

Paper Reference(s) 9PH0/03

Pearson Edexcel Level 3 GCE

Physics

Advanced

Paper 3: General and Practical Principles in Physics

Monday 3 June 2019 – Afternoon

Time: 2 hours 30 minutes plus your additional time allowance

INSTRUCTIONS TO CANDIDATES

Write your centre number, candidate number, surname, other names and your signature in the boxes below. Check that you have the correct question paper.

Centre No.					
Candidate No.					
Surname					
Other names					
Signature					
Paper Reference	9	P	H	0	/ 0 3



- Use **BLACK** ink or ball-point pen.
- Answer **ALL** questions.
- Answer the questions in the spaces provided – there may be more space than you need.

MATERIALS REQUIRED FOR EXAMINATION

Ruler

ITEMS INCLUDED WITH QUESTION PAPERS

Separate sheet for use with Question 9(b)
Data, Formulae and Relationships Booklet

INFORMATION FOR CANDIDATES

- The total mark for this paper is 120.
- The marks for **EACH** question are shown in brackets – use this as a guide as to how much time to spend on each question.
- You may use a scientific calculator.
- In questions marked with an **ASTERISK (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

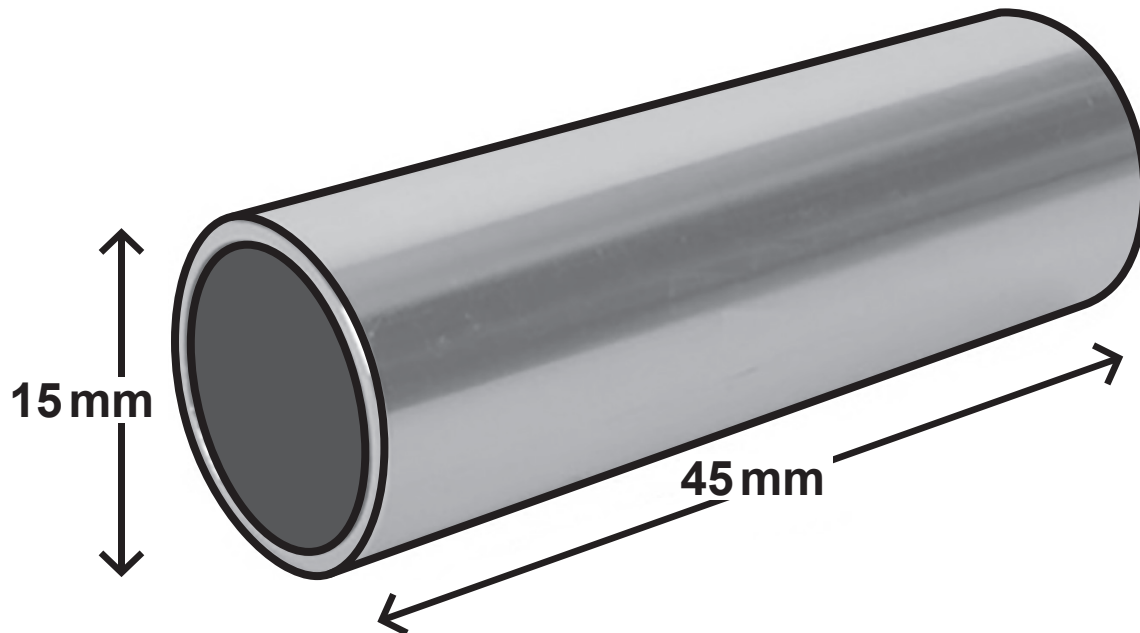
ADVICE TO CANDIDATES

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- You are advised to show your working in calculations, including units where appropriate.

(Turn over)

Answer ALL questions in the spaces provided.

- 1** An engineer was checking the dimensions of a steel tube. The tube had a length of about 45mm and an external diameter of about 15mm as shown.



She used a digital micrometer to measure the diameter of the tube. Before taking the reading she closed the jaws of the micrometer to check for a zero error.

- (a)** State the type of error she avoided by doing this.

(1 mark)

(Question continues on next page)

(Turn over)

- (b) Describe the procedure she should follow to determine an accurate value for the external diameter of the tube. (3 marks)**

(Question continues on next page)

(Turn over)

- (c) The engineer determined the length of the tube using the micrometer. The reading on the micrometer scale was 45.043 mm. She recorded the reading as 45.0 mm.
State why recording a reading of 45.043 mm could not be justified. (1 mark)

(TOTAL FOR QUESTION 1 = 5 MARKS)

(Questions continue on next page)

(Turn over)

- 2 A student determined the specific heat capacity of aluminium.**

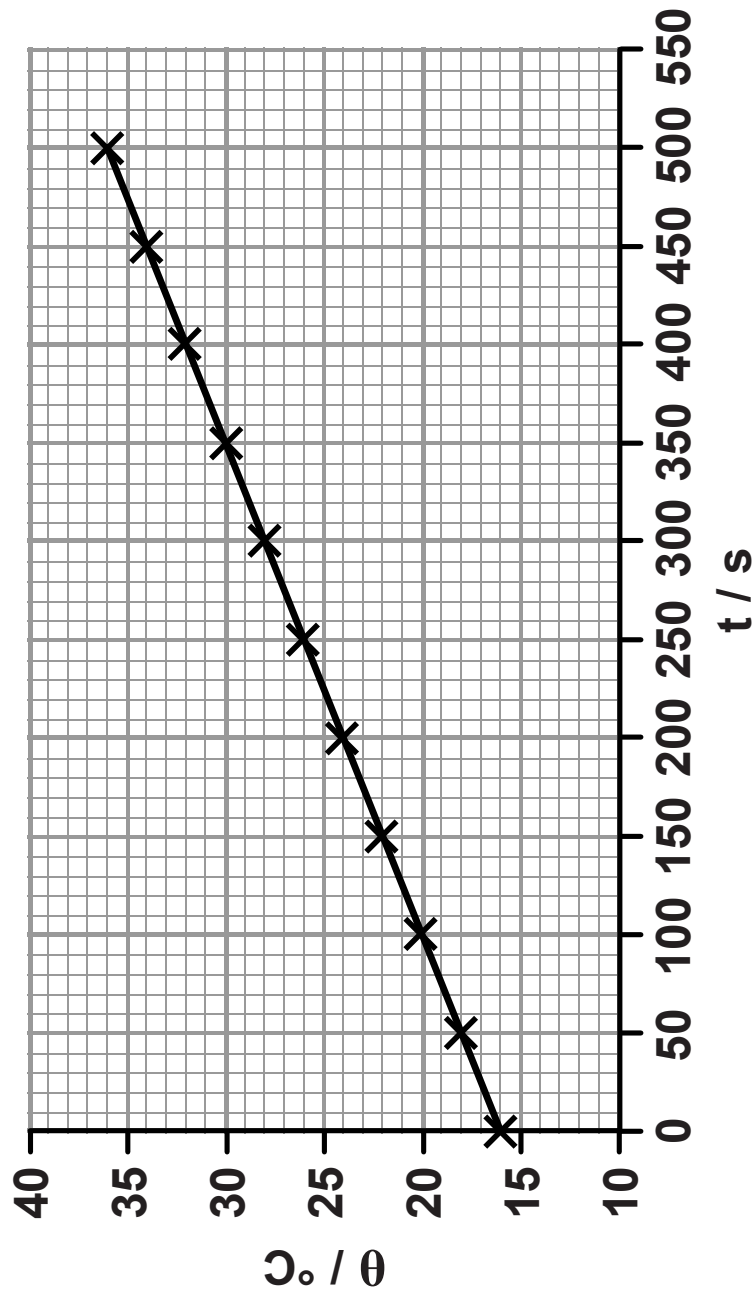
She used an electrical heater to heat an aluminium block and measured the temperature of the block with a digital thermometer.

- (a) She connected the electrical heater into a circuit and took measurements to determine the power of the heater.**

**Draw a circuit diagram of a suitable circuit.
(2 marks)**

- (b) The student monitored the temperature θ of the aluminium block over the time t for which the heater was switched on.

Her results are plotted on the graph.



(Question continues on next page)

(Turn over)

- (i) Determine the specific heat capacity of aluminium. (3 marks)

power of heater = 37.5 W

mass of aluminium block = 0.986 kg

Specific heat capacity of aluminium = _____

(Question continues on next page)

(Turn over)

- (ii) The student looked up the accepted value for the specific heat capacity of aluminium. Using this value, the student predicted that it should have taken 240 s for the temperature of the aluminium block to increase by 10°C .

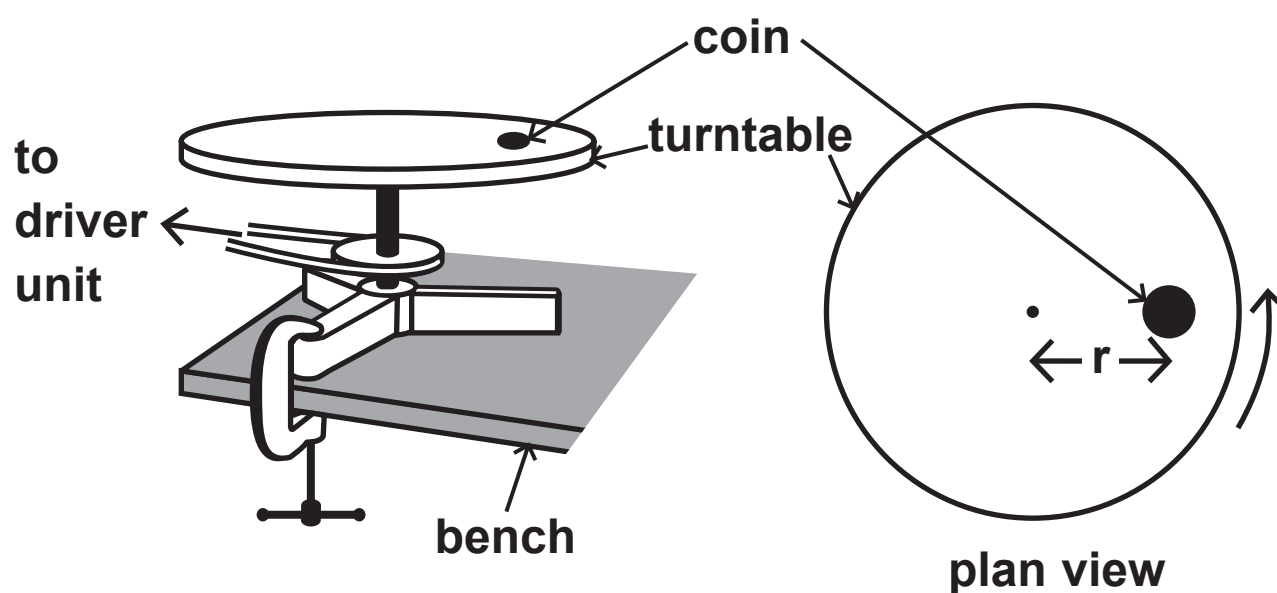
Explain the difference between the predicted time and the student's actual observations.

(2 marks)

(TOTAL FOR QUESTION 2 = 7 MARKS)

- 3 A student was investigating the forces involved in circular motion.

He placed a small coin on a horizontal turntable as shown. The turntable was connected to a driver unit so that it could be rotated at a constant rate.



(Question continues on next page)

(Turn over)

- (a) The student measured the distance r between the centre of the turntable and the centre of the coin, with a metre rule as shown.



(Question continues on next page)

(Turn over)

Explain why the percentage uncertainty in the value of r is about 1%.

Your answer should include a calculation.

(3 marks)

(Question continues on next page)

(Turn over)

- (b) The student switched on the driver unit and increased the rate of rotation until the coin slid off the turntable. He read the angular velocity ω of the turntable from a digital display on the driver unit. He then replaced the coin in the original position on the turntable and repeated the procedure.

His results are shown.

$\omega / \text{rad s}^{-1}$				
0.125	0.112	0.118	0.123	0.116

- (i) The student used the results to calculate a mean value of ω .

State the purpose of calculating a mean.

(1 mark)

(Question continues on next page)

(Turn over)

- (ii) Calculate the percentage uncertainty in the mean value of ω . (3 marks)

Percentage uncertainty = _____

(Question continues on next page)

(Turn over)

- (iii) The student used ω and r to calculate the centripetal acceleration of the coin at the instant it started to slide.

Calculate the percentage uncertainty in this centripetal acceleration. (3 marks)

Percentage uncertainty = _____

(Question continues on next page)

(Turn over)

- (c) The student repeated the procedure with different values of r .

Explain how the value of ω at which the coin started to slide varied as r increased. (3 marks)

(TOTAL FOR QUESTION 3 = 13 MARKS)

(Questions continue on next page)

(Turn over)

- 4 A student carried out an experiment to determine the focal length of a converging lens.**

He placed the lens a distance u from an illuminated object. He placed a screen on the other side of the lens and moved the screen until a sharp image of the object was produced. He measured the corresponding image distance v .

The student repeated the procedure for four more values of u .

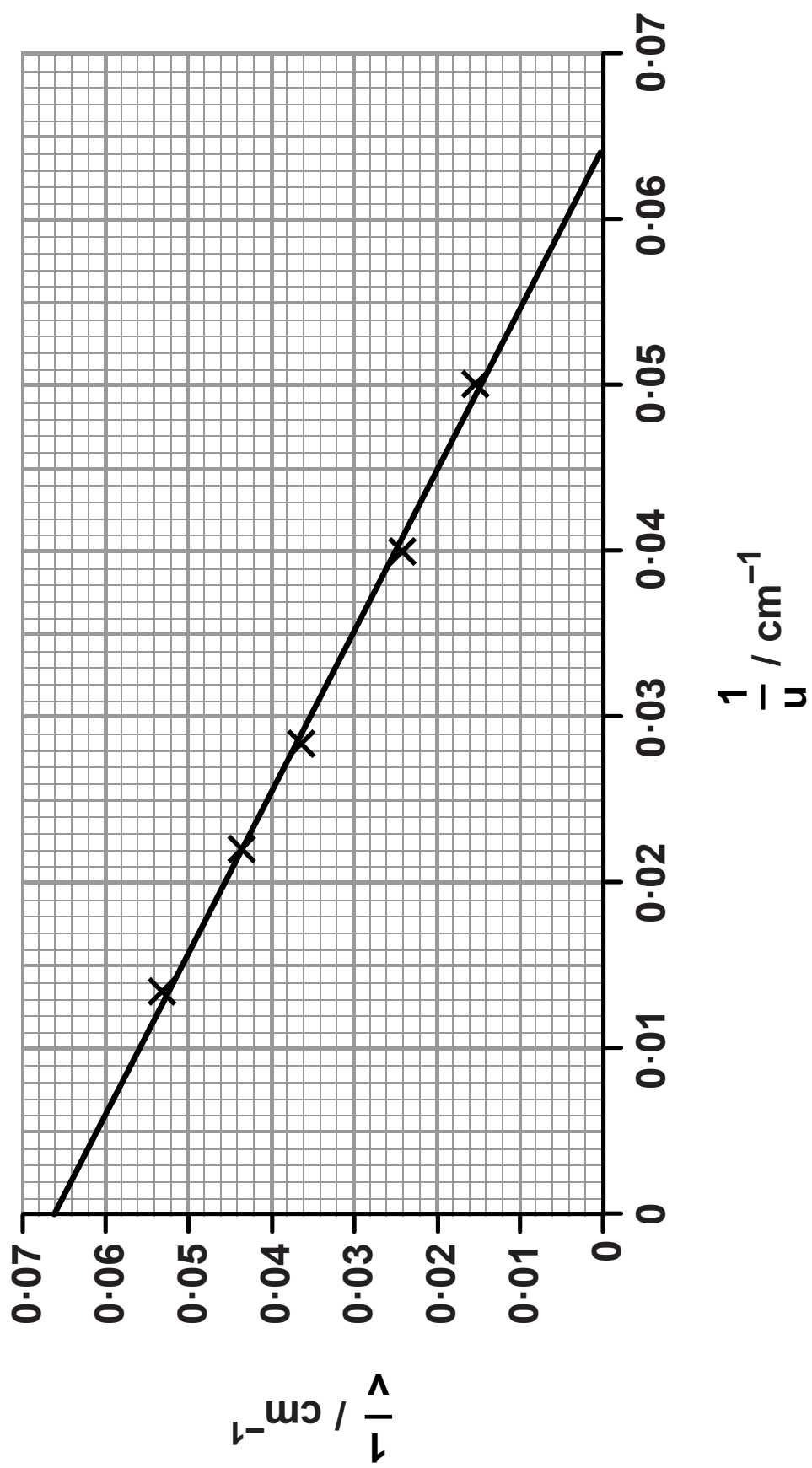
In his lab report he wrote:

“I made an initial determination of the focal length of the lens and concluded that it was about 15 cm. When I plotted a graph it confirmed my initial determination of the lens focal length.”

The student’s graph is shown on page 18.

(Question continues on next page)

(Turn over)



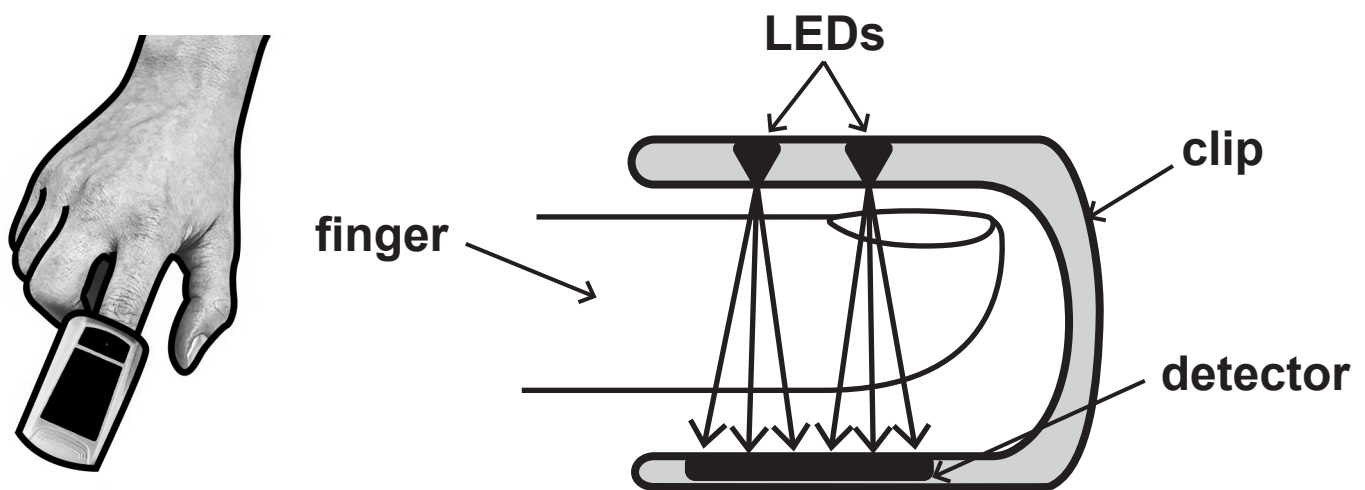
(Question continues on next page)

(Turn over)

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 5 An oximeter is a device used in hospitals to monitor the oxygen level in a patient's blood.

In an oximeter, two light-emitting diodes (LEDs) are mounted opposite light sensors in a clip and attached to the patient's finger. One of the LEDs produces red light and the other produces infrared.



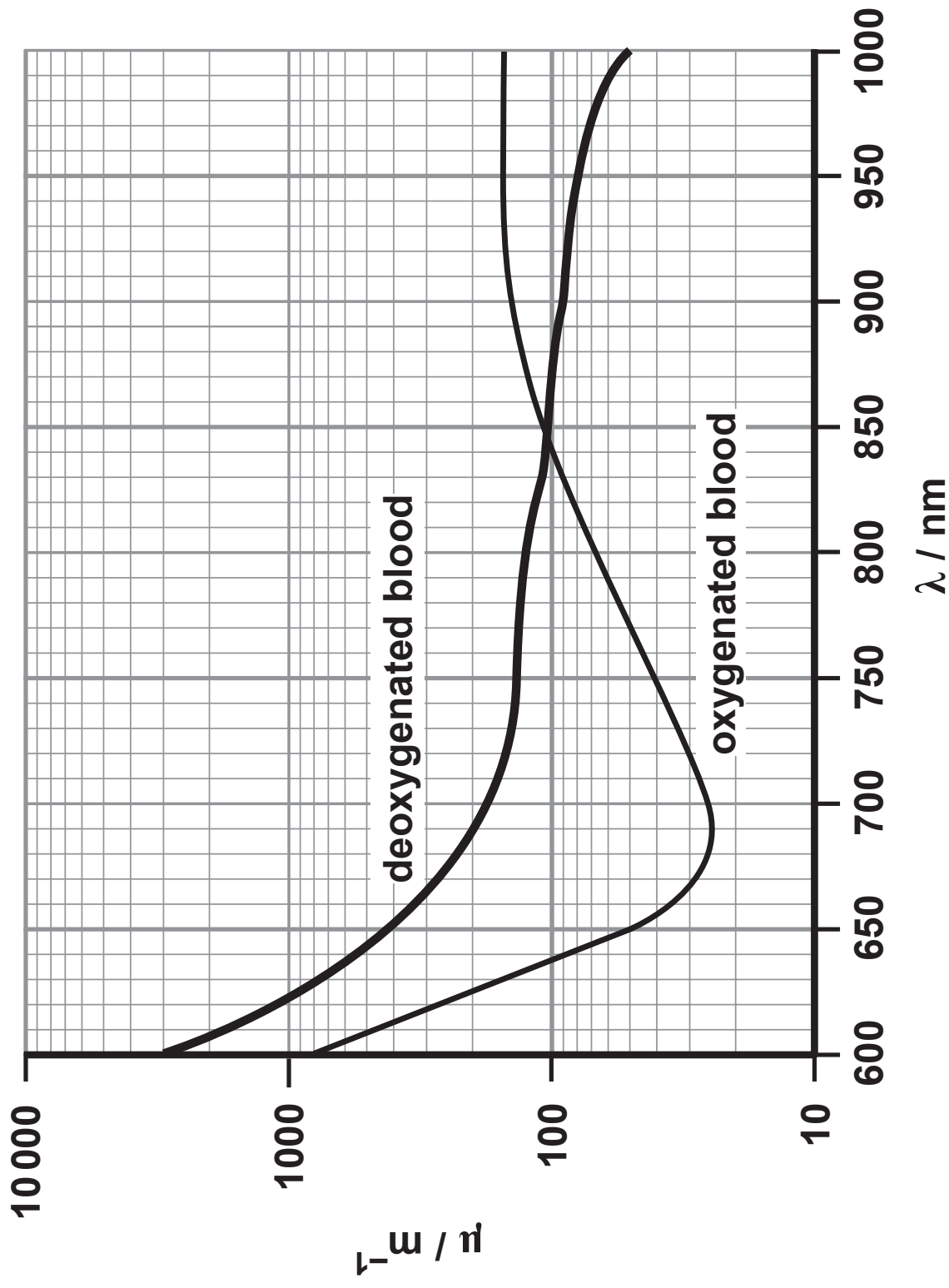
The intensity I of electromagnetic radiation received by the detector, after passing through a thickness x of blood, is given by

$$I = I_0 e^{-\mu x}$$

where I_0 is the intensity that would have been received if the blood were not present and μ is the attenuation coefficient of blood.

The red LED emits visible light of wavelength 650 nm and the infrared LED emits infrared of wavelength 950 nm.

The graph shows how μ varies with wavelength λ for oxygenated blood and deoxygenated blood.



(Question continues on next page)

(Turn over)

(a) I_0 for the infrared LED is 1.8 W m^{-2} .

Calculate I for the infrared after passing through
1.4 mm of oxygenated blood. (3 marks)

$I =$ _____

(Question continues on next page)

(Turn over)

- (b) The oximeter determines I/I_0 the fraction of radiation transmitted at each wavelength.

Deduce whether I/I_0 will be smaller for the red or the infrared radiation if the blood is deoxygenated.

(3 marks)

(Question continues on next page)

(Turn over)

It is suggested that ambient light could affect the readings produced by the oximeter.

Halogen lamps have a filament temperature of 3200 K.

(c) Deduce whether the light from such a lamp would have a significant effect on the oximeter readings.

(3 marks)

(TOTAL FOR QUESTION 5 = 9 MARKS)

(Questions continue on next page)

(Turn over)

6 In 1990, the Hubble Space Telescope (HST) was launched into a low Earth orbit above the Earth's atmosphere.

(a) HST orbits the Earth in a circular orbit with a speed of 7.59 km s^{-1} .

mass of Earth = $5.97 \times 10^{24} \text{ kg}$

radius of Earth = $6.37 \times 10^6 \text{ m}$

(i) Show that the height of HST above the surface of the Earth is about $6 \times 10^5 \text{ m}$. (3 marks)

- (ii) Calculate the increase in the gravitational potential energy as HST is raised, from its initial position at the Earth's surface, to its orbital height. (2 marks)

mass of HST = 11 600 kg

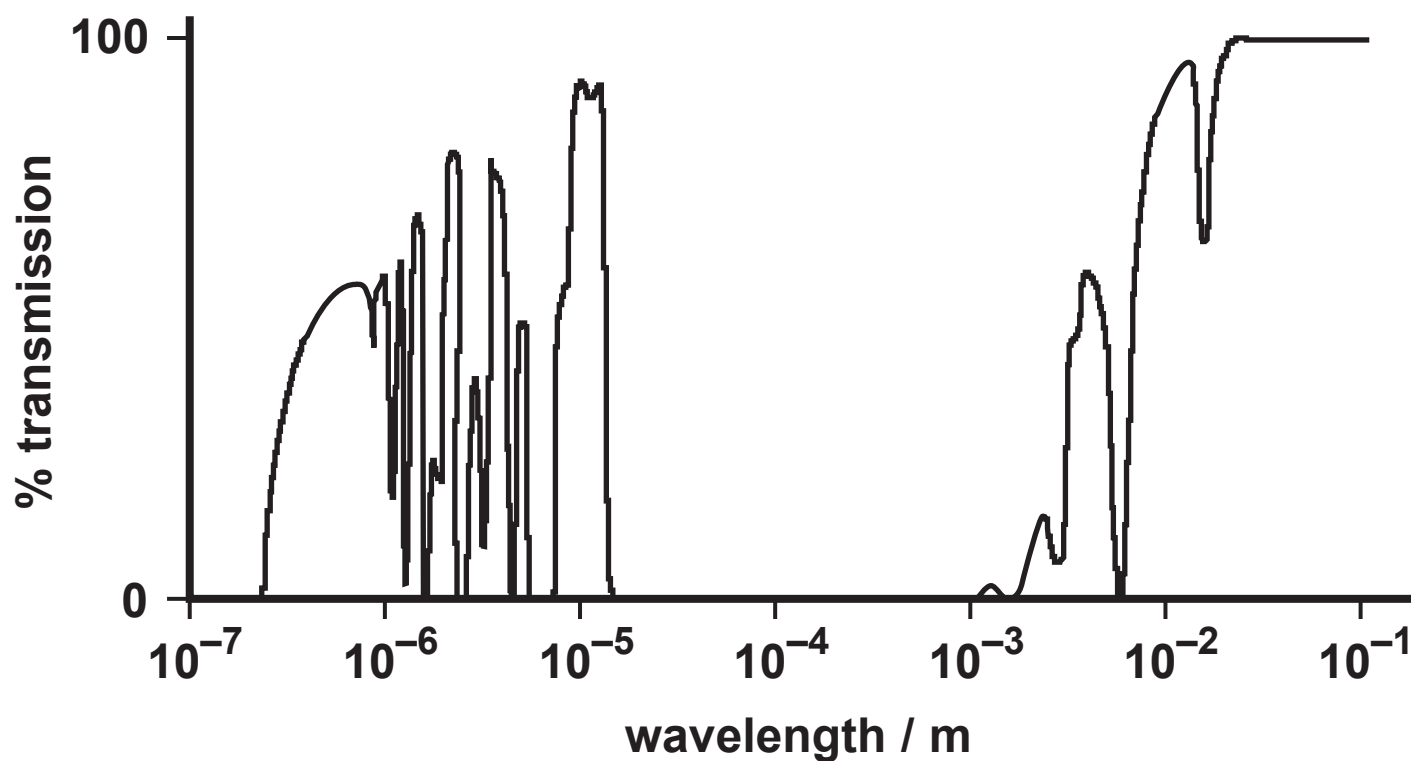
Increase in gravitational potential energy = _____

(Question continues on next page)

(Turn over)

[illegible]

(b) The transmission of electromagnetic radiation through the atmosphere is shown on the graph.



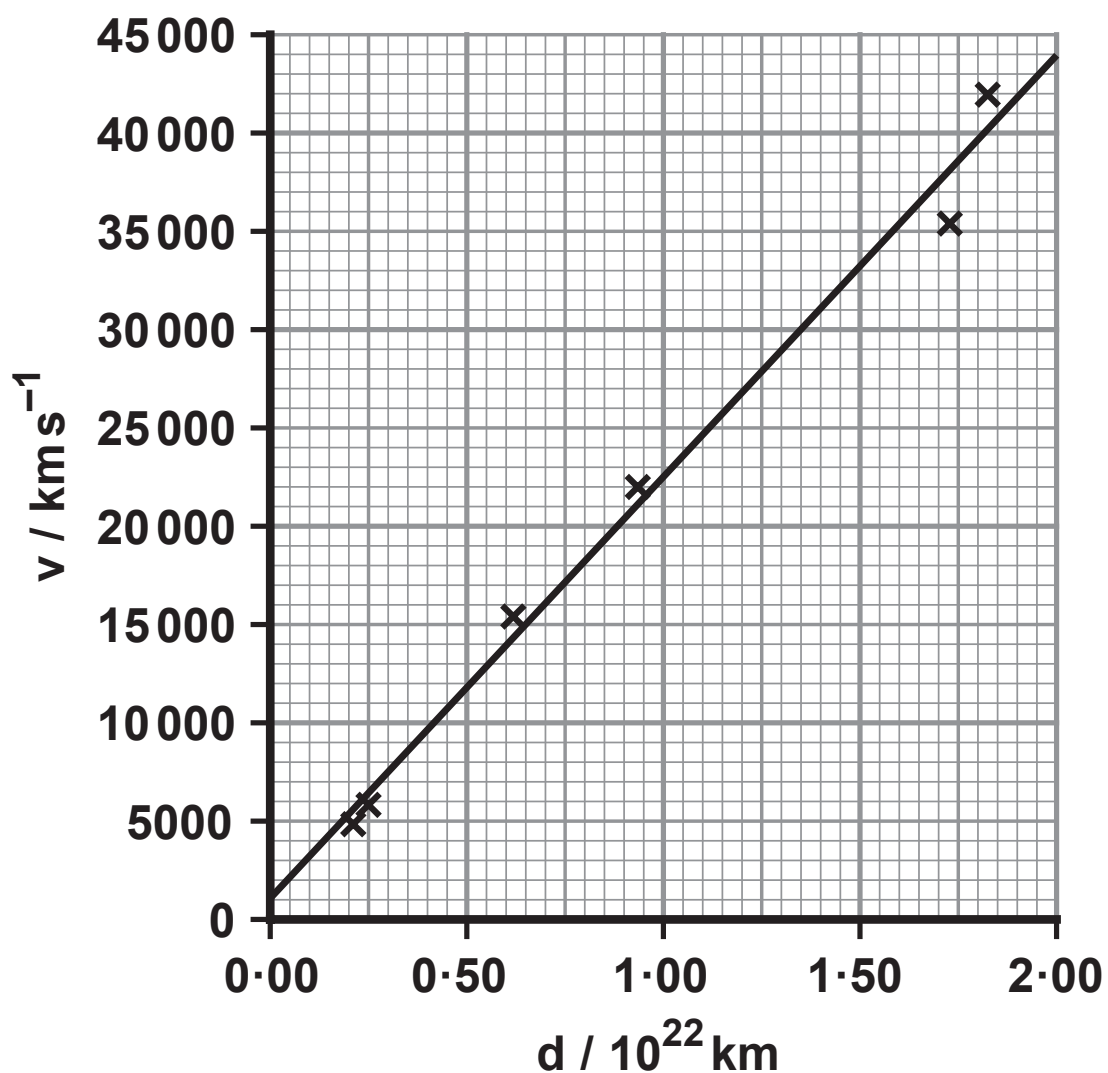
State one advantage shown by this graph of positioning a telescope above the atmosphere.

(1 mark)

(Question continues on next page)

(Turn over)

- (c) High resolution images from HST allow astronomers to make detailed measurements of very distant galaxies. The graph shows how the recessional velocities of distant galaxies depend on their distance from Earth.



(Question continues on next page)

(Turn over)

Determine an age for the universe. (3 marks)

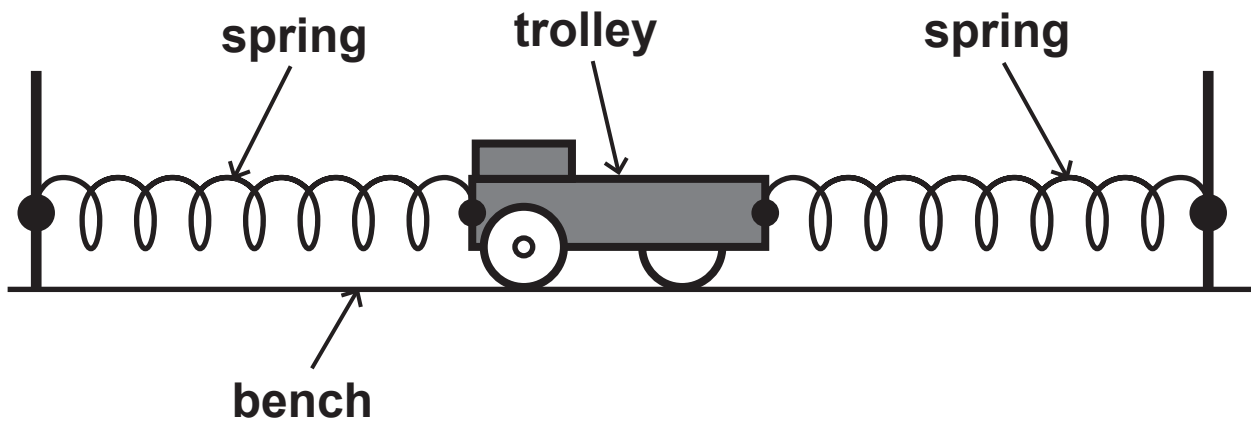
Age for the universe = _____

(TOTAL FOR QUESTION 6 = 13 MARKS)

(Questions continue on next page)

(Turn over)

- 7 A trolley is attached to the ends of two springs as shown. When displaced from its equilibrium position, the trolley moves with simple harmonic motion.



- (a) A student has a stopwatch and metre rule available.
- (i) Explain the procedure that the student should follow to make an accurate determination of the time period T of the trolley. (6 marks)

(Turn over)

- (ii) Describe how the student should use her value of T to determine the maximum speed of the trolley. (3 marks)

(Question continues on next page)

(Turn over)

- (b) Another student suggests that a more accurate value for T could be obtained by using a position sensor and data logger.

Comment on this suggestion. (1 mark)

(Question continues on next page)

(Turn over)

- (c) The student displaces the trolley a greater distance from the equilibrium position, so the amplitude of oscillation is doubled. The trolley still moves with simple harmonic motion.

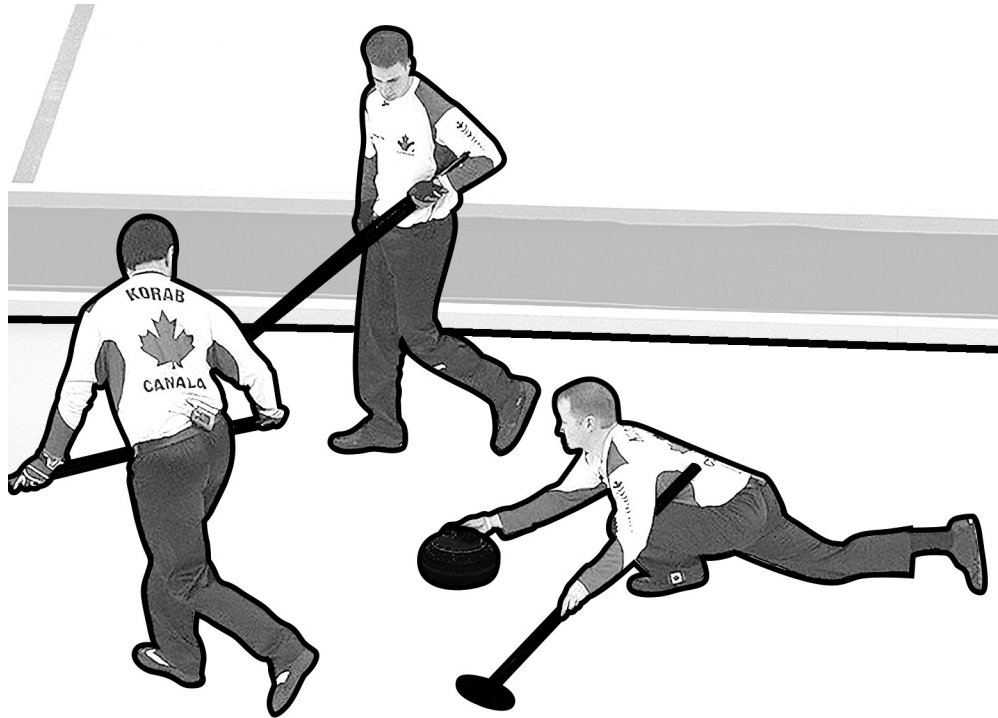
Explain how the maximum kinetic energy of the trolley will change. (3 marks)

(TOTAL FOR QUESTION 7 = 13 MARKS)

(Questions continue on next page)

(Turn over)

- 8 In the sport of curling, two teams of 'curlers' take turns sliding polished granite stones across an ice surface towards a circular target marked on the ice.



- (a) A stone of mass 19.6 kg is accelerated uniformly for 1.25 s before being released by a curler. The stone then decelerates uniformly to rest, travelling 32.5 m in a time of 17.5 s .

(Question continues on next page)

(Turn over)

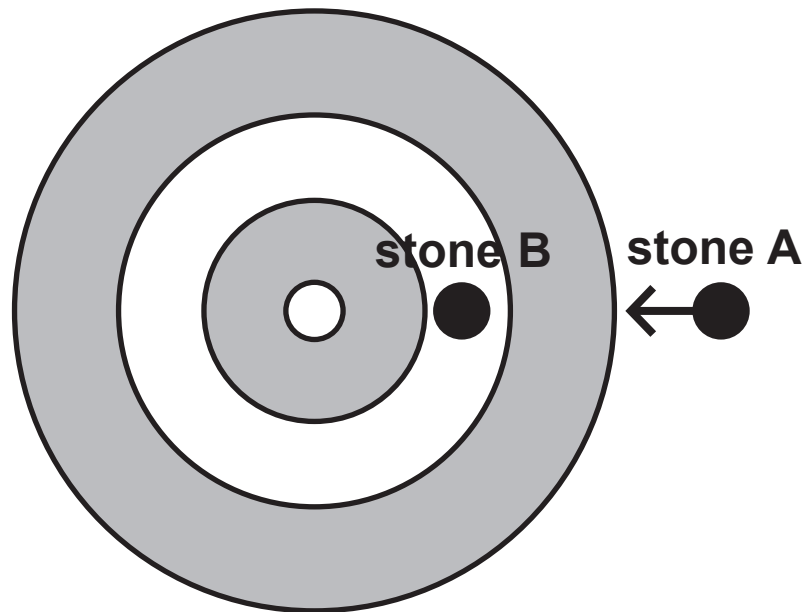
Calculate the average useful power developed by the curler in accelerating the stone. (4 marks)

Average power = _____

(Question continues on next page)

(Turn over)

- *(b) Stone B is stationary. Stone A travels towards the target and makes a direct hit on stone B as shown. Both stones have mass m .**



The collision is elastic. Just before the collision stone A has a velocity v . After the collision stone B moves off with velocity v .

Discuss how the relevant conservation laws apply to this collision. (6 marks)

(Turn over)

- (c) While a stone is moving towards the target, the curlers vigorously sweep the ice directly in front of the stone.

Explain why this may make the stone travel further.

(2 marks)

(TOTAL FOR QUESTION 8 = 12 MARKS)

(Questions continue on next page)

(Turn over)

- 9 The Beaufort scale is used to describe wind intensity. On this scale the average wind speed v increases with the Beaufort scale value B .

The relationship between v and B is given by

$$v = kB^p$$

where k and p are constants.

- (a) Explain why a graph of $\log v$ against $\log B$ should give a straight line. (2 marks)

(Question continues on next page)

(Turn over)

- (b) The table gives some values of v and corresponding values of B .

v / ms^{-1}	B		
2.00	1		
10.0	3		
21.5	5		
36.0	7		
50.5	9		
68.0	11		

- (i) On the separate sheet provided plot a graph of $\log v$ against $\log B$.
Use the columns provided to show any processed data. (5 marks)

(Question continues on next page)

(Turn over)

(ii) Determine the values of p and k . (3 marks)

$p =$ _____

$k =$ _____

(TOTAL FOR QUESTION 9 = 10 MARKS)

(Questions continue on next page)

(Turn over)

- 10** Seat belts are being tested by a car manufacturer. In the test, a car moving at a steady speed of 28 m s^{-1} collides with a wall and stops.

A crash-test dummy in the driving seat is wearing a seat belt made from polyester webbing. The seat belt has a cross-sectional area of 0.85 cm^2 and a total length of 2.0 m . A student suggests that in the collision the seat belt absorbs all the kinetic energy of the dummy.

(Question continues on next page)

(Turn over)

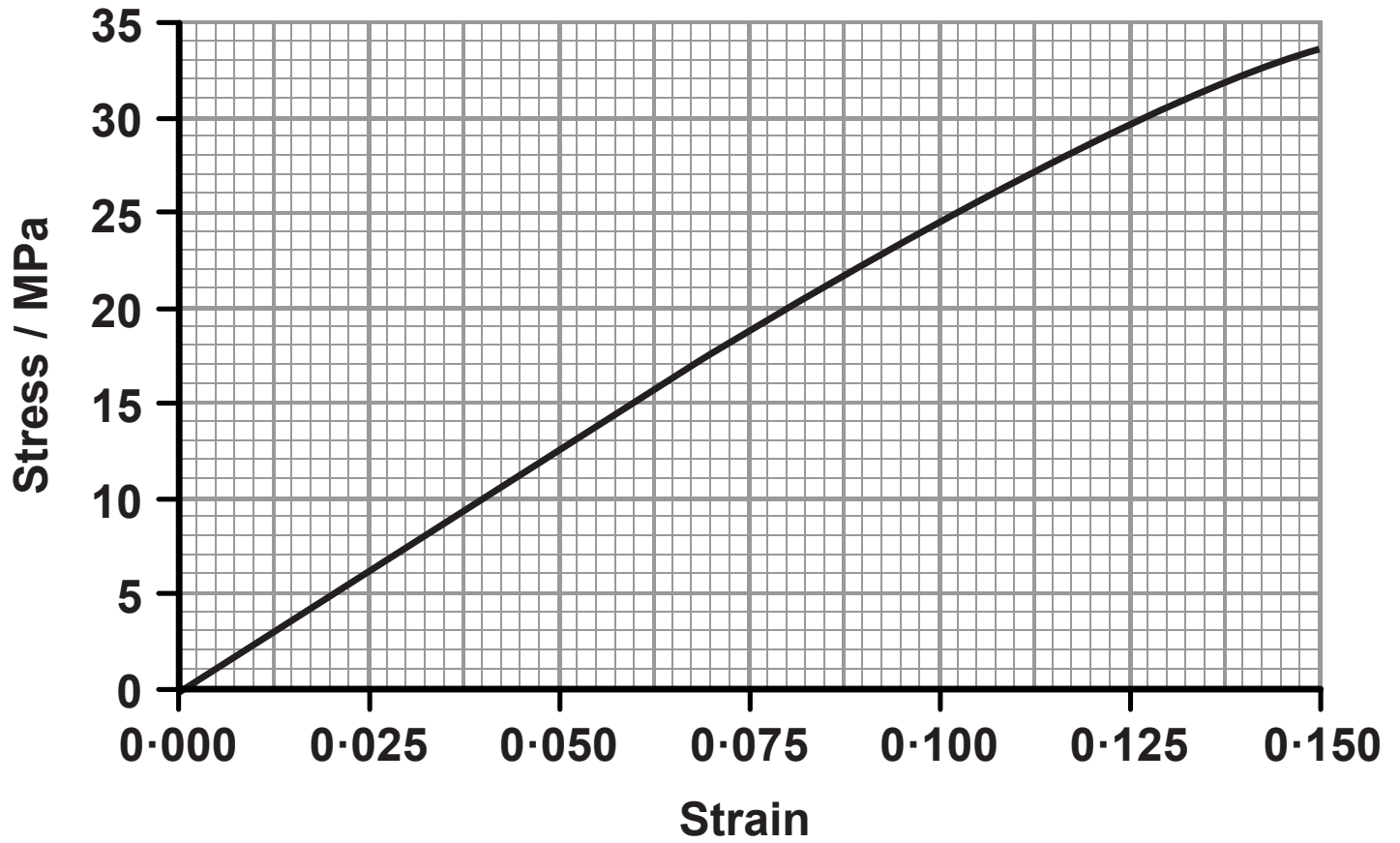
- (a) Show that the energy per unit volume that would have to be absorbed by the seat belt is about $2 \times 10^8 \text{ J m}^{-3}$. (3 marks)

mass of dummy = 75 kg

(Question continues on next page)

(Turn over)

(b) The graph shows how stress varies with strain for the seat belt.



(Question continues on next page)

(Turn over)

- (i) Show that the area under the graph represents the energy stored per unit volume in the seat belt. (2 marks)

(Question continues on next page)

(Turn over)

- (ii) Use the graph to determine whether the seat belt absorbs all the kinetic energy of the dummy from part (a).

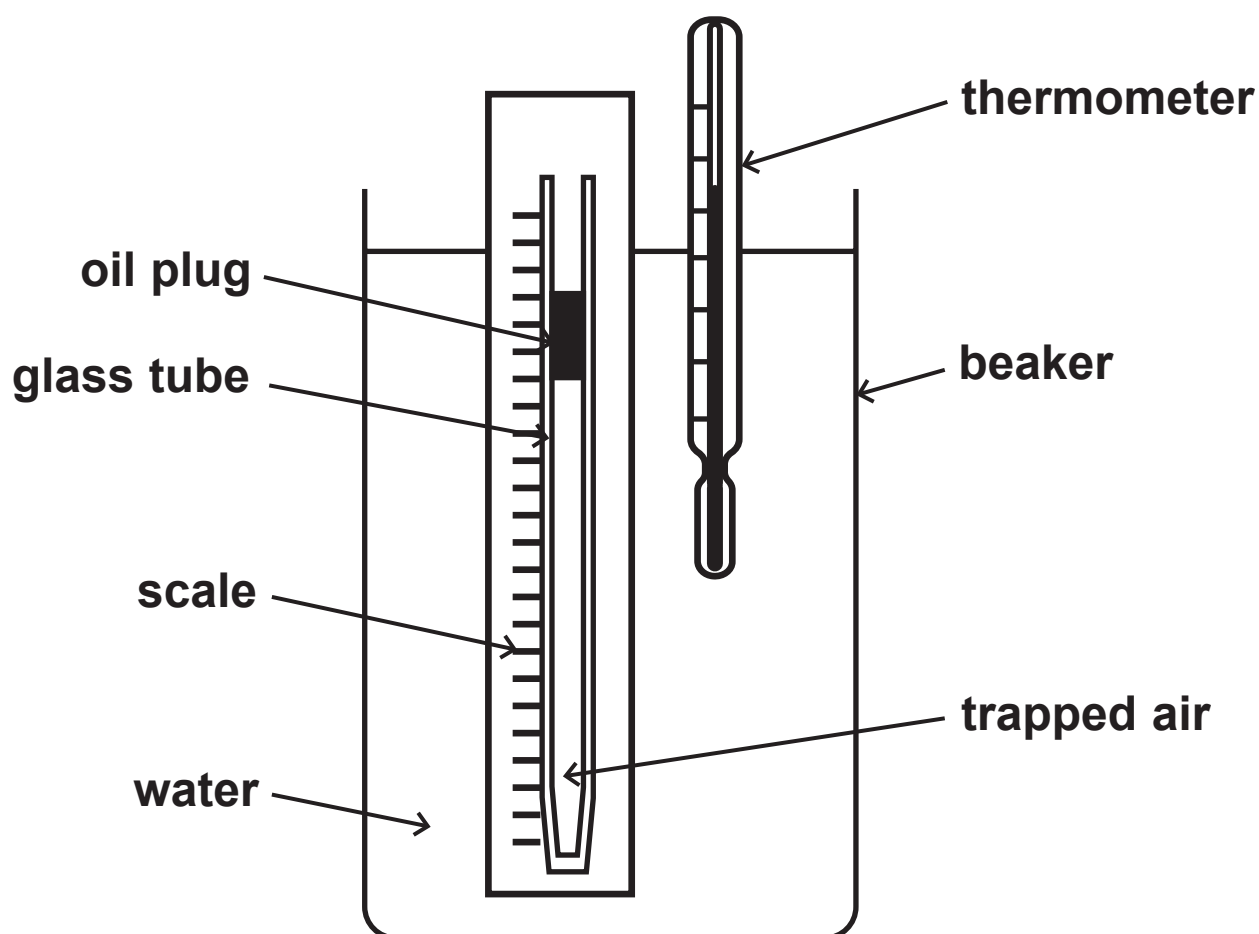
In this collision, the maximum strain of the seat belt is 0.075 (3 marks)

(TOTAL FOR QUESTION 10 = 8 MARKS)

(Questions continue on next page)

(Turn over)

- 11 A student investigated how the volume of a fixed mass of air varies with the temperature of the air. She used the apparatus shown.



A glass tube was sealed at one end. A plug of oil trapped a length l of air in the tube. The water in the beaker was heated to a temperature θ . The corresponding value of l was measured. This was repeated for a range of temperatures.

The thermometer had a resolution of 0.5°C . The scale had mm divisions.

(Question continues on next page)

(Turn over)

The student's results are shown in the table.

$\theta / ^\circ\text{C}$	l / cm
24	8.8
60	9.8
78.5	10.3
95.5	10.9

(a) (i) Criticise the student's results. (3 marks)

(ii) Explain two possible sources of error in this investigation. (4 marks)

(Question continues on next page)

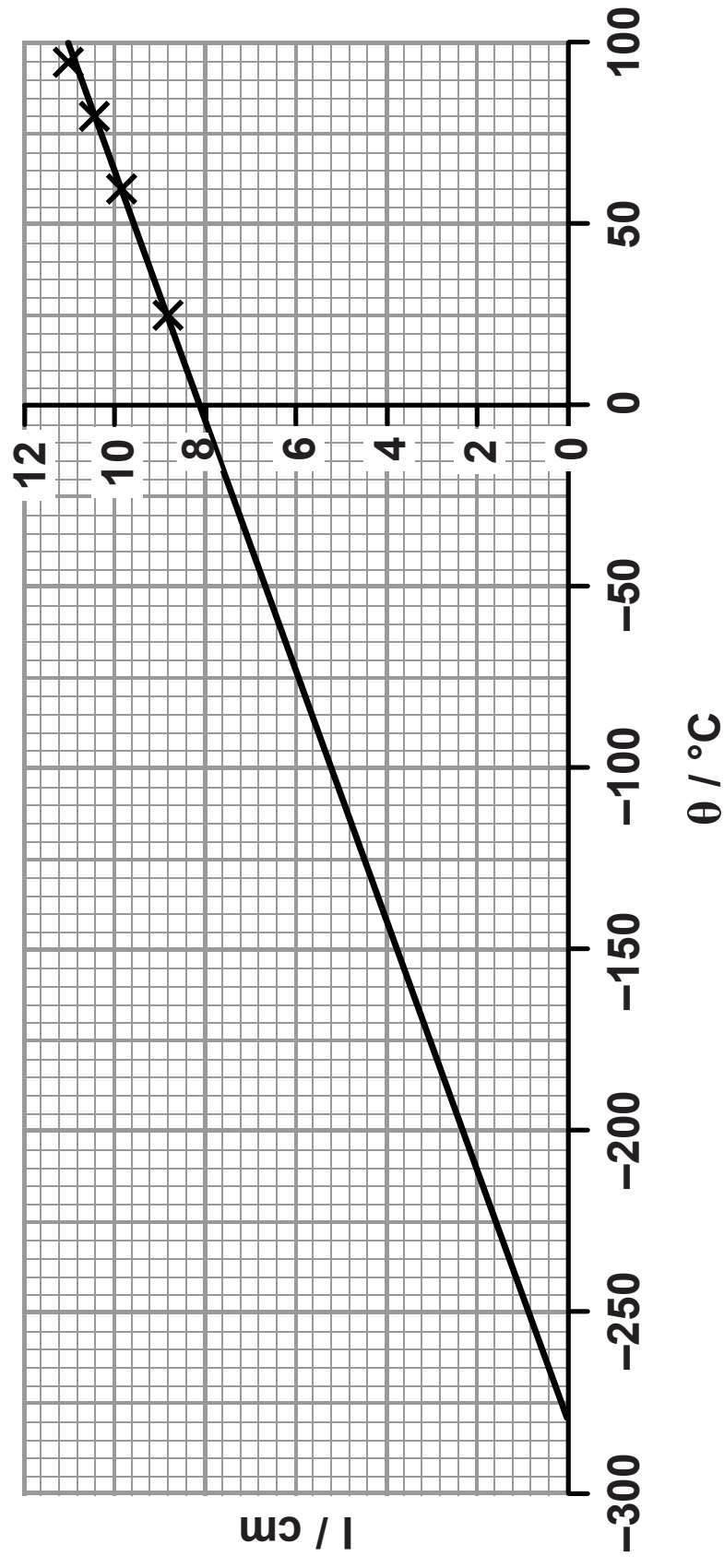
(Turn over)

(iii) Describe two improvements that would increase the accuracy of measurements obtained in this investigation. (2 marks)

(Question continues on next page)

(Turn over)

(b) The student plotted a graph of l against θ as shown.



(Question continues on next page)

(Turn over)

- (i) Explain the significance of the intercept on the x-axis. (3 marks)

(Question continues on next page)

(Turn over)

- (ii) The student wrote a report of the investigation in her lab book. In the conclusion she wrote:

“In this investigation uncertainties were minimised by selecting measuring instruments with a high resolution. The points lie on a perfect straight line, indicating that the investigation is accurate.”

Discuss the student’s conclusion. (4 marks)

(Continue your answer on next page)

(Turn over)

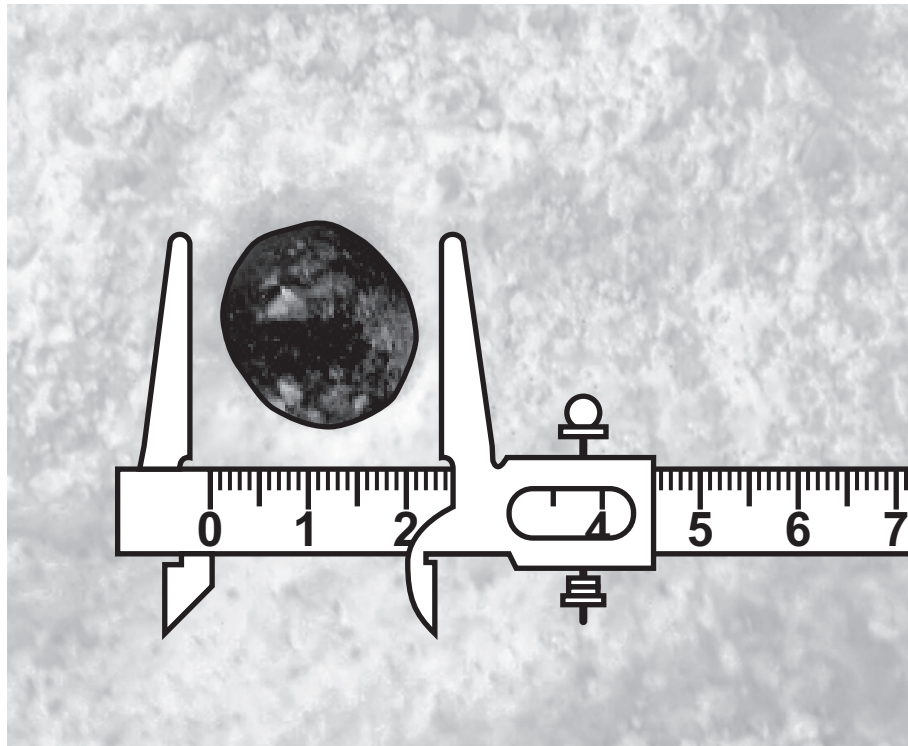
(TOTAL FOR QUESTION 11 = 16 MARKS)

(Questions continue on next page)

(Turn over)

- 12** Impact craters are formed when meteorites strike the surface of a planet. A student investigated some factors that might influence the formation of impact craters. He did this by dropping spheres of modelling clay into a tray of sand.

The diameter of the crater produced by each sphere was measured using vernier calipers as shown.



This process was repeated for spheres of different diameters.

(Question continues on next page)

(Turn over)

- (a) In one test, the spheres were dropped from the same height.

Determine the factor by which the kinetic energy of the sphere just before impact increases when the sphere diameter is increased from 2.0 cm to 4.0 cm. (3 marks)

Factor = _____

(Question continues on next page)

(Turn over)

- *(b) The student also dropped the spheres from different heights. His results are shown in the table.**

Drop height / m	Sphere diameter / cm	Crater diameter / cm
0.30	2.0	3.6
	4.0	7.0
	6.0	6.8
0.60	2.0	4.8
	4.0	7.5
	6.0	7.3
0.90	2.0	5.6
	4.0	8.0
	6.0	8.3

(Question continues on next page)

(Turn over)

The student wrote the following conclusion:

“The greater the drop height, the greater the diameter of the crater formed when a sphere hits the sand. This is because the impact velocity increases as the drop height is increased. As the speed of the sphere increases the diameter of the crater formed also increases. Also, the bigger the sphere the bigger the crater.”

Assess the validity of the student’s conclusion.

(6 marks)

(Continue your answer on next page)

(Turn over)
