

Friday 17 May 2019 – Morning

LEVEL 3 CAMBRIDGE TECHNICAL IN ENGINEERING

05822/05823/05824/05825/05873

Unit 2: Science for engineering

Time allowed: 1 hour 30 minutes plus your additional time allowance

You must have:

**the formula booklet for Level 3
Cambridge Technical in Engineering
a ruler (cm/mm)
a protractor
a scientific calculator**

Modified Enlarged 18pt

Please write clearly in black ink.

**Centre
number**

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**Candidate
number**

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First name(s) _____

Last name _____

**Date of
Birth**

D	D	M	M	Y	Y	Y	Y
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INSTRUCTIONS

Use black ink. You may use an HB pencil for graphs and diagrams.

Answer ALL the questions.

Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

The acceleration due to gravity is denoted by $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION

The total mark for this paper is 60.

The marks for each question are shown in brackets [].

Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.

An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.

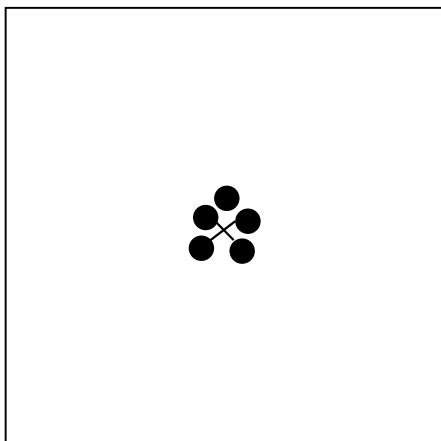
Final answers should be given to a degree of accuracy appropriate to the context.

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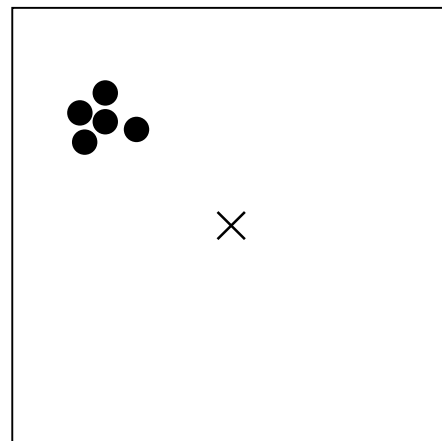
Answer ALL the questions.

- 1 (a) Three automatic positioning systems are being tested for quality. The results for each system are shown in Fig.1.**

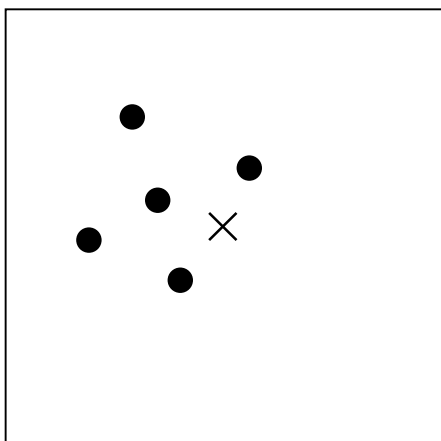
Fig. 1



System A



System B



System C

Key

× **true position**

● **measured position**

5

Put ONE tick (✓) in each row of the table below to indicate the precision of each system. [3]

	Precision	
System	Precise	Imprecise
A		
B		
C		

(b) Complete the statements below. Use the format 10^x , the first one has been done for you. [3]

1 kilowatt is equal to 10^3 W

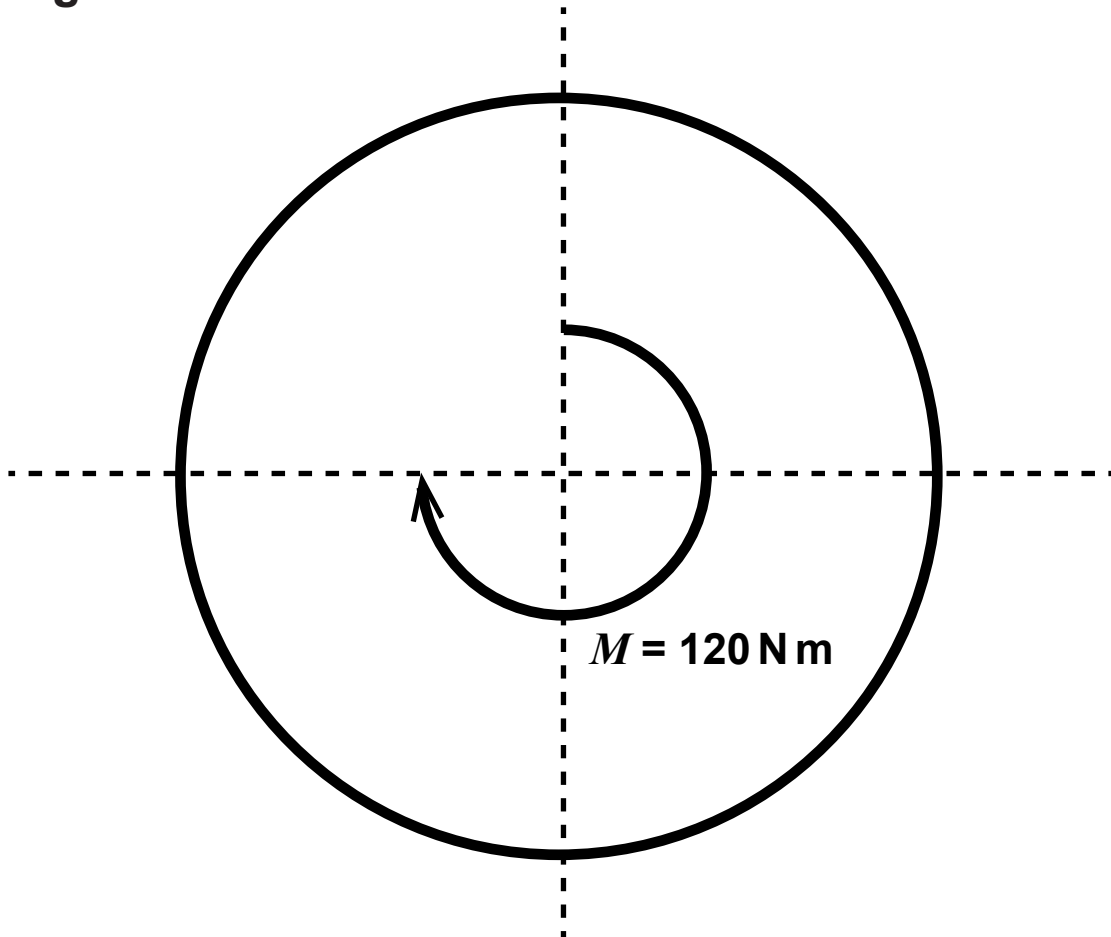
1 metre is equal to _____ mm

1 gram is equal to _____ Mg

1 litre is equal to _____ mm^3

- 2 (a) Fig. 2 shows the cross section of a metal bar of diameter $d = 40$ mm which is subjected to a moment about its centre, $M = 120$ N m.

Fig. 2



- (i) Calculate the magnitude of the couple needed to act on the surface of the bar to maintain equilibrium.

Magnitude of couple = _____ N [2]

- (ii) Add arrows to Fig. 2 to show the direction of the couple. [2]

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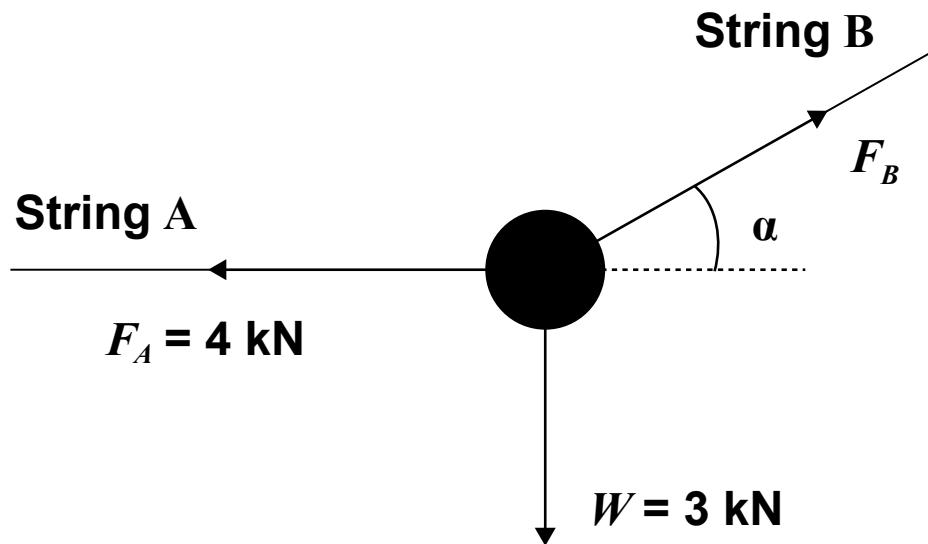
- (b) Fig. 3 shows an object suspended in equilibrium from two strings.

String A is horizontal and string B is at an angle α to the horizontal axis.

String A and string B are in the same vertical plane.

The weight of the object $W = 3 \text{ kN}$ and the horizontal force $F_A = 4 \text{ kN}$.

Fig. 3



- (i) Calculate the magnitude of the force acting along string B, F_B .

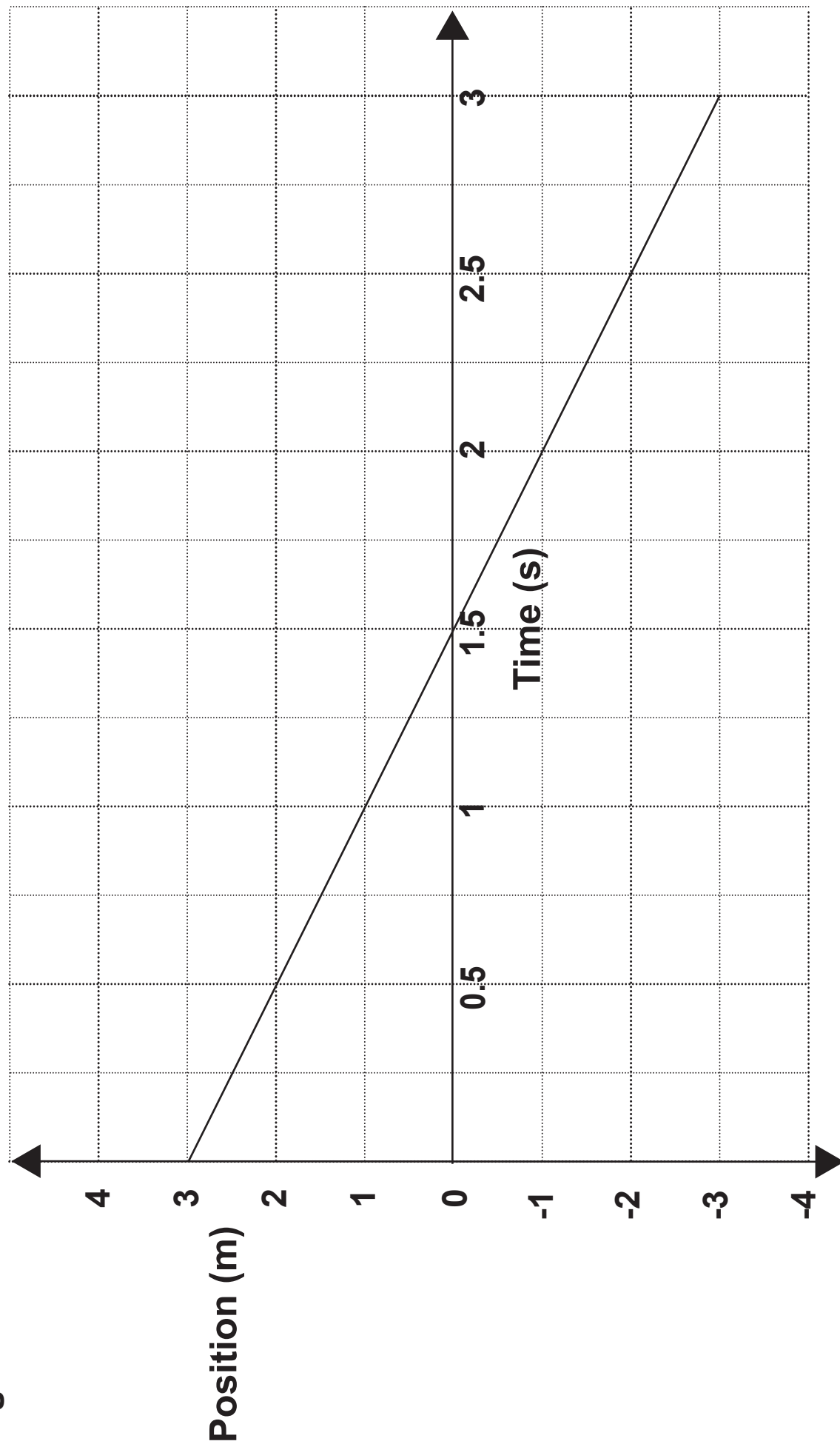
$F_B =$ _____ kN [2]

- (ii) Determine the angle α between the F_B and the horizontal axis.

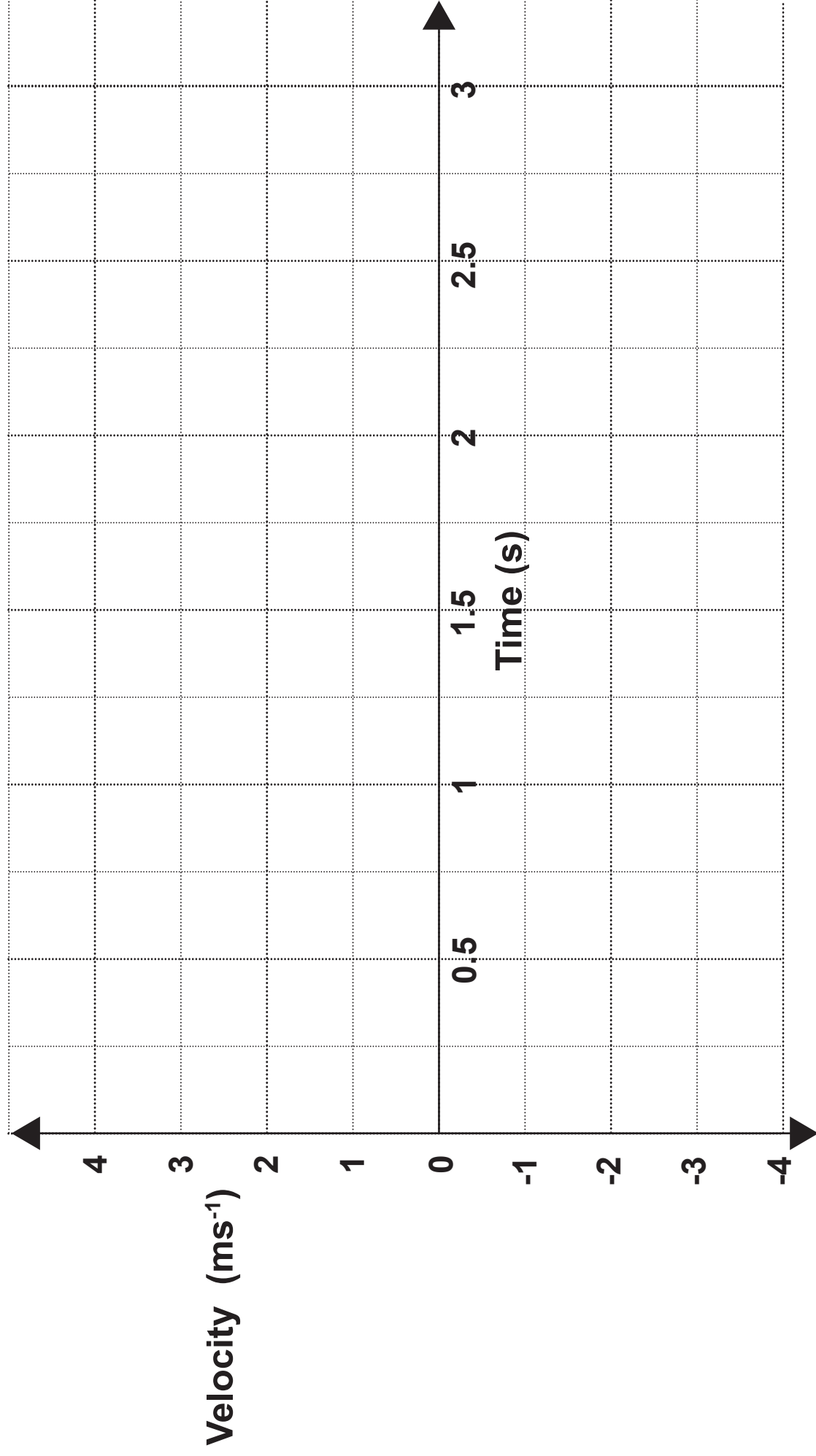
$$\alpha = \underline{\hspace{2cm}}^\circ [1]$$

(c) Fig. 4 shows the position of an object as it varies with time while moving along a horizontal plane.

Fig. 4



- (i) On the grid below draw the corresponding velocity-time graph for the movement shown in Fig. 4. [2]



- (ii) State and explain the magnitude of acceleration.

[1]

- (iii) A horizontal force acting on the object of 5 kN causes the movement shown in Fig. 4.

Calculate the work done by the force on the object.

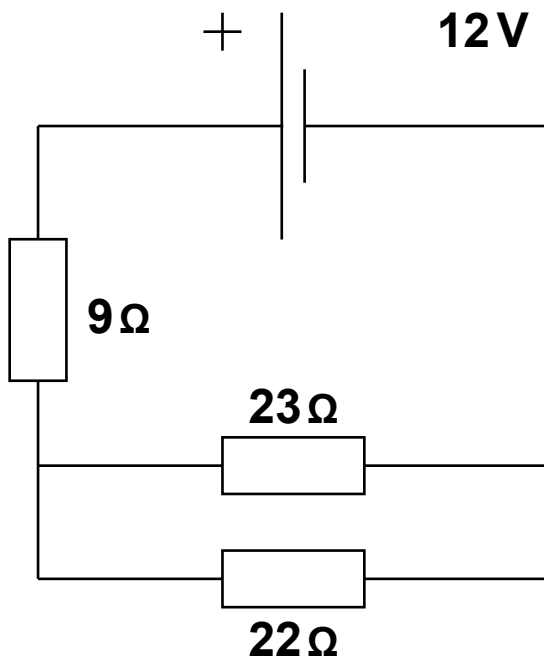
Include a unit in your answer.

Work done = _____ [2]

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3 (a) Fig. 5 shows a resistor circuit.

Fig. 5



(i) Show that the total equivalent resistance is approximately $20\ \Omega$. Use the space below. [3]

15

- (ii) Calculate the current I through the circuit when the supply is 12 V.

$I =$ _____ A [2]

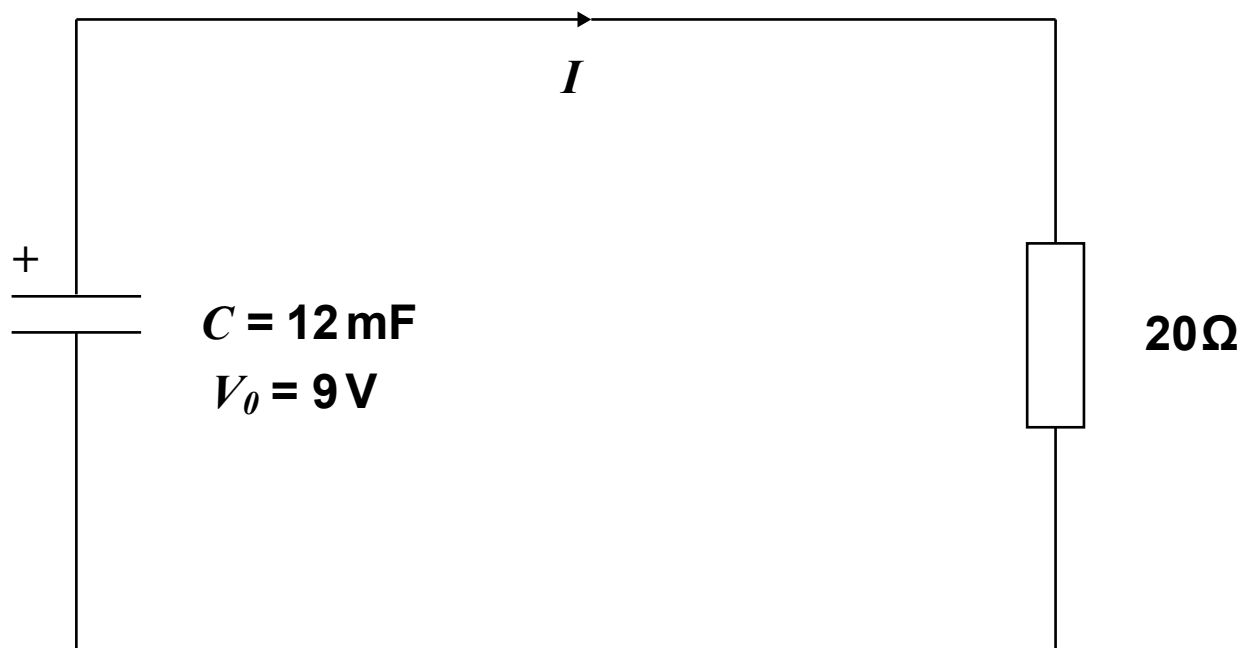
- (b) A capacitor of capacitance $C = 12 \text{ mF}$, is fully charged by applying a potential difference $V_0 = 9.0 \text{ V}$.

- (i) Calculate the total energy stored by the capacitor.

Energy stored = _____ J [2]

The fully charged capacitor is then placed in the RC circuit shown in Fig. 6.

Fig. 6



- (ii) Calculate the time constant, τ for the circuit in Fig. 6.

$$\tau = \text{_____ s [2]}$$

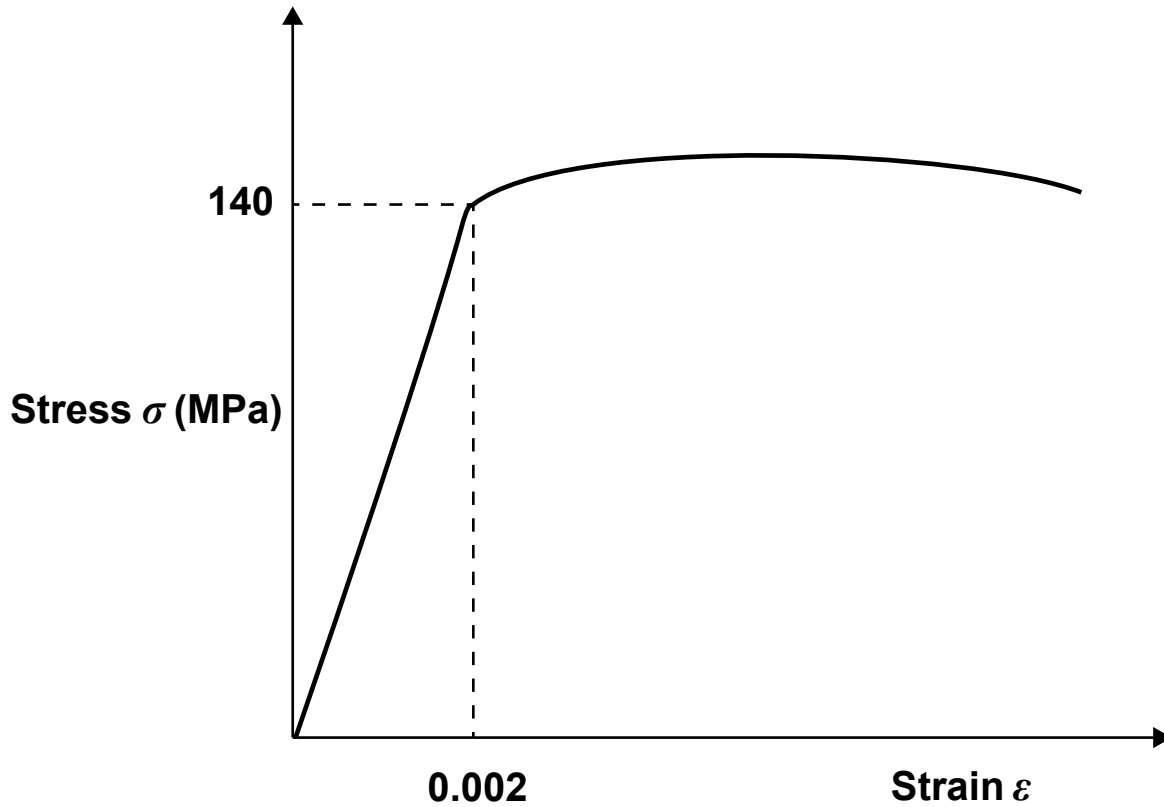
- (iii) Calculate the potential difference across the capacitor at time $t = 0.4$ s.

The initial potential difference $V_0 = 9.0$ V.

$$V_{0.4} = \text{_____ V [2]}$$

- 4 (a) Fig. 7 shows the stress-strain curve of a metallic material.

Fig. 7



- (i) Calculate the Young's modulus of the material.

Young's modulus = _____ MPa [2]

- (ii) Draw a cross (X) on Fig. 7 to show the ultimate tensile strength of the metallic material. [1]
- (iii) Metallic materials undergo two types of deformation, both of which are shown in Fig. 7. State the two types of deformation and explain the key difference between them on both a macroscopic and microscopic level.

[4]

- (b) Place a tick (✓) against the statement in the table below that describes non-destructive testing. [1]

Statement	Tick (✓)
A component is tested for any internal flaws or cracks using ultrasonic waves.	
A tensile test is performed on a specimen of a material to find its strain at failure.	

- (c) A vehicle body panel must withstand repeated vibration loading during the life cycle of a car.

It must also be resistant to scratches and abrasions.

State the material properties associated with these requirements.

Repeated vibration: _____

Resistant to scratches and abrasions: _____

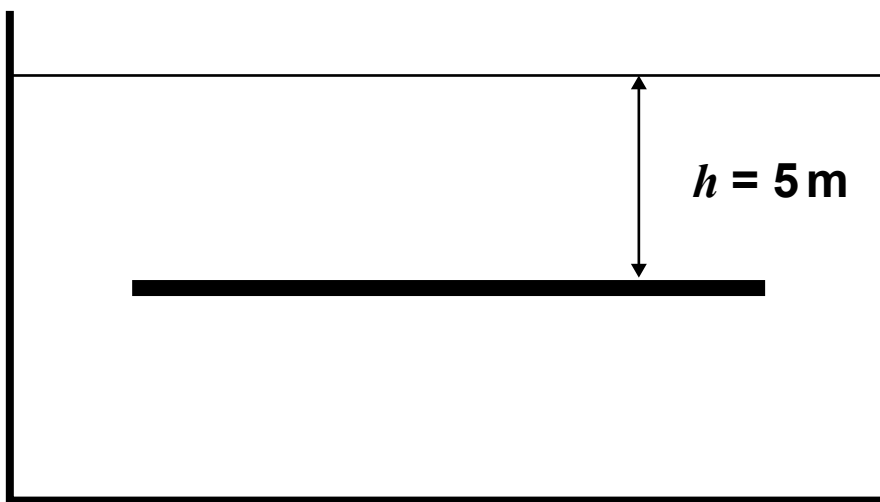
[2]

5 (a) Define viscosity of a fluid.

[1]

(b) Fig. 8 shows a plate submerged in a container filled with ethanol.

Fig. 8



(i) Draw arrows on Fig. 9 below to show the pressure acting on the plate. [2]

Fig. 9



- (ii) Calculate the force exerted by the ethanol on the top surface of the plate.

Density of ethanol $\rho_{ethanol} = 790 \text{ kg m}^{-3}$.

The top surface area of the plate is 15 m^2 .

Force = _____ N [3]

- (iii) Calculate the absolute pressure exerted on the plate.

Atmospheric pressure is 101 kPa.

Absolute pressure = _____ Pa [2]

- (iv) The upthrust force acting on the submerged plate is 22 kN.

Calculate the thickness of the plate. Include a unit in your answer.

Thickness = _____ [4]

- 6 (a) A gas in an insulated container has the following properties.

$$P_1 = 250 \text{ kPa},$$

$$T_1 = 300 \text{ K},$$

$$V_1 = 0.13 \text{ m}^3.$$

- (i) Calculate the pressure of the gas if the volume decreases to $V_2 = 0.07 \text{ m}^3$ and the temperature rises to $T_2 = 305 \text{ K}$.

Pressure = _____ kPa [3]

- (ii) Calculate the number of moles in the container.

The ideal gas constant $R_{\text{gas}} = 8.3 \text{ J mol}^{-1} \text{ K}^{-1}$.

Number of moles = _____ moles [3]

- (b) (i) Explain what is meant by the 'internal energy' of a system.

[2]

- (ii) State the physical significance of absolute zero on the Kelvin scale.

[1]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown – for example 1(a) or 2(a)(i).

This image shows a single 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.



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