Index Number		Name	

Anglo-Chinese School (Independent)

A Methodist Institution

(Founded 1886)

PRELIMINARY EXAMINATION 2024
YEAR 4 EXPRESS

PHYSICS **6091 / 03**

Tuesday **30 July 2024** **1 hour 50 minutes**

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an 2B pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.
All of your answers should be written in this Question Paper: scrap paper must **not** be used.
Graph paper is provided in this Question Paper. Additional sheets of graph paper should be used only if it is necessary to do so.

You will be allowed to work with the apparatus for a maximum of 55 minutes for each section.
You are expected to record all your observations as soon as they are made.
An account of the method of carrying out the experiments is not required.

The use of an approved scientific calculator is expected, where appropriate.

At the end of the examination, **fasten all your work securely together**.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's use	
1	
2	
3	
Total	

Section A

1 *In this experiment, you will deduce the path taken by a light ray undergoing total internal reflection in a glass block.*

12 points: any 3 for 1m

1. Trace of block (labelled ABCD)
2. Normal 1.0 cm from corner B
3. Incident ray drawn and actually 30°
4. P1 and P2 are marked and labelled
5. P3 and P4 are marked and labelled
6. Pins are 5 cm apart
7. Emergent ray is drawn
8. N is labelled
9. X distance matches calculations
10. O is labelled
11. Transmission rays are drawn
12. Normal at N and angle e is correct if numerically labelled

*** Accuracy: [deduct 1m for accuracy]

- r = 18° $\pm$ 2 (16-21°)
- e = 30° $\pm$ 3

if normal is not actually 90°, this affects subsequent measurements.

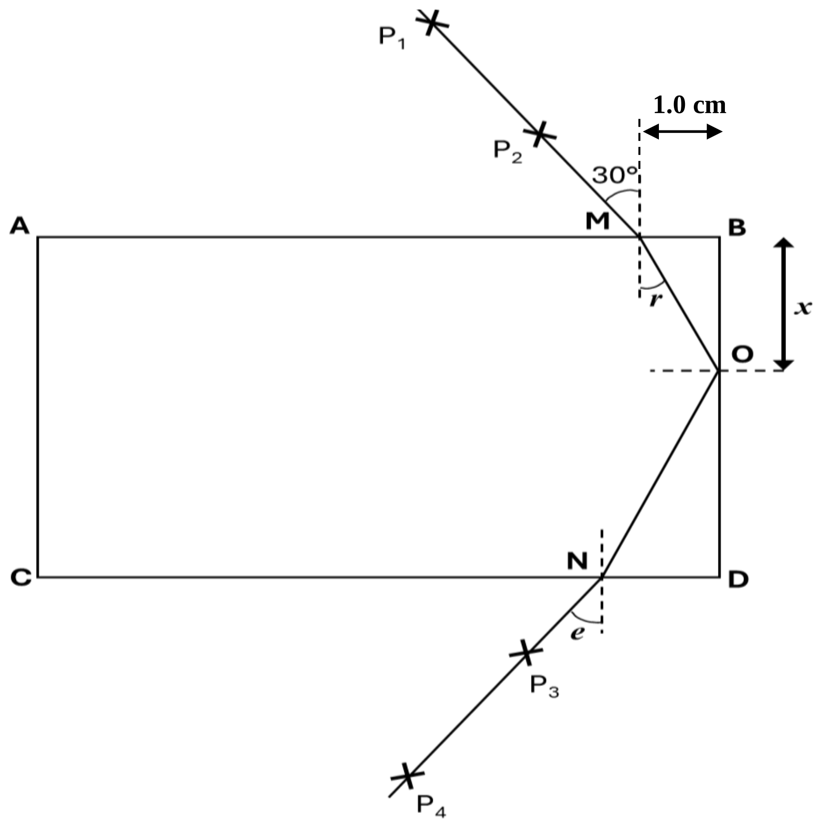


Fig. 1.1 (not to scale)

(a) Place the largest surface of the block in the middle of the sheet of plain paper. Draw around the block to mark its position.

Remove the glass block and label the corners **ABCD** as shown in **Fig. 1**.
Draw a normal at **M**, 1.0 cm from the corner of the block, as shown in **Fig. 1**.
Use the protractor to construct an incident ray at an angle of incidence ***i*** of 30°.

Replace the block and place the plain paper on the cork mat.
Stick two object pins $\mathbf{P_1}$ and $\mathbf{P_2}$ along the incident ray.
Position your eyes to look through side **CD** of the glass block, at side **BD** of the glass block. You should observe 2 reflected images of $\mathbf{P_1}$ and $\mathbf{P_2}$ appear at side **BD** when looking through side **CD**.
Place two further pins $\mathbf{P_3}$ and $\mathbf{P_4}$ in line with the reflected images of $\mathbf{P_1}$ and $\mathbf{P_2}$ so that, when viewed through the block, the four pins appear to be one behind the other.

Remove the block and draw a line joining $\mathbf{P_4}$ and $\mathbf{P_3}$ to the edge of the block. This is the emergent ray. Mark the point where the emergent ray exits the block as **N**.

Measure and record the distances **BD** and **ND** from your trace using the ruler.

BD = ...

Mark for instrument's precision and unit (1 d.p. & cm)

[1]

(b) **(i)** Calculate the value of $\boldsymbol{x}$, using the equation $\boldsymbol{x} = \frac{\boldsymbol{BD}}{\boldsymbol{ND}+1.0} \times 1.0\ cm$, where **BD** and **ND** are expressed in metres.

Mark for correct working, answer, s.f. (2 s.f.)

$\boldsymbol{x}$ = ... [1]

(ii) At a distance of $\boldsymbol{x}$ below corner **B** of the block, mark out the point **O** on side **BD**, as shown in **Fig. 1**.

Draw straight lines from **M** to **O**, and **O** to **N** to represent the path taken by the incident ray after entering the block.

Measure the angle of refraction ***r*** inside the block.

r = ... [1]

Mark for instrument's precision and unit.
(nearest whole number & °, must be accurate to trace $\pm 1°$)

(c) State 2 precautions you took to improve the accuracy of the experiment.

1. Pins are placed at least 5 cm apart, to reduce uncertainty when aligning the pins, and determine a more accurate path travelled by the incident ray. This will give a more accurate r value.
2. Pins are inserted vertically into the corkboard, so that when aligning the pins to determine the path of the incident ray, the alignment matches the constructed light ray on the paper more accurately, giving a more accurate r value.
3. Place my eyes level with the glass block and when performing alignment of the pins, to avoid parallax error and to obtain a more accurate r value.
4. When drawing the outline of the block, I ensure my eye was vertically level with the flat sides of the block when drawing the trace (block was not a perfect cuboid) to avoid parallax error.
5. When aligning the images and pins, I moved my eye rather than rotate the mat to avoid any movement that may accidentally cause the block to shift from its original position.

(d) Comment on the relationship between the angle of incidence, ***i***, and the angle of emergence, ***e***, based on your experiment.

From my experiment, ***i*** and ***e*** are equal in magnitude / to each other.
OR
From my experiment, **i** and ***e*** are very close to each other in value.
Ecf from diagram (either based on the labelled angle, or within 1 degree of *e)*

(e) Submit your trace together with this answer sheet at the end. [4]

Refer to Fig. 1.1

2 *In this experiment, you will investigate the current in a circuit where a fixed resistor and variable resistor arranged in parallel.*

You are provided with:

- a battery
- a switch
- an ammeter
- a voltmeter
- a length of resistance wire mounted on a metre rule
- connecting leads
- a resistor labelled **R**
- a jockey.

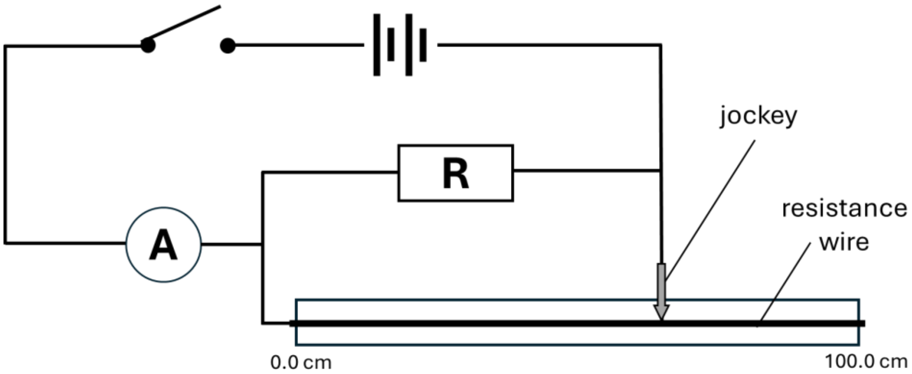


Fig. 2.1

Set up the apparatus as shown in **Fig. 2.1**.

The jockey can be connected at different points along the length of the resistance wire. Connect the jockey to the wire at the 50.0 cm mark of the ruler.

Close the switch.

(a) With the jockey still connected in this position,

(i) Record the length, ***L***, from the 0.0 cm mark of the metre rule to the position of the jockey on the wire, in metres.

Mark for instrument's precision and unit, 0.500 ± 0.020 m (3 d.p., m)

... m [1]

(ii) Record the reading of current on the ammeter, ***I***.

Mark for instrument's precision and unit (0.40 – 1.00 A) (2 d.p., A)

I = ... [1]

(b) Open the switch. Disconnect the jockey from the resistance wire.

Connect the voltmeter across the two ends of the battery.
Record the reading of electromotive force (e.m.f.) on the voltmeter, ***V***.

Mark for instrument's precision and unit (2.40 – 3.20 V)
(2d.p., nearest 0.05, V)

V = ... [1]

(c) Calculate the value of 1/***L***.

Mark for correct working, answer, unit and s.f. (m^{-1})

1/***L*** = ... [1]

(d) Quantities ***I*** and ***L*** are related by the equation

$$I = \frac{V}{L \times R_w} + \frac{V}{R_1}$$

where
I is the current in the circuit,
V is the e.m.f. of the battery,
L is the position of the jockey on the resistance wire (in metres)
$\boldsymbol{R_w}$ is the resistance of the full 1.000 m length of resistance wire,
$\boldsymbol{R_1}$ is the resistance of resistor **R**.

Using the same apparatus provided as the above experiment, plan an experiment to determine the values of $\boldsymbol{R_w}$ and $\boldsymbol{R_1}$.

Your plan should include:

- a description of how you would perform the experiment,
- one precaution taken to ensure the accuracy of your experiment,
- a statement of the graph that you would plot to test the relationship,
- a sketch of the graph that you would expect to obtain,
- an explanation of how you would obtain a value of the constant $\boldsymbol{R_w}$ and $\boldsymbol{R_1}$ from your graph if the suggested relationship is correct.

[6]

....

....

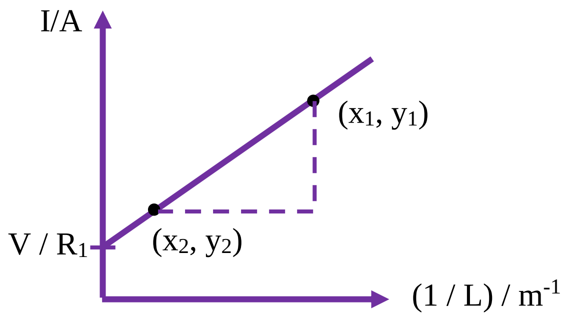
....

....

1. Set up the apparatus according to Fig. 2.1.
2. Repeat step (a) 7 times for varying positions of the jockey, L, according to values stated in the table drawn below.
3. For each value of L, calculate 1/L.
4. Tabulate your measurements of L and I, and the calculations of 1/L in a table similar to the one below.

L / m	(1 / L) / m^{-1}	I / A
0.150		
0.300		
0.450		
0.600		
0.750		
0.900		

5. Any 1 will do:
   - Close the switch only when taking readings, and let the circuit cool for a short while before each reading is taken so that changes in resistance due to heating effect is reduced, in order to obtain more accurate I readings.
   - Hold the jockey perpendicular to the resistance wire when pressing down on it so that the contact point is precisely at the measured value of L.
   - apply gentle pressure on the jockey when making contact with the resistance wire, enough to have good electrical contact, but not so hard to deform the malleable resistance wire or cause kinks, which would affect the resistance of the wire. This will give more accurate readings of I.
6. Plot a graph of I/A against (1/L)/m^{-1}.
7. This a sketch of the expected graph:



8. Repeat step (b) to obtain the value of the e.m.f. of the circuit, **V**.
9. To find the value of $\boldsymbol{R_w}$, select two coordinates from the best fit line of your plot, and calculate the gradient using the equation: gradient = (y1-y2)/(x1-x2).
   Since V / $\boldsymbol{R_w}$ = gradient, calculate $\boldsymbol{R_w}$ using $\boldsymbol{R_w}$ = V / gradient.
10. To find $\boldsymbol{R_1}$, read off the y-intercept directly from your best fit line.
    Since V / $\boldsymbol{R_1}$ = y-intercept of your graph, calculate $\boldsymbol{R_1}$ = V / y-intercept.
    (alternatively, instead of reading off y-intercept: substitute one of the selected coordinates (x1, y1) and the calculated gradient of your graph into the equation $y1 = (x1)(gradient) + c$, and calculate for c. $\boldsymbol{R_1}$ = c)

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

Section B

3 *In this experiment, you will investigate how the time taken for the different lengths of the wool holding the rotating tube momentarily come to rest.*

You are provided with:

- a pair of wooden blocks
- a retort stand,boss and clamp
- a hollow tube with groove in the middle and a mark at one end
- a wool string tied to the hollow tube
- a metre rule.

In this experiment, a tube is suspended from a length of wool. The tube will be rotated. You will investigate how the time taken for the rotating tube to momentarily come to rest dependson the length of the wool holding the tube.

Attach the wool to the middle of the tube making use of the groove on the tube to position the wool correctly. Clamp the other end of the wool securely using the two wooden blocks. The length ***l*** should be 50 cm, as shown in **Fig. 3.1**.

Assemble the apparatus as shown in **Fig. 3.1**.

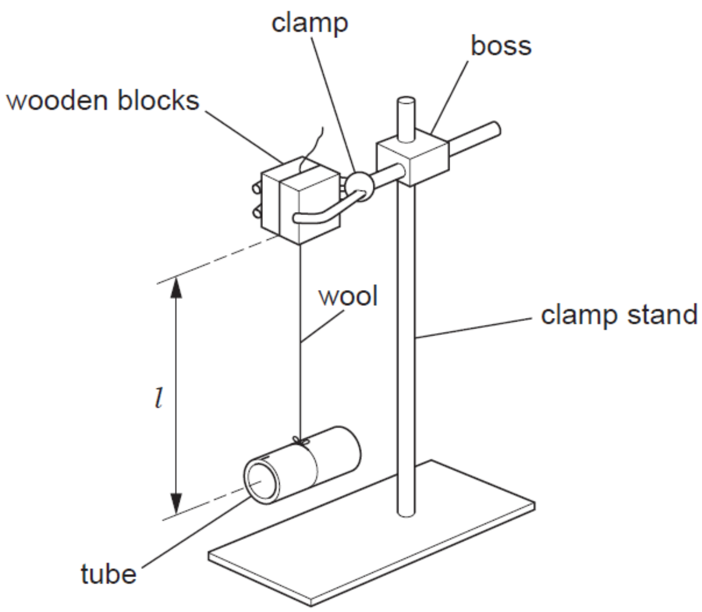


Fig. 3.1

The distance from the bottom of the wooden blocks to the centre of the hollow tube is ***l***. Loosen the clamp and adjust the wool string until ***l*** is equal to 50 cm. Tighten the clamp.

(a) Record the length of the wool string from the bottom of the wooden blocks to the centre of the hollow tube.

(i)

50.0 cm
(Precision and Unit)

l = ...

[1]

(a) **(ii)** Explain one difficulty in obtaining an accurate value for ***l***.

It is difficult to measure the exact length of ***l*** from the center of the tube to the required length as the ruler could not be placed exactly next to the suspended string.

....

[1]

Keeping the wool taut and the tube horizontal, turn the tube through ten complete turns in order to twist the wool, as shown in **Fig. 3.2**.

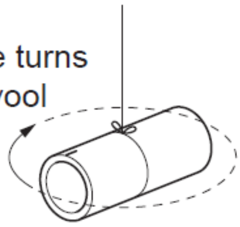


Fig. 3.2

The mark at one end of the tube is to help you count complete turns.

When you release the tube, the wool will untwist and then twist again, before coming to rest momentarily. It will then untwist in the other direction.

(b) Release the tube, and record the time ***t*** taken for the tube to come to rest momentarily for the first time. Determine an accurate value for the time ***t***.

t_1 = 29. 2 s
t_2 = 30.6 s

t_{ave} = (29.2 + 30.6) / 2 = 29.9 s

Mark for correct working, instrument's precision and unit.

29.9 s
(Precision and Unit)

t = ...

[3]

(c) Change ***l*** and repeat the experiment until you have five sets of values for ***l*** and ***t***. The length ***l*** of the string from **Fig. 3.1** should be in the range 10 cm to 50 cm.

Include the values of $\sqrt{l}$ in your table of results.

Record all of your measurements and calculations in your table. [5]

l/cm	$\sqrt{l}/cm^{1/2}$	t_1/s	t_2/s	t_{ave}/s
10.0	3.16	14.2	15.2	14.7
20.0	4.47	21.0	21.0	21.0
30.0	5.48	23.3	25.1	24.2
40.0	6.32	27.6	26.8	27.2
50.0	7.07	29.2	30.6	29.9

Trend: As length ***l*** increases, time ***t*** also increases. [A1]
Range length *l*: From 10 cm to 50 cm [A1]
Column headings with correct/appropriate units (solidus is expected) & no units in the Table. [A1]
Correct significant figures when calculating $\sqrt{l}$ from the value of ***l***. [A1]
Record length ***l*** and time ***t*** with the ***correct instruments'precision***. [A1]

(d) Using the grid provided,

(i) plot a graph of ***t*** against $\sqrt{l}$. Draw the line of best fit. [5]

(ii) determine the gradient and y-intercept of this line.

Gradient = $\frac{29.0-19.4}{6.90-4.00}$ = 3.31
Working shown with correct s.f answer, coordinates obtained from graph

Obtain y-intercept, substitute coordinates (6.90, 29.0) into equation y = mx + C,

29.0 = (3.31) (6.90) + C
C = 6.16 s
y-intercept correctly read from graph or calculated using correct read-offs.

- include ***unit*** for the y-intercept.
- give the y-intercept to the correct ***precision of the graph***.
- In order for candidates to be able to read from the y-axis, the graph must start from zero at the x-axis.

(e) Describe **one** improvement to the experiment that reduce experimental error.

- Measure the diameter of the tube using a digital caliper, then find the radius of the tube and add that to the length of the string from the top of the tube to the point where the wooden block clamped onto the string to give a more accurate value of length $\boldsymbol{l}$.

- Place the metre ruler vertically beside the suspended string with the tube. Then use a set square to align at the bottom of the wooden blocks (record the initial length $\boldsymbol{l_i}$) and at the centre point of the tube (record the final length $\boldsymbol{l_f}$). Then find the actual length $\boldsymbol{l} = \boldsymbol{l_f} - \boldsymbol{l_0}$.

- Use a solid tube or paste paper at the ends of the hollow tube, then we can mark the centre of the tube so that we can measure the length $\boldsymbol{l}$ more accurately, from the bottom of the blocks to the centre of the tube.

Any other possible improvements.

Axes

- Correct axes labels:
  → t on y-axis
  → $\sqrt{l}$ on x-axis
- Include units after a "/"
- ***No squiggly lines***

Scale

- Total area of the graph from first data point to last data point is at least 4 big squares wide and 6 big squares tall
- ***No odd scales***
  (e.g. 3, 6, 7, 9, 11)
- ***Scale is consistent throughout each axis***

Points

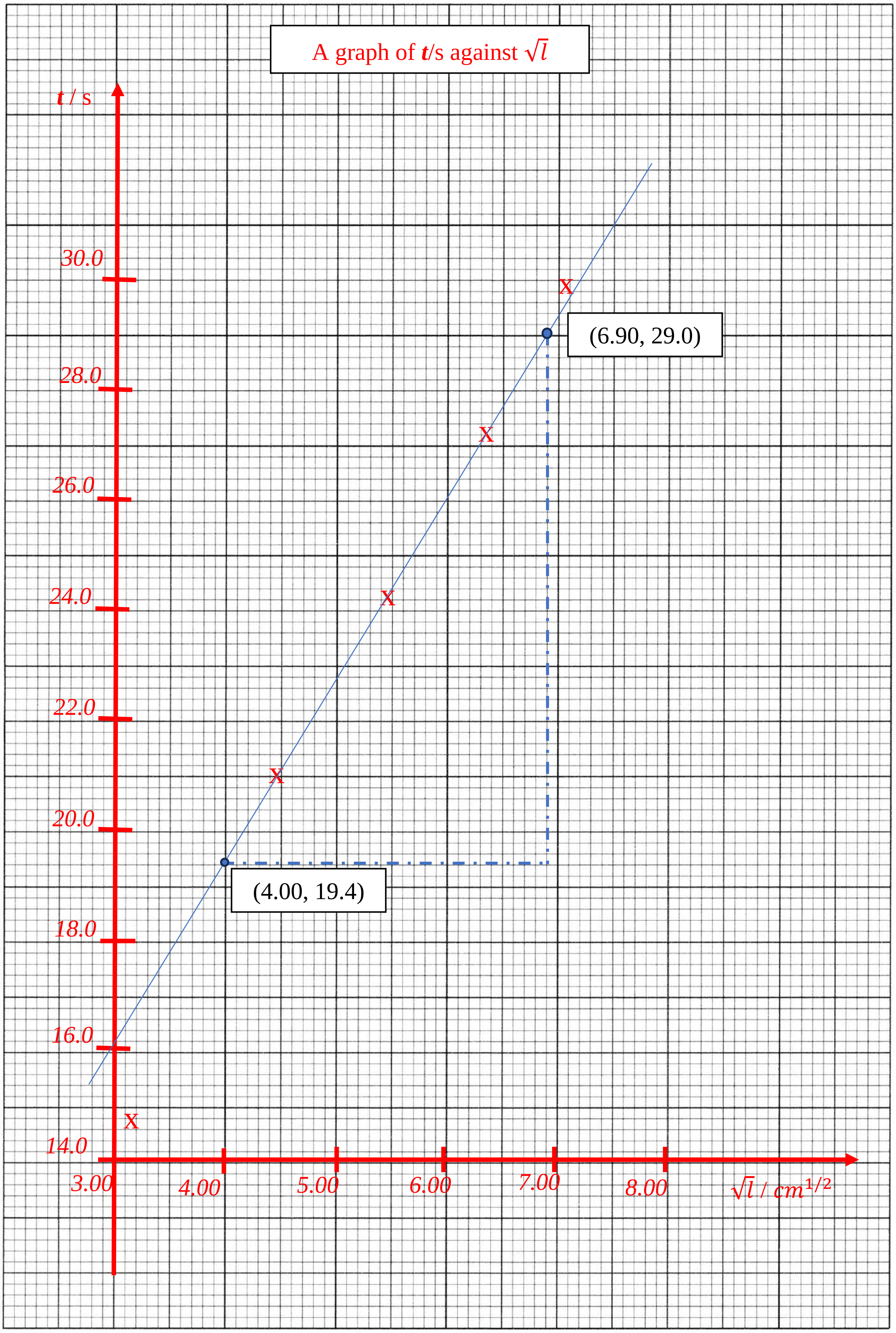
- Points are labelled to the nearest half of smallest square accuracy
- Points are correctly marked
- ***Points are marked with a small but visible "x"***

Line

- approximately equal no. of points above and below line of best fit
- the distance between data points and the line are minimised
- anomalous points are circled and labelled "anomalous" and ignored when choosing line of best fit.

Evidence

- ***Mark two points on the best fit line with a dot '.' And not a 'x'.***
- These two points are the coordinates selected on the line to determine the gradient of the best fit line.
- Using these two points, draw the triangle. Triangle must 'cover' at least ¾ of the line with the 5 plotted points of the best-fit line.
- ***State the coordinates to the correct precision of the graph.***


A graph of t/s against $\sqrt{l}$
t / s
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
3.00
4.00
5.00
6.00
7.00
8.00
$\sqrt{l}$ / $cm^{1/2}$
(6.90, 29.0)
(4.00, 19.4)