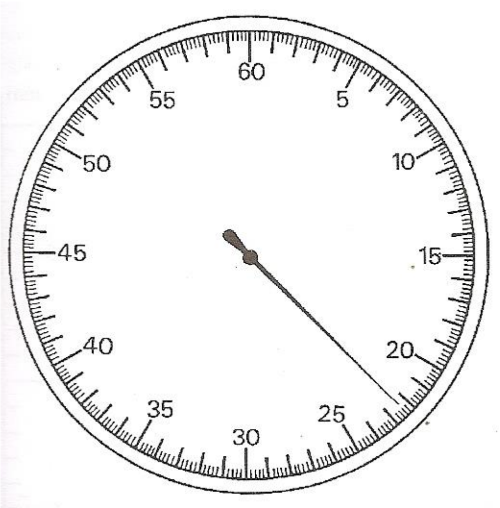
Name: ____ Class: ________ Date: ___________

Sec 3 Physics

Worksheet 1: Basic Ideas in Physics

Multiple Choice Questions

1. A stopwatch hand stops in the position as shown.



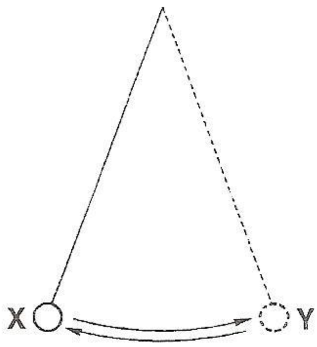
What is the reading?

A 21.2 s
B 22.4 s
C 27.6 s
D 32.0 s
E 38.0 s

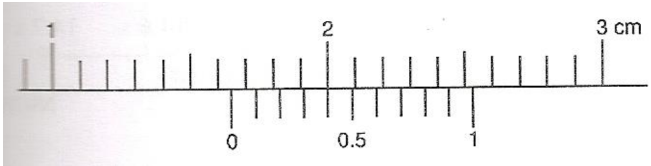
N92/I/1

2 It takes 13.8 s for a pendulum to swing from X to Y and back again twenty times.
What is the period of the pendulum?

A 0.345 s
B 0.690 s
C 1.38 s
D 4.60 s
E 13.8 s



3 A student used a vernier caliper to measure the diameter of a wooden cylinder. The diagram shows an enlargement of the calipers scale.



What was the reading recorded?

A 2.40 cm **B** 1.64 cm
C 0.62 cm **D** 0.42 cm

4 A student has been asked to calculate the volume of a piece of wire, which is about 80 cm long and about 0.2 cm in diameter.

Which of the following instruments should the student use?

	Length		**Diameter**
A	Metre rule		Micrometer
B	Metre rule		Vernier calipers
C	Micrometer		Vernier calipers
D	Vernier calipers		Micrometer

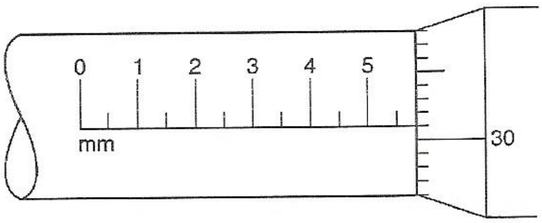
N97/I/1

5 Which of the following physical quantity is measured using a micrometer?

A current **B** length
C time **D** weight

N98/I/1

6 The diagram shows part of a micrometer screw gauge.

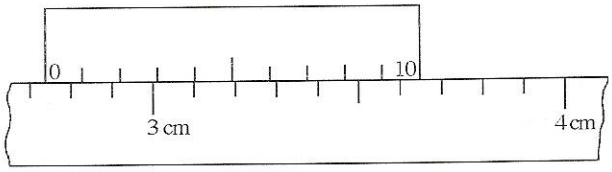


What is the reading shown?

A 5.31 mm **B** 5.79 mm
C 5.81 mm **D** 6.31 mm

N91/I/2

7 The diagram shows part of the vernier scale on a pair of calipers.

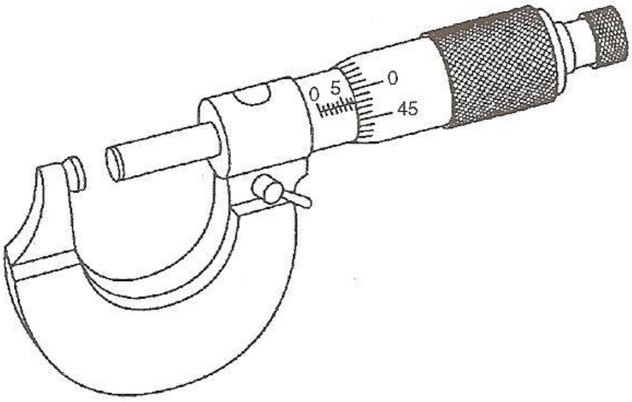


Which reading is correct?

A	2.74 cm	**B**	3.10 cm
C	3.26 cm	**D**	3.64 cm

N99/I/1

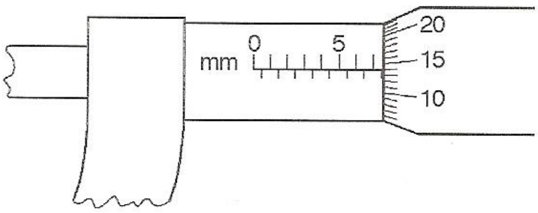
8 The diagram shows a micrometer screw gauge. What is the reading shown?



A	5.25 mm	**C**	7.02 mm
B	5.48 mm	**D**	7.48 mm

N2000/I/1

9 The diagram shows a micrometer scale.

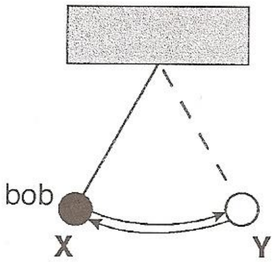


Which reading is shown?

A	5.64 mm	**C**	7.16 mm
B	7.14 mm	**D**	7.64 mm

N2002/I/1

10

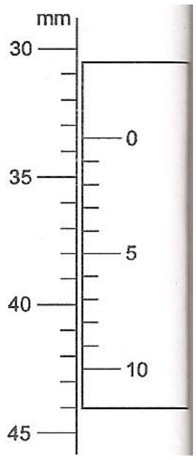


One oscillation of a swinging pendulum occurs when the bob moves from **X** to **Y** and back to **X** again.
Using a stopwatch, which would be the most accurate way to measure the time for one oscillation of the pendulum?

A Time 20 oscillations and multiply by 20.
B Time 20 oscillations and divide by 20.
C Time one oscillation.
D Time the motion from **X** to **Y** and double it.

N2003/I/1

11 The diagram shows part of a vernier scale.
What reading is correct?



A 30.5 mm
B 33.5 mm
C 38.0 mm
D 42.5 mm

N2004/I/1

Discussion Questions

1 Fill up the table with the appropriate formulas and units:

Derived Quantity	**Formula**	**S.I. unit**	**Another common unit**
Area of a rectangle	length × width	m^2	cm^2
Density	$\frac{\text{mass}}{\text{volume}}$	$kg\ m^{-3}$	$g\ cm^{-3}$
Average speed	$\frac{\text{total distance}}{\text{total time}}$	$m\ s^{-1}$	$km\ h^{-1}$

2 Fill in the blanks with units of the appropriate prefixes.

(a) 1 kg = 10^3 g

(b) 1 μs = 10^{-6} s

(c) 1 mA = 1×10^{-3} A

(d) 1 GW = 10^9 W

3 When using the Vernier callipers,

(a) state two precautions you would take in order to make your determination of the diameter of a coin as accurate as possible.

Check zero reading and incorporate it into the measurement if necessary;

Obtain several readings of its diameter (by rotating the coin) and calculate the average value;

(b) state two advantages of using this instrument compared with using a rule reading in millimetres for making this measurement.

Jaws can close around the round object properly, making the measurement of the diameter easier;

More precise measurement as precision is up to ±0.01 cm. Ruler can only measure up to ±0.1 cm.

4 When using the micrometer screw gauge, state the purpose of the ratchet.

Ratchet prevents the user from exerting too much pressure on the object to be measured.

5 A pile of 500 sheets of paper has a mass of 2.0 kg. The pile is 300 mm long, 200 mm wide, and 50 mm thick. Calculate

(a) the thickness of one sheet;

$$\text{Thickness} = \frac{50\times10^{-3}}{500} = 1\times10^{-4}\ \text{m}\ \ (1\ \text{s.f.})$$

(b) the mass of one sheet;

$$\text{Mass of 1 sheet} = \frac{2.0}{500} = 4\times10^{-3}\ \text{kg}$$

(c) the volume of the pile;

$$\text{Volume of the pile} = 300\times200\times50\times10^{-9} = 3\times10^{-3}\ \text{m}^3$$

(d) the density of the paper;

$$\text{Density} = \frac{2}{3\times10^{-3}} = 7\times10^{2}\ \text{kg m}^{-3}$$

(e) the mass of a one-square-metre sheet of this paper.

$$\text{mass} = \left(7\times10^{2}\ \text{kg m}^{-3}\right)\left(1\ \text{m}^2\right)\left(1\times10^{-4}\ \text{m}\right) = 7\times10^{-2}\ \text{kg}$$

[Avison]

6 When a block of metal is hung in air from a spring balance, the reading is 9.6 N.

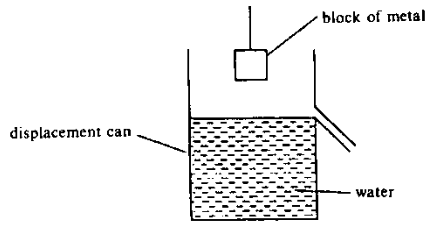
(a) What is the weight of the block of metal?

$Weight = 9.6\ \text{N}$

(b) Assuming that the weight of a 1.0 kg mass is 10 N, calculate the mass of the block of metal?

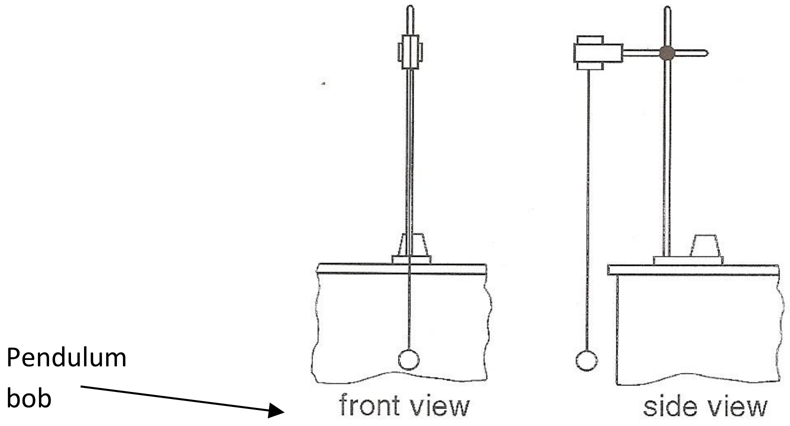
0.96 kg

(c) The figure shows a displacement can which has been filled with water. When the block of metal in **(a)** is lowered into the can until it is totally immersed in the water, 110 cm^3 of water overflows. Calculate the density of the metal.



$$Density = \frac{960 \text{ g}}{110 \text{ cm}^3} = 8.7 \text{ g cm}^{-3} \text{ or } 8700 \text{ kg m}^{-3}$$

7 The following figure shows a simple pendulum suspended from a clamp.



(a) Describe briefly how you would use a stopwatch or a stopclock to determine, as reliably as possible, the period of oscillation of a pendulum.

(b) A student obtains the following values for the time for 20 complete oscillations of a pendulum.

14.6 s	14.7 s	14.5 s	14.6 s	14.7 s

Determine the period of the pendulum.

$$\text{Period} = \frac{14.6 + 14.7 + 14.5 + 14.6 + 14.7}{20 \times 5} = 0.731 \text{ s}$$

20 and 5 in the denominator are exact numbers.

N97/II/1

Further Questions

(i) In a simple pendulum, what is the physical quantity that determines the period *T* of the oscillation? What is the relationship between *T* and that quantity?

Length of the pendulum. $T \propto \sqrt{L}$ or $T = 2\pi\sqrt{\frac{L}{g}}$

(ii) One important consideration when doing a pendulum experiment is to ensure that the maximum angle of swing must not exceed 10°. What is the reason for it?

The relationship in (i) is only valid for small angles.

(iii) Imagine you are explaining what it meant by an oscillation of the pendulum to a Sec 1 student, how would you describe it?

(iv) Why do we need to repeat the timing several times?

Correct the human reaction time [??]. The human reaction time is slightly greater than 0.1s.

(v) What is the most significant source of error in this experiment?

The experimenter. Human reaction time.

(vi) The typical stopwatch used in the laboratory can measure up to centi or milliseconds. Should we take the readings to that level of precision?

No. The readings cannot be more precise than the error.

(vii) After a few swings, the amplitude of the oscillations becomes smaller as air resistance is dissipating energy from the pendulum. Will the period of the pendulum change in response?

No. The period of oscillation remains constant. It is dependent on the length of the pendulum only.

(viii) If the pendulum bob is changed to a more massive one, would the period *T* of the oscillation change?

As with the answer in part (vii), the period *T* will not change.

(ix) One way to improve on the readings of the period is to use a light-operated solid state switch instead of the human hand to start and stop the stopclock. The light switch is placed at the centre of the oscillation and will take note each time the bob passes in between the light switch. The light switch has a response time of a few nanoseconds. With reference to (vi), can we now take the readings to a milliseconds?

Yes, the response time (reaction time error) is now a million times smaller than the accuracy of the readings. We can take the readings to milliseconds.

8 In the opening scenes of the movie *Raiders of the Lost Ark*, Indiana Jones tried to remove a gold idol from a booby-trapped pedestal. He replaced the idol with a bag of sand of approximately the same volume (see picture on left).

(a) Calculate the ratio of the mass of the idol to the mass of the bag of sand.
(Density of gold = 19.32 g/cm^3; density of sand $\approx$ 2 g/cm^3.)

$$\frac{\text{Mass of idol}}{\text{Mass of sand bag}} = \frac{\rho_{idol}}{\rho_{sandbag}} = \frac{19.32}{2}$$
$$= 10$$

Ratio = ………………………

(b) Give a short explanation whether Jones will succeed in not activating the mass-sensitive booby trap?

Low chance of not springing the trap as the mass ratio is too large; *OWTTE*

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(c) In a later scene, he and an unscrupulous guide played catch with the idol. The volume of the idol was about 1.0 L (litre). If it were solid gold, what mass would the idol have?

$$\text{Mass} = \rho V = \left(\frac{19.32}{1000}\right)\left(1.0 \times 10^{3}\right)$$

$$= 19 \text{ kg}$$

Mass of idol = …………………….. kg

(d) Based on your answer in part **(c)**, explain if it is plausible for a typical man to play catch with the idol?

Not likely, 20 kg is too massive for a normal human to play catch;

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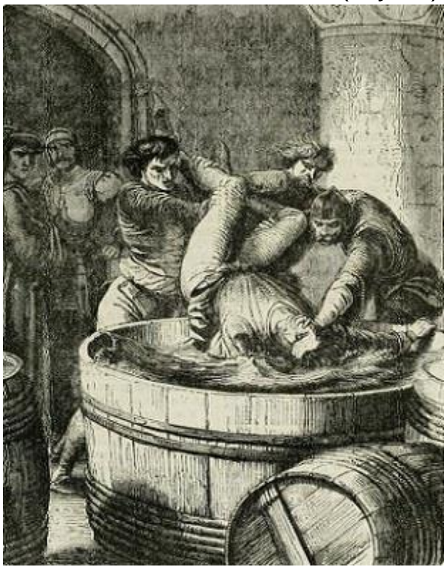
9 This question is about estimation. (SMTP)

In Shakespeare's *Richard III*, the First Murderer says:

"Take that, and that! [*Stabs Clarence*]
If that is not enough, I'll drown you in a malmsey butt within!"

In the space below, show relevant working (*with reasonable assumptions and estimates*) and conclude whether the unfortunate Clarence will drown?

Useful definitions:
1 butt $\approx$ 475 litres (historically)
malmsey is a foul brew similar to mead



Assuming this is a 3-mark question, this is how the marks can be allocated.

1 mark: Any valid estimate such as the height of the container / base area of container / cross section area of human being etc

1 marks: Any valid mathematical working showing the height of the liquid. This should be a two-step process.

E.g.:

estimate of minimum container base area
$= \text{shoulder width} \times \text{chest width}$
$= 1\text{ m} \times 0.5\text{ m} = 0.5\text{ m}^2$

An estimate of an Englishman's cross-sectional area.

$\Rightarrow \text{Height of malmsey in barrel} = \dfrac{0.5\text{ m}^3}{0.5\text{ m}^2} = 1\text{ m}$ $\quad (\because 1\text{ butt} \approx 475\text{ L} \approx 0.5\text{ m}^3)$

1 mark: Any valid conclusion based on the mathematical working. Other logical answers are premissible since drowning is possible even in basin if the head is pressed into the water.

As you can see, the answers are not exact because of the nature of the question. In many real-life examples, exact answers are not easy to find and estimates often form part of the final solutions to real-life problems.

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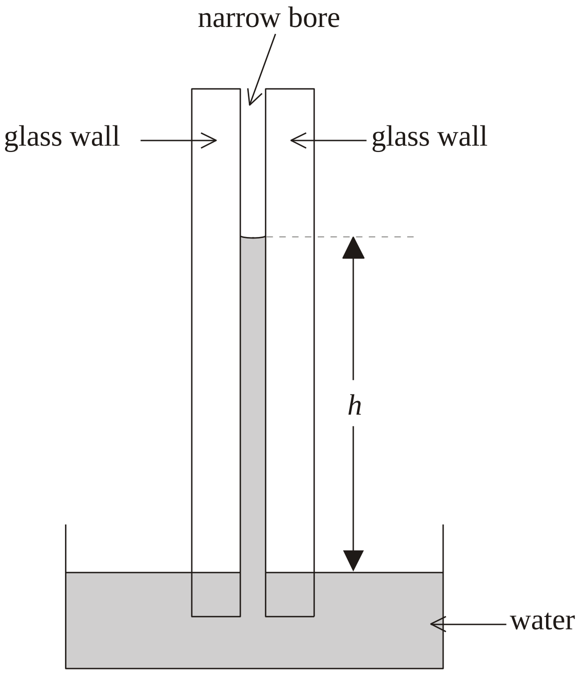
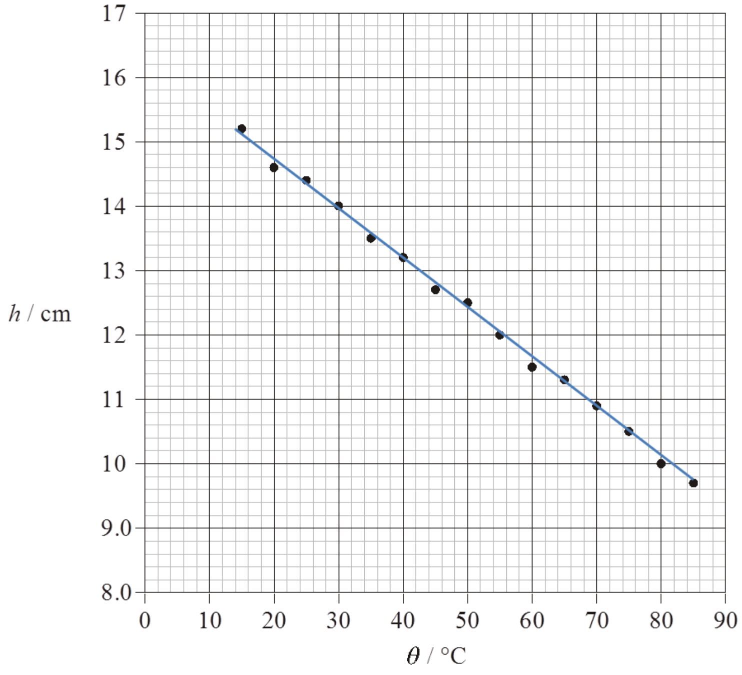
10 This question is about the rise of water in a capillary tube. (IB exam question)

A capillary tube is a tube that is open at both ends and has a very narrow bore. A capillary tube is supported vertically with one end immersed in water. Water rises up the tube due to a phenomenon called capillary action. The water in the bore of the tube forms a column of height h as shown below.



(a) The height h, for a particular capillary tube was measured for different temperatures of the water. The variation with temperature θ of the height h is shown below. Uncertainties in the measurements are not shown.



Marking points:

- sensible line of fit with reasonable distribution of points either side of line;

(i) On the graph above, draw a best-fit line for the data points. [1]

(ii) Determine the height h_0 of the water column at temperature $\theta = 0^{\circ}\mathrm{C}$.

h_0 = 16.2 ($\pm$ 0.2)cm;

[1]

(b) Explain why the results of this experiment suggest that the relationship between the height h and temperature θ is of the form

$$h = h_0(1 - k\theta)$$

where k is a constant

this is a straight-line graph so has equation of the form $y = mx + c$;

$h = h_0(1 - k\theta)$ gives $h = h_0 - h_0 k\theta$

Compare it with $y = mx + c$, we have

$m = -h_0 k$

$c = h_0$

essentially look for:
stating equation of a straight-line graph, showing that $h = h_0(1 - k\theta)$ *can be written in this form, identifying m and c.*

[4]

(c) Deduce that the value of k is approximately 4.8×10^{-3} °C^{-1}.

Method 1

$$k = \frac{\text{gradient of graph}}{h_0}$$

gradient of graph $= 0.077(\pm 0.003)$ [calculated by taking two points on best fit line]

$$\therefore k = \frac{0.077}{16.2} \approx 4.8 \times 10^{-3} \text{ °C}^{-1}$$

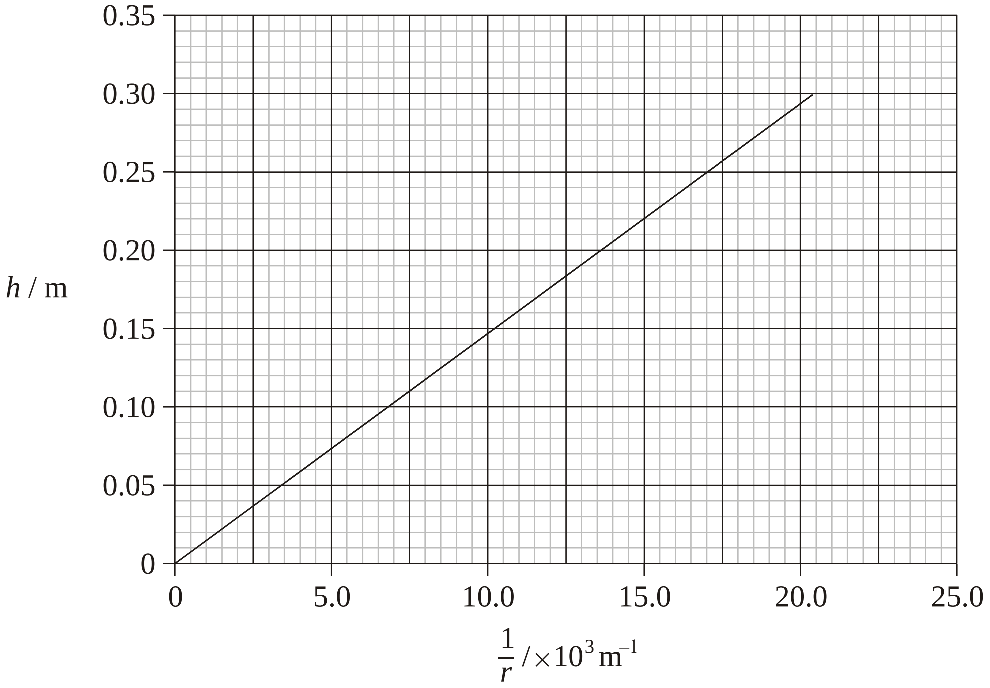
Method 2

Use the coordinates of a point on the best fit line, and substitute the numbers into $h = h_0(1 - k\theta)$.

Then make k the subject of the formula: $k = \frac{1}{\theta}\left(1 - \frac{h}{h_0}\right)$.

The final answer should lie between 4.6×10^{-3} to 4.9×10^{-3} °C^{-1} [3]

(d) The experiment is repeated using tubes with bores of different radii r but keeping the water temperature constant. The graph below shows the variation with $\frac{1}{r}$ of the height h for capillary tubes of different radii r for a water temperature of 20°C.



It is suggested that capillary action is one of the means by which water moves from the roots of a tree to the leaves. A particular tree has a height of 25 m.

Use the graph to estimate the radius of the bore of the tubes that would enable water to be raised by capillary action from ground level to the top of the tree. Comment on your answer.

Estimate: $\text{Gradient} = \frac{h}{1/r} \Rightarrow h = \frac{\text{Gradient}}{r}$

From graph, gradient $= 1.5(\pm 0.2) \times 10^{-5}$

$r = \frac{1.5 \times 10^{-5}}{25} = 6.0(\pm 0.8) \times 10^{-7}$ m

Comment: 10^{-7} m is too small to be the radius so it is unlikely that capillary action is the only mechanism / *OWTTE* / this assumes that the direct proportion holds for values of *h* up to 25m / *OWTTE*;

[4]