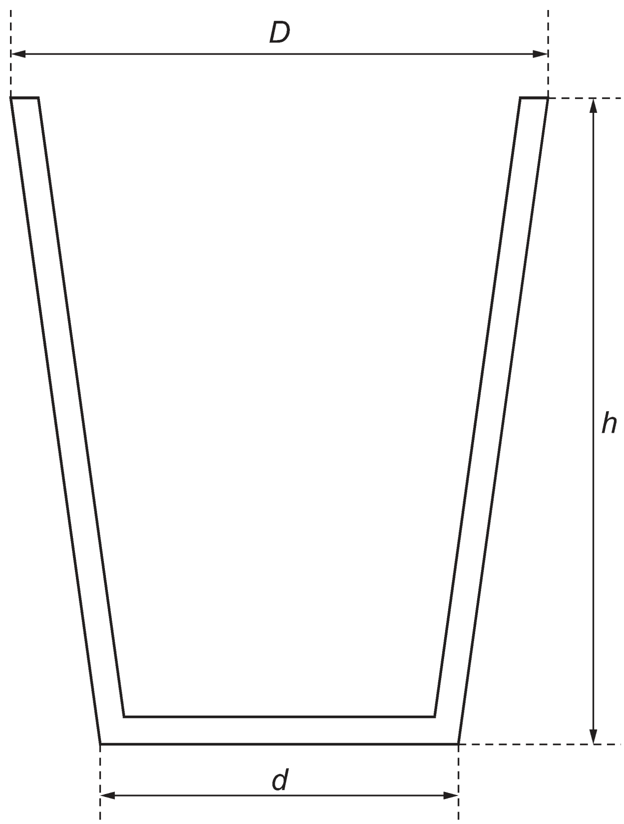


Fig. 1.1

(i) Measure the height h, the diameter D and the diameter d of the cup in the diagram.

h = ... cm

D = ... cm

d = ... cm

[2]

(ii) Calculate the average diameter d_A of the cup using your readings from **(a)(i)** and the equation:

$$d_A = \frac{(D+d)}{2}$$

d_A = ... cm [1]

(iii) Calculate a value for the capacity V_1 of the cup using the equation:

$$V_1 = \frac{\pi {d_A}^2 h}{4}$$

V_1 = ... cm^3 [1]

(b) method 2

The student uses a length of string and a metre rule to determine the average circumference C of the cup.

The student:

- wraps some of the string 5 times around the cup
- measures the length l of string used.

$$l = 87.9 \text{ cm}$$

(i) Calculate the average circumference C of the cup.

C = ... cm [1]

(ii) Use your values of h from **(a)(i)** and C from **(b)(i)** to calculate a value for the capacity V_2 of the cup using the equation:

$$V_2 = \frac{C^2 h}{4\pi}$$

V_2 = ... cm^3 [1]

(c) method 3

The student:

- fills a measuring cylinder with water, up to the 220 cm^3 mark
- pours water from the measuring cylinder into the cup until the cup is full
- records the new reading R on the measuring cylinder.

Fig. 1.2 shows the new reading R.

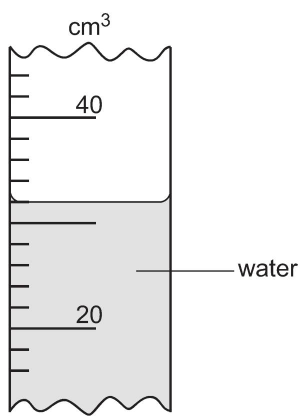


Fig. 1.2

(i) Write down the new reading R.

R = ... cm^3 [1]

(ii) Determine the volume of water V_3 in the cup.
Show your working.

V_3 = ... cm^3 [1]

(d) All three methods of determining the capacity of the drinks cup give values which are approximate.
State **one** reason why the volume calculated in **method 2** and **one** reason why the volume calculated in **method 3** are **not** accurate.

method 2 ....

....

....

method 3 ....

....

....

[2]

[Total: 10]

Question 2

A student investigates the effective resistance of different combinations of resistors and lamps in circuits.
The student sets up the circuit shown in Fig. 2.1.

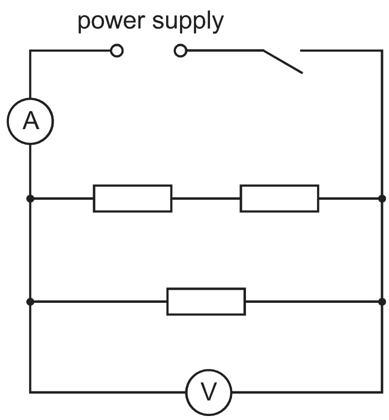


Fig. 2.1

(a) The student:

- closes the switch
- measures the potential difference V_1 across the resistors and the current I_1 in the circuit
- opens the switch.

The readings on the voltmeter and ammeter are shown in Fig. 2.2 and Fig. 2.3.

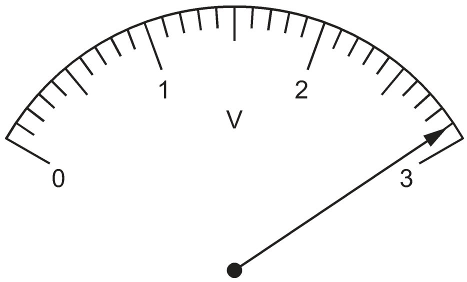


Fig. 2.2

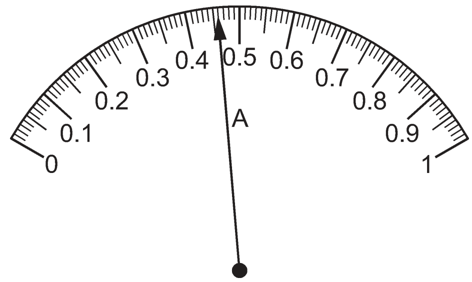


Fig. 2.3

(i) Record the potential difference V_1 and the current I_1 shown in Fig. 2.2 and Fig. 2.3.

V_1 = ... V

I_1 = ... A

[2]

(ii) Calculate the effective resistance R_1 of the combination of resistors using the equation:

$$R_1 = \frac{V_1}{I_1}$$

R_1 = ... Ω [1]

(iii) Suggest why the switch is opened after the readings of potential difference and current have been taken.

....

.... [1]

(b) The student:

- rearranges the circuit so that the resistors are connected as shown in Fig. 2.4
- closes the switch
- measures the potential difference V_2 and the current I_2
- opens the switch.

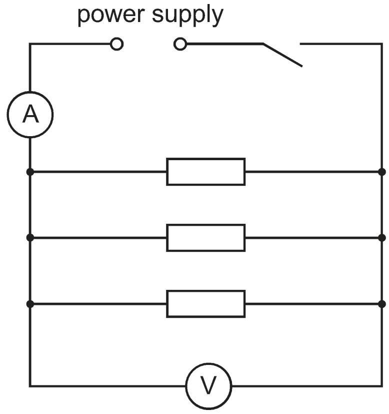


Fig. 2.4

The new readings are:

$$V_2 = 2.8\ \text{V}$$

$$I_2 = 0.88\ \text{A}$$

Calculate the effective resistance R_2 of the combination of resistors using the equation:

$$R_2 = \frac{V_2}{I_2}$$

Record your answer on the answer line.

Write down the value of $2R_2$

R_2 = ... Ω

$2R_2$ = ... Ω

[1]

(c) If the resistors are identical, theory suggests that $R_1 = 2R_2$.

Two quantities can be considered to be equal within the limits of experimental accuracy if their values are within 10% of each other.

State whether the results indicate that the resistors are identical. Support your statement with a calculation.

calculation

statement ....

.... [2]

(d) The student repeats the experiments in **(a)** and **(b)** but replaces the resistors with lamps. He obtains the following results:

The effective resistance R_3 of the combination of lamps connected as in Fig. 2.1 is 5.2 Ω.

The effective resistance R_4 of the combination of lamps connected as in Fig. 2.4 is 3.4 Ω.

The teacher explains that the resistance of the lamp filaments changes due to a heating effect and therefore R_3 is not equal to $2R_4$.

Suggest **one** observation that the student makes while doing the experiment that supports the teacher's explanation.

....

.... [1]

(e) The student extends the investigation using a different combination of the three lamps to the two combinations already used in **(a)** and **(b)**.

Complete the circuit diagram in Fig. 2.5 to show a third way of connecting three lamps between X and Y. **[2]**

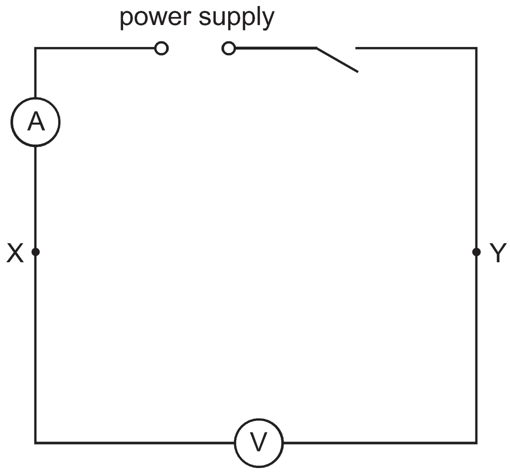


Fig. 2.5

[Total: 10]

Question 3

A student investigates the image formed by a converging lens.

The student arranges the apparatus as shown in Fig. 3.1.

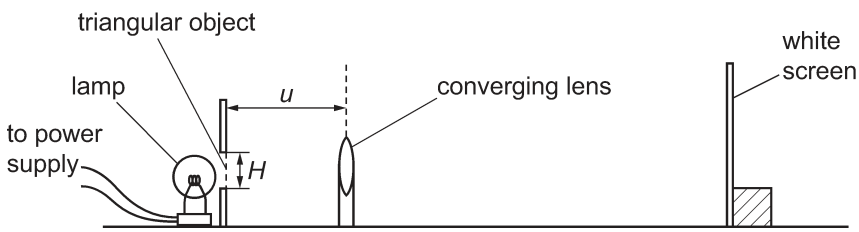


Fig. 3.1 (not to scale)

The illuminated triangular object is shown full size in Fig. 3.2.

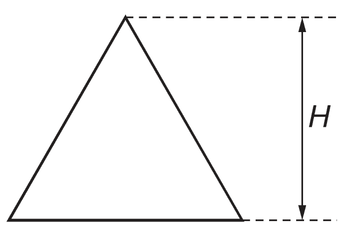


Fig. 3.2

(a) Measure and record the height H of the triangular object.

H = ... cm [1]

(b) The student:

- switches on the lamp and places the lens a distance u = 20.0 cm from the triangular object
- adjusts the position of the screen until a sharp, focussed image of the triangular object is formed on the screen.

SOLUTIONS - JUNE 2023

Q1 - Solution

(a) (i) $h = 8.3$ cm
$D = 6.9$ cm
$d = 4.6$ cm

(ii) $d_A = \frac{(D+d)}{2}$
$= \frac{6.9+4.6}{2} = 5.75$ cm

(iii) Capacity, $V_1 = \frac{\pi d_A{}^2 h}{4}$
$= \frac{\pi \times (5.75)^2 \times 8.3}{4} = 215.5 \text{ cm}^3$

(b) (i) Average circumference, $C = \frac{87.9}{5}$
$= 17.58$ cm

(ii) Capacity, $V_2 = \frac{C^2 h}{4\pi}$
$= \frac{(17.58)^2 \times 8.3}{4 \times \pi} = 204.13 \text{ cm}^3$

(c) (i) $R = 32 \text{ cm}^3$

(ii) Capacity, V_3 = Volume of water in measuring cylinder
− water left in cylinder after filling the cup
$= 220 - 32$
$= 188 \text{ cm}^3$

(d) Method 2: The circumference of the cup is not uniform over the height of the cup.

Method 3: Water may spill while trying to fill the cup to the brims.

COMMENT on ANSWER

"**(d) Method 2 :**
Other Reasons:
— string not correctly / closely positioned.
— loops of string may overlap.
— string too tightly or too loosely wrapped
— string may stretch
— string has thickness
— external diameter is measured.
Method 3 :
Other Reasons:
— cup underfilled or overfilled.
— water left in the cup / measuring cylinder.
— readings not taken perpendicularly to scale / parallax error."

Q2 - Solution

(a) (i) $V_1 = 2.90$ V
$I_1 = 0.46$ A

(ii) $R_1 = \frac{V_1}{I_1}$
$= \frac{2.90}{0.46} = 6.30\ \Omega$

(iii) The switch is opened after taking the readings to prevent the overheating of the circuit components.

COMMENT on ANSWER

"**(a) (iii)** *Other Reasons:*
— to allow resistors to cool down
— to prevent cell running down / to save power"

(b) $R_2 = \dfrac{V_2}{I_2}$

$= \dfrac{2.8}{0.88} = 3.2\,\Omega$

$2R_2 = 2 \times (3.2)$

$= 6.4\,\Omega$

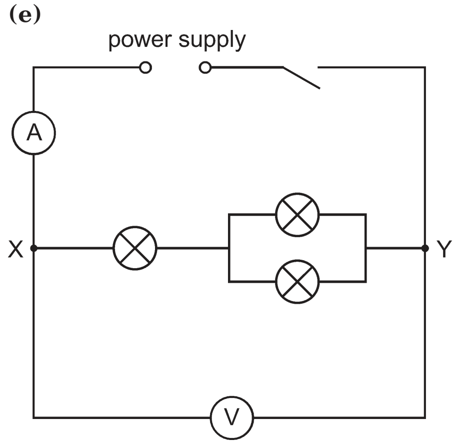
(c) Calculation: The ratio of R_1 to $2R_2$

$$\frac{R_1}{2R_2} = \frac{6.3}{6.4} = 0.9 \text{ (or } 90\%)$$

Statement: Yes, the resistors are identical as the above calculation shows that $R_1 = 2R_2$ within the limits of experimental accuracy.

(d) The lamps glow with different brightness in the two circuits.

(e)



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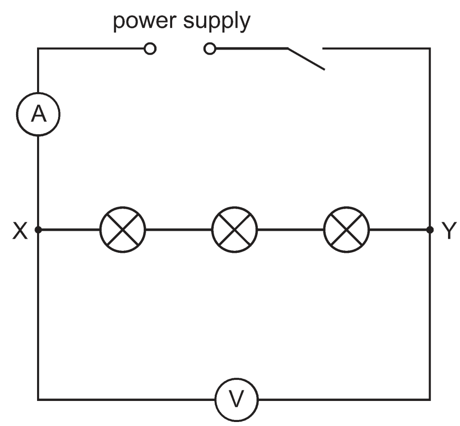


Q3 - Solution

(a) H = 2.6 cm

(b) (i) h = 7.8 cm

(ii) $\dfrac{1}{h} = 0.13$

(c) (i) & (ii)

u / cm	h **/cm**	$\frac{1}{h}$ / $\frac{\mathbf{1}}{\mathbf{cm}}$
20.0	**7.8**	**0.13**
25.0	3.9	**0.26**
30.0	2.6	**0.38**
40.0	1.6	**0.63**
50.0	1.1	**0.91**

(d) For the values of $u < 20$ cm, the image becomes too big to fit on the screen.

COMMENT on **ANSWER**

❝ **(d)** *Other Reasons:*

— object inside focal length

— image becomes virtual ❞

NOVEMBER 2024 **PAPER** 4

Answer **all** questions.

Question 1

A student determines an approximate value for the density of the glass from which a test-tube is made.

The height h and the external diameter d of the test-tube are shown in a full-size diagram of the test-tube in Fig. 1.1.

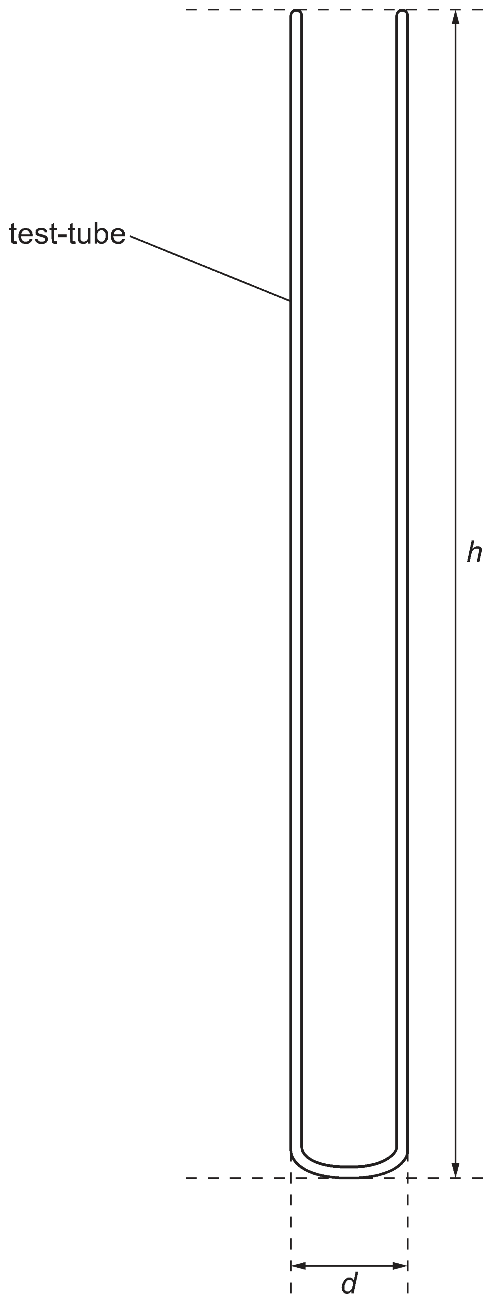


Fig. 1.1

(a) **(i)** Measure the height h of the test-tube in Fig. 1.1 to the nearest 0.1 cm.

h = ... cm [1]

(ii) Measure the external diameter d of the test-tube in Fig. 1.1.

d = ... cm [1]

(b) The student uses a ruler and two wooden blocks to help obtain an accurate answer for the height h.

Fig. 1.2 shows how the student uses the wooden blocks.

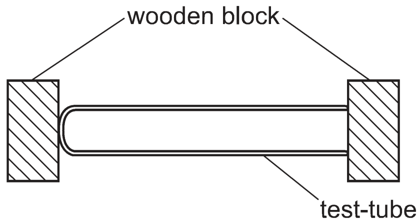


Fig. 1.2

Explain why it is important for the student to ensure that the blocks are parallel to one another.

....

.... [1]

(c) The shape of the test-tube is approximately a cylinder.

Calculate the external volume V_E of the test-tube using the equation:

$$V_E = 0.79\, d^2 h$$

V_E = ... cm^3 [1]

(d) The student:

- fills the test-tube to the top with water
- pours the water from the test-tube into a measuring cylinder.

Fig. 1.3 shows the measuring cylinder.

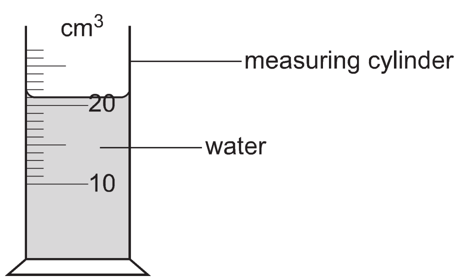


Fig. 1.3

Record the reading V_I on the measuring cylinder.

This is the internal volume of the test-tube.

V_I = ... cm^3 [1]

(e) Calculate the volume V_G of the glass in the test-tube using the equation:

$$V_G = V_E - V_I$$

V_G = ... cm^3 [1]

(f) Suggest **one** source of inaccuracy in measuring the internal volume of the test-tube V_I.

....

.... [1]

(g) (i) The student uses a balance to measure the mass m of the test-tube.
Fig. 1.4 shows the reading on the balance.

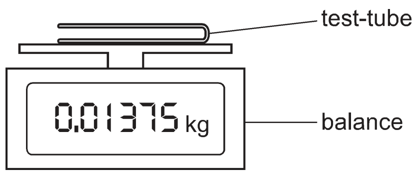


Fig. 1.4

Record m to the nearest **gram.**

m = ... g [1]

(ii) Use your results from **(g)(i)** and **(e)** to calculate the density ρ of the glass from which the test-tube is made using the equation:

$$\rho = \frac{m}{V_G}$$

Give the unit for your answer.

ρ = ... unit = ... [2]

[Total: 10]

Question 2

A student investigates the resistance of a light-emitting diode (LED) when different currents flow through it.

The student sets up the circuit shown in Fig. 2.1.

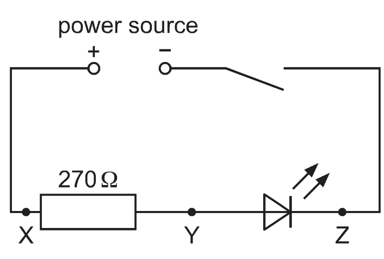


Fig. 2.1

(a) The student:

- connects a voltmeter across the 270 Ω resistor between points X and Y
- closes the switch
- records the voltmeter reading of the potential difference V_{XY} in the top row of Table 2.1
- opens the switch.

Table 2.1

resistance between X and Y / Ω	V_{XY} / V	V_{YZ} / V	$(V_{XY} + V_{YZ})$ / V	I / A	R_{LED} / Ω
270	....	2.1	....	....	....
470	2.6	2.0	4.6	0.0053	380
560	....	2.0	4.6	0.0046	430

(i) On Fig. 2.1, draw the symbol for a voltmeter connected to measure the potential difference V_{XY} across the 270 Ω resistor. [1]

(ii) Fig. 2.2 shows the voltmeter reading of the potential difference V_{XY} when the voltmeter is connected across the 270 Ω resistor.

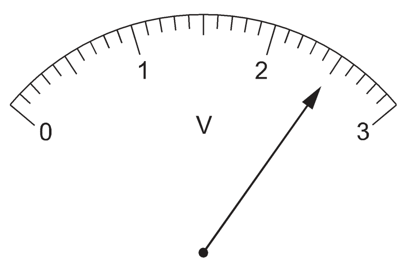


Fig. 2.2

Record V_{XY} in Table 2.1. [1]

(b) The student:

- disconnects the voltmeter from points X and Y
- reconnects the voltmeter across the LED between points Y and Z
- closes the switch
- records the voltmeter reading of the potential difference V_{YZ} in the correct row of Table 2.1
- opens the switch.

(i) Calculate the value of $(V_{XY} + V_{YZ})$ for the 270 Ω resistor. Record your answer in Table 2.1.

[1]

(ii) The current I in the circuit can be calculated using the equation:

$$I = \frac{V_{XY}}{R}$$

where $R = 270\ \Omega$.

Calculate I. Record your answer in Table 2.1.

[1]

(iii) The resistance R_{LED} of the LED can be calculated using the equation:

$$R_{LED} = \frac{V_{YZ}}{I}$$

Calculate R_{LED}. Record your answer in Table 2.1.

[1]

(c) The student repeats the procedure in **(a)** and **(b)**, replacing the 270 Ω resistor, first with a 470 Ω resistor and then with a 560 Ω resistor.

The student's results are shown in Table 2.1, but the value of V_{XY} for the 560 Ω resistor is missing. Calculate V_{XY} and record your answer in Table 2.1.

[1]

(d) As the resistance between terminals X and Y changes, the current in the circuit changes.

Examine the results in Table 2.1.

Describe how the change in current affects:

(i) $(V_{XY} + V_{YZ})$

....

.... [1]

(ii) R_{LED}.

....

.... [1]

(e) Another student assembles a circuit using the circuit diagram shown in Fig. 2.1. This student finds that, when the switch is closed, the LED does not light up.

The student tests the components and finds that the power source is producing an e.m.f., and that none of the other components are broken.

Suggest the error this student has made while assembling the circuit.

....

.... [1]

(f) Name and draw the symbol of a single device that can be used to change the current in the circuit without the need to connect different resistors across the terminals X and Y in the circuit in Fig. 2.1.

name of device ....

symbol for device

[1]

[Total: 10]

Question 3

A student investigates the image formed by a converging lens.

(a) The student:

- arranges the apparatus as shown in Fig. 3.1

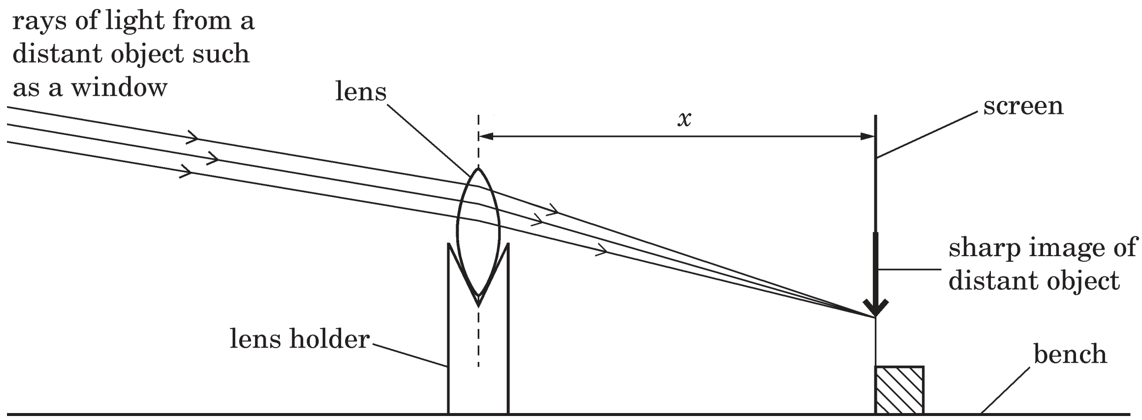


Fig. 3.1

- places a white screen approximately 30 cm from the lens
- adjusts the position of the screen until a sharp image of a window in the laboratory, a few metres distant from the lens, is formed on the screen.

(i) Measure and record, in centimetres to the nearest 0.1 cm, the distance x on Fig. 3.1 from the lens to the screen.

x = ... cm [1]

(ii) The distance x shown on Fig. 3.1 is drawn to a scale of one-third full size.

Use your answer from **(a)(i)** to calculate the actual distance from the lens to the screen.

This distance is the focal length f of the lens.

f = ... cm [1]

(b) The student:

- rearranges the apparatus as shown in Fig. 3.2

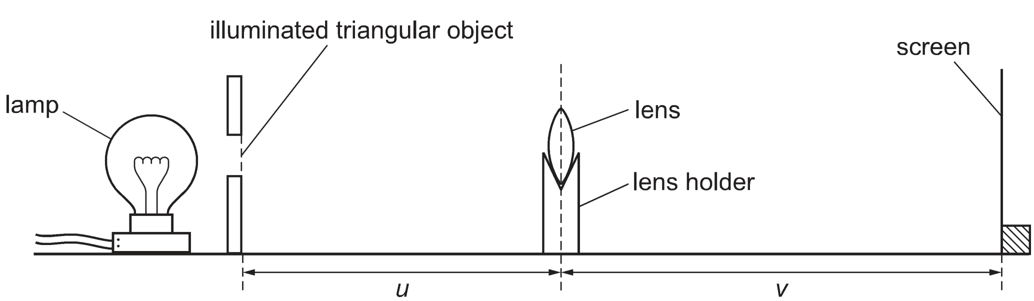


Fig. 3.2

- switches on the lamp
- places the lens a distance u = 20.0 cm from an illuminated triangular object
- adjusts the position of the screen until a sharp image of the triangular object is formed on the screen
- measures the image distance v from the lens to the screen.

v = 60.5 cm

SOLUTIONS - NOVEMBER 2024

Q1 - Solution

(a) (i) $h = 15.0$ cm

(ii) $d = 1.5$ cm

(b) Using parallel blocks provide a more accurate and consistent value of height / length (h) of test-tube, between any two points of the blocks.

(c) $V_E = 0.79 \times (1.5)^2 \times 15.0$

$= 26.66 \text{ cm}^3$

(d) $V_I = 21 \text{ cm}^3$

(e) $V_G = 26.66 - 21$

$= 5.66 \approx 5.7 \text{ cm}^3$

(f) The measuring cylinder can not measure the volume of water precisely as scale can only read to nearest 1 cm^3.

(g) (i) $m = 0.01375$ kg

$= 0.01375 \times 1000$ g

$= 13.75 \text{ g} \approx 14$ g

(ii) Density $(\rho) = \dfrac{m}{V_G}$

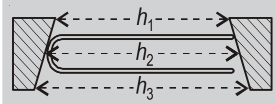
$= \dfrac{14}{5.7}$

$= 2.456 \approx 2.5 \text{ g/cm}^3$

COMMENT on **ANSWER**

" **(b)** If the blocks are not parallel, the height (h) of the test-tube measured between any two points of the blocks will not be consistent i.e., h varies.

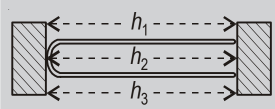
Non-parallel blocks:



$h_1 \neq h_2 \neq h_3$

If the blocks are parallel The height (h) of test-tube i.e., the horizontal distance between any two points of the blocks is consistent and accurate.

Parallel blocks:



$h_1 = h_2 = h_3$

(f) ***Alternatively:***

— Not all the water is transferred from test-tube to measuring cylinder. Some water is left stuck to the sides of the test-tube.

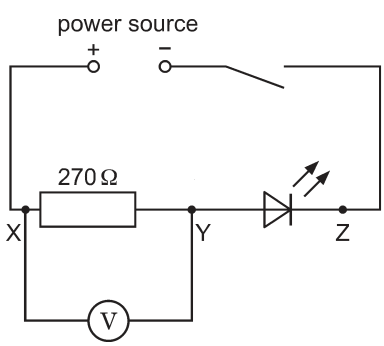
— Cannot tell when test-tube is full.

— Can overfill the test-tube.

— Water spilled on transfer "

Q2 - Solution

(a) (i)



(ii)

resistance between X and Y / Ω	V_{XY} / V	V_{YZ} / V	$(V_{XY} + V_{YZ})$ / V	I / A	R_{LED} / Ω
270	**2.5**	2.1	**4.6**	**0.0093**	**226**
470	2.6	2.0	4.6	0.0053	380
560	**2.6**	2.0	4.6	0.0046	430

(b) (i) $V_{XY} + V_{YZ} = 2.5 + 2.1$
$= 4.6 \text{ V}$

(ii) $I = \dfrac{2.5}{270}$
$= 0.00926 \approx 0.0093 \text{ A}$

(iii) $R_{LED} = \dfrac{2.1}{0.0093}$
$\approx 226\,\Omega$

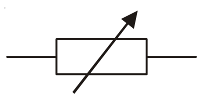
(c) $V_{XY} = (V_{XY} + V_{YZ}) - V_{YZ}$
$= 4.6 - 2.0$
$= 2.6 \text{ V}$

(d) (i) The value of the total voltage = $(V_{XY} + V_{YZ})$ remains constant.

(ii) As the current decreases, the resistance R_{LED} increases.

(e) The diode is connected the wrong way around.

(f) Name of device: Variable resistor

Symbol of device: 

COMMENT on ANSWER

" **(c)** ***Alternatively:***

Total voltage in circuit
$V = V_{XY} + V_{XY}$
$= 4.6\ V$ (from table)
Total current in circuit
when $R_{XY} = 560\,\Omega$
$I = \dfrac{V}{R}$
$= \dfrac{4.6}{560 + 430}$
$\approx 0.0046 \text{ A}$
Thus, $V_{XY} = IR$
$= 0.0046 \times 560$
$= 2.576\ V$

(e) ***Alternatively:***

Possible errors:
— the battery is connected the wrong way around
— voltmeter is connected in series. "

Q3 - Solution

(a) (i) x = 5.1 cm

(ii) Actual distance from lens to screen $= x \times 3$
$= 5.1 \times 3 = 15.3 \text{ cm}$

therefore, focal length, $f = 15.3$ cm.

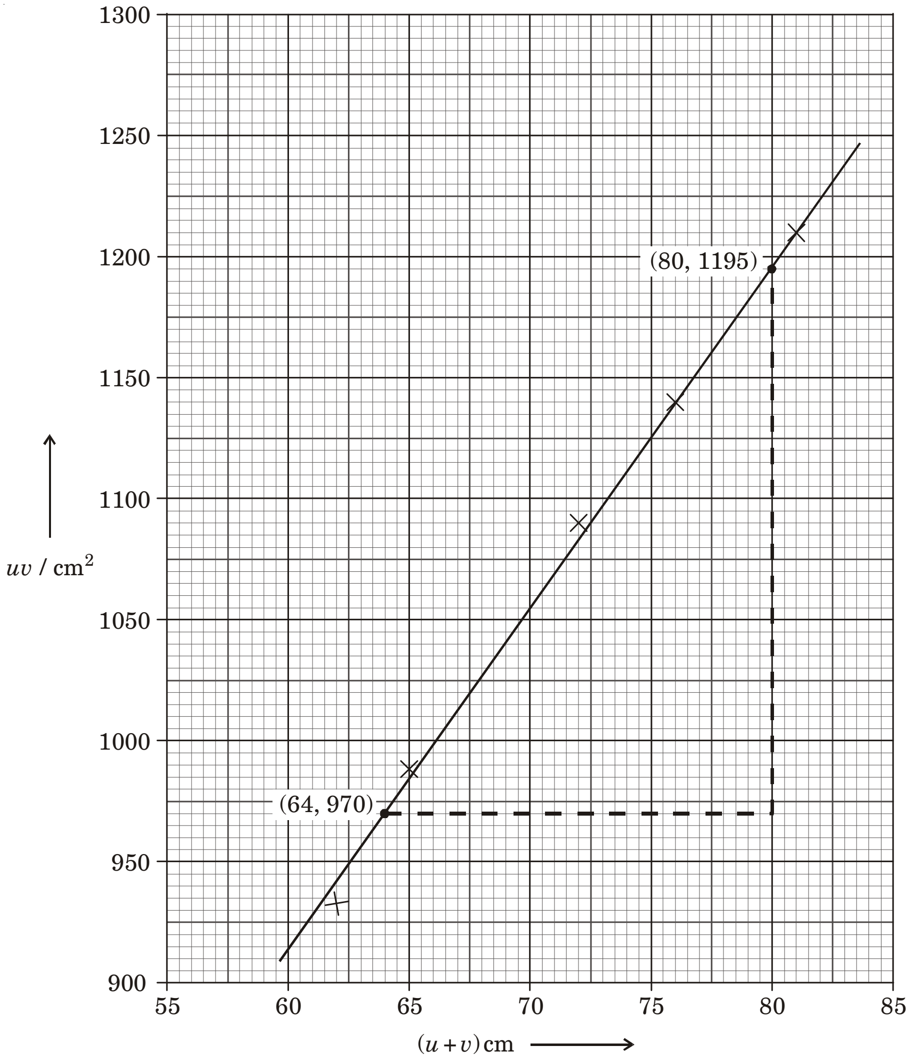
(b) $u + v = 20.0 + 60.5$
$= 80.5 \text{ cm} \approx 81 \text{ cm}$

$uv = 20.0 \times 60.5$
$= 1210 \text{ cm}^2$

(c)

u / cm	v / cm	$(u+v)$ / **cm**	uv / **cm²**
20.0	60.5	**81**	**1210**
25.0	37.3	62	933
40.0	24.7	65	988
50.0	21.7	72	1090
55.0	20.7	76	1140

(d)



(e) Taking points (64, 970) and (80, 1195),

$$\text{gradient} = \frac{1195-970}{80-64}$$

$$= \frac{225}{16} = 14.1$$

(f) Calculation: From **(a)(ii)**, focal length (f_1) = 15.3 cm

From graph, focal length (f_2) = 14.1 cm

Since, these two values are within 10% of each other as shown below:

$$\frac{15.3-14.1}{15.3}\times 100 = 7.84\%$$

Thus they can be considered to be the same within the limits of experimental accuracy.

Statement: Yes, the two values of the focal length (f) of the lens can be considered to be the same i.e., $f_1 \approx f_2$.

(g) (i) View the scale reading from vertically above, such that the line of sight is perpendicular to the scale reading.

(ii) Move the screen slowly backwards and forwards until the image is as sharp as possible.