Section A [10 marks]

Answer **ALL** questions. Record your choices in the table on the cover page.

1 The period T of a simple pendulum is given by the formula

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where l is the length of the pendulum and g is the acceleration due to gravity.

Which quantity is a vector?

A T **B** π **C** l **D** g

2 A rope has a length of 26.0 cm.

Its length can be expressed as 2.60×10^{n} μm, where n is an integer.

What is the value of n?

A -5 **B** -2 **C** 2 **D** 5

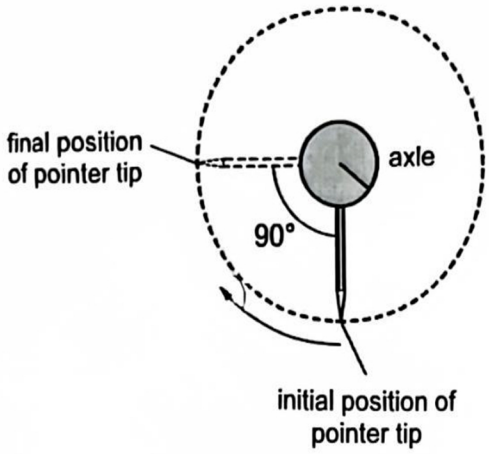
3 What is the unit, newton, expressed in SI base units?

A kg m s^{-1} **B** kg m^{-1} s^{-1} **C** kg m s^{-2} **D** kg m^{-2} s^{-2}

4 Which row best describes the properties of a random error?

	possible elimination of error	sign and magnitude of error
A	no	constant
B	no	varying
C	yes	constant
D	yes	varying

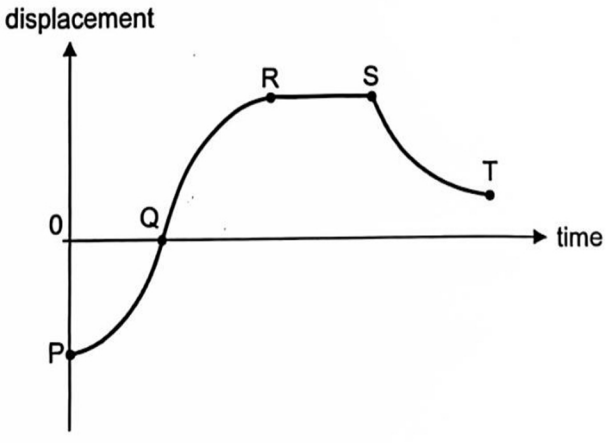
5 The diagram shows the top view of a pointer rotating in a circle, of radius r and circumference d, about an axle.



Which row shows the displacement and distance travelled by the pointer tip?

	displacement	distance travelled
A		$d / 4$
B	$\sqrt{2}\,r$	$d / 4$
C		$3d / 4$
D	$\sqrt{2}\,r$	$3d / 4$

6 The diagram shows a displacement-time graph.



In which region is the speed increasing?

A PQ B QR C RS D ST

7 A solid block of alloy is made by mixing copper with tin.

The table below shows the density and the mass of copper and tin used.

	copper	tin
density / g cm^{-3}	8.96	7.26
mass / g	860	140

What is the density of the block of alloy?

A 7.8 g cm^{-3} **B** 8.1 g cm^{-3} **C** 8.4 g cm^{-3} **D** 8.7 g cm^{-3}

8 An object returns from the Moon to the Earth. The gravitational field strength on the Moon is 1.6 N/kg. Which statement is correct?

A The object has no weight on the Moon.

B The object has the same mass on the Moon and the Earth.

C The object has a greater density on the Moon than on the Earth.

D The object is more reluctant to start moving on the Moon than on the Earth

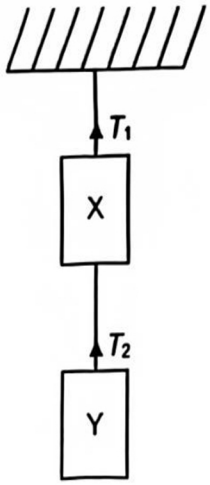
9 The table below shows the velocity and acceleration of objects P, Q, R and S at a particular instant in time.

	velocity / m s^{-1}	acceleration / m s^{-2}
P	- 15	- 5
Q	- 15	+ 5
R	+ 10	- 20
S	+ 10	+ 20

Which two objects are decreasing in speed?

A P and R **B** P and S **C** Q and R **D** Q and S

10 Two blocks X and Y of weight 10 N and 4 N respectively, are suspended by two strings and are in equilibrium, as shown below.



What is the size of tensions, T_1 and T_2, in the two strings?

	T_1 / N	T_2 / N
A	10	4
B	10	10
C	14	4
D	14	14

Section B [30 marks]

Answer **ALL** questions. Write your answers in the spaces provided.

1 An aircraft flies at a constant height.

The resultant force acting on the aircraft is due north, as shown in Fig. 1.1.

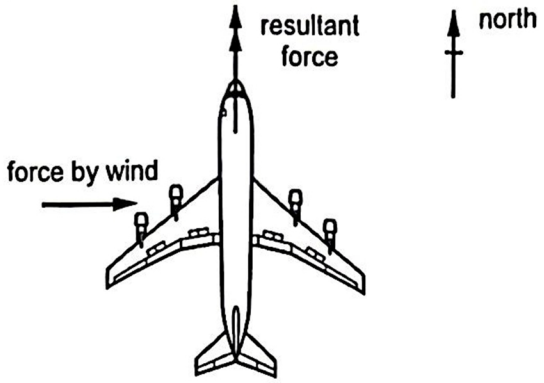


Fig. 1.1 (not to scale)

(a) Fig. 1.2 shows the resultant force drawn to scale.

Scale: 1.0 cm represents 6.0 kN

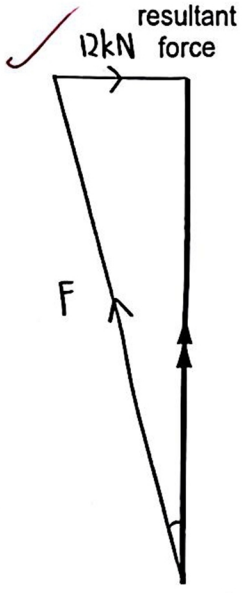


Fig. 1.2 (to scale)

(i) Using Fig. 1.2, determine the magnitude of the resultant force.

magnitude of resultant force = ... 42 kN ..... [1]

(ii) The wind produces a constant 12 kN force towards the east.

The force by the wind and the force F from the aircraft's engines together produce the resultant force acting on the aircraft, causing it to fly north, as shown in Fig. 1.1.

On Fig. 1.2, complete the scale drawing to show the force by the wind and the force F.

Use your drawing or otherwise, determine the magnitude of the force F and the angle θ between the force F and north.

$7.3 \times 6 = 43.8$

magnitude of force F = 43.8 kN

angle θ = 16° [3]

(b) The aircraft undergoes uniform acceleration of 0.70 m s^{-2}.

(i) State what is meant (definition) by *uniform acceleration.*

The acceleration is constant so the rate of change of velocity is constant. [1]

(ii) Determine the mass of the aircraft.

$F = ma$

$42\,000\ \text{N} = m(0.70\ \text{m s}^{-2})$

$m = 60\,000\ \text{kg}$ (2 s.f.)

mass of aircraft = 60 000 kg [2]

(iii) Calculate the distance travelled by the aircraft as its velocity increases from 210 m s^{-1} to 240 m s^{-1}.

$v = u + a(t)$

$t = \frac{v-u}{a}$

$= \frac{240-210}{0.70}$

$= 42.857$

$\text{distance} = \frac{1}{2}(210+240)(42.857)$

$= 9600\ \text{m}$ (2 s.f.)

distance travelled = 9600 m [2]

[Total: 9]

2 Fig. 2.1 shows a drone.

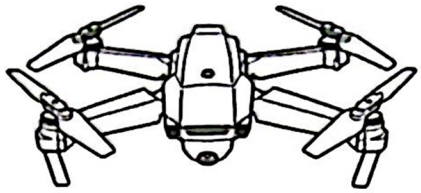


Fig. 2.1

Fig. 2.2 shows the velocity-time graph of the drone that flies vertically upwards for the first 1.00 s.

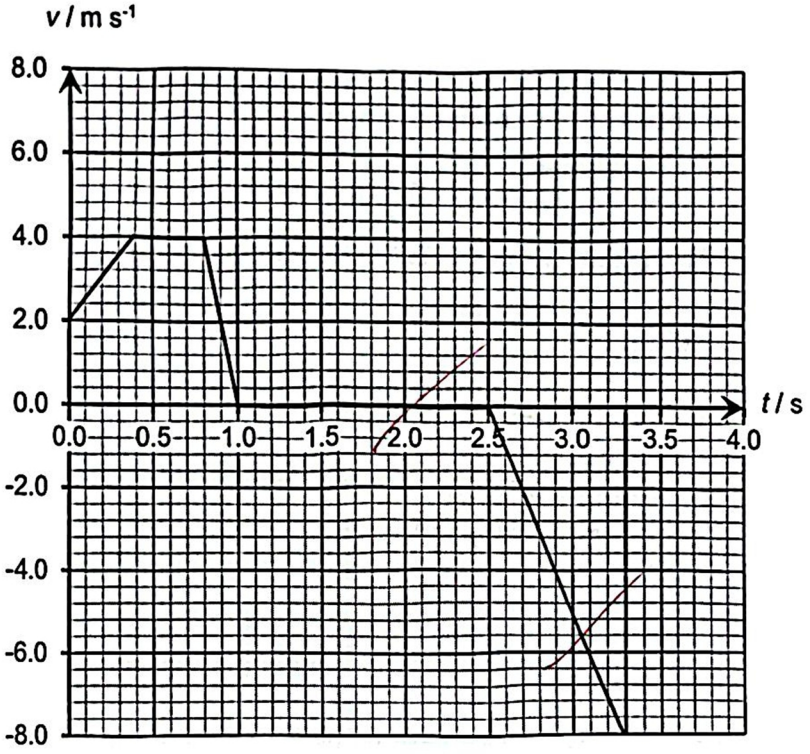


Fig. 2.2

(a) Calculate the acceleration of the drone at $t = 0.20$ s.

$v = u + a(t)$

$a = \frac{3.0-2.0}{0.20}$

$= 5.0 \text{ m s}^{-2}$

acceleration = ... 5.0 m s^{-2} ..... [2]

(b) Describe the acceleration of the drone between $t = 0.80$ s to $t = 1.00$ s.

The acceleration is constant and negative. [1]

(c) Show that the distance travelled by the drone in the first 1.00 s is 3.2 m. [1]

Distance $= \frac{1}{2} \times (2.0 + 4.0)(0.4) + \frac{1}{2} \times (0.6 + 0.4)(4.0)$

$= 3.2\,m$

(d) After $t = 1.00$ s, the drone remains stationary in mid-air for 1.50 s before its motor fails and it falls back to its initial position at $t = 0$ s. $u = 0$

The effect of air resistance can be ignored during the fall. The acceleration of free fall is 10 m s^{-2}.

(i) Determine the time that the drone takes to fall from the maximum height to its initial position.

$s = ut + \frac{1}{2}at^2$

$3.2\,m = 0 + \frac{1}{2}(10\,m\,s^{-2})\,t^2$

$t^2 = \frac{6.4\,m}{10\,m\,s^{-2}}$

$t = 0.80\,s$ (2 s.f.)

time taken = 0.80 s [2]

(ii) On Fig. 2.2, draw the velocity-time graph from $t = 1.00$ s to the time when the drone falls back to its initial position. [2]

[Total: 8]

3 Fig. 3.1 shows a horizontal force **A** acting on rear wheel of a moving bicycle. Only the rear wheel of the bicycle is driven by the pedalling of the rider.

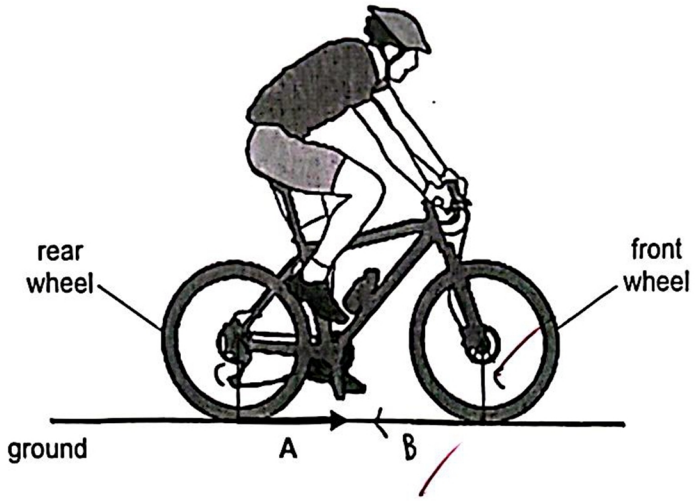


Fig. 3.1

(a) **(i)** State the name of force **A**.

Frictional force ..... [1]

(ii) Explain, using Newton's third law, how force **A** occurs.

The force exerted by the rear wheel on the ground has an equal and opposite force exerted by the ground on the rear wheel. As the rear wheel turns clockwise, the force exerted by the wheel on the ground is towards the left, so force A is opposite and towards the right. [2]

(b) On Fig. 3.1, draw and label

(i) the force **B**, which causes the front wheel to roll, [1]

(ii) the force **C**, which supports the wheels as they move across the ground. [1]

[Total: 5]

4 A student investigates the terminal speeds of small steel spheres of different diameters falling through oil.

He fills a large glass cylinder with oil and places two rubber bands around the cylinder, one above the other, at a distance of 10.0 cm apart, as shown in Fig. 4.1.

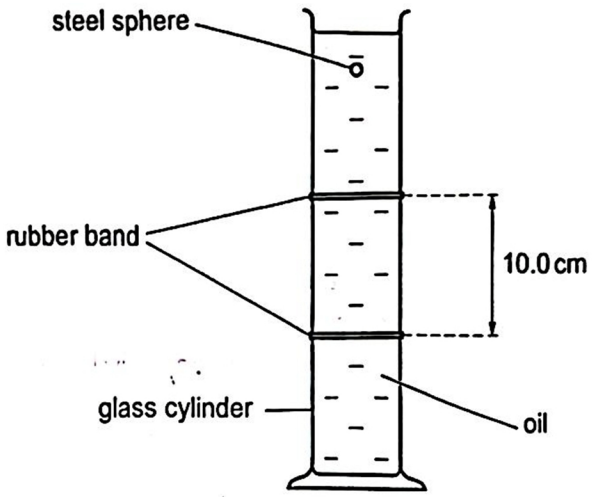


Fig. 4.1

(a) The student measures the diameter of a steel sphere using an instrument. He records down every digit of the reading on the instrument and writes 3.162 mm.

State the name of the instrument used.

Micrometre screw gauge (Digital micrometer) [1]

SP

(b) The student drops the steel sphere into the oil and as it passes the first rubber band, he starts a stopwatch. He stops the stopwatch as the sphere passes the second rubber band.

He removes the steel sphere from the oil at the bottom of the cylinder and repeats the time measurement twice for the same sphere.

The following values of time for the sphere to fall through 10.0 cm of oil are obtained.

0.83 s 0.69 s 0.60 s

(i) Calculate the average time that the sphere takes to fall through 10.0 cm of oil. Give your answer to 2 decimal places.

$$\text{average time} = \frac{0.83 + 0.69 + 0.60}{3}$$

$$= 0.71\text{ s (2 d.p.)}$$

average time = 0.71s [1]

(ii) Determine the average speed of the sphere as it falls between the rubber bands

average speed = 10 ÷ 0.71
= 14 cm s^{-1} (2 s.f.)

average speed = ... 14 ..... cm s^{-1} [1]

(iii) The average speed determined in (b)(ii) is the terminal speed of the sphere.

Explain, in terms of the forces, why the sphere reaches terminal speed.

no mention of oil.

It reaches terminal speed as the speed of the sphere is increasing, so the (drag oil) water resistance is increasing, which decreases the acceleration until the forces acting on it are balanced and the net force is zero.

What forces? (drag force and weight)

..... [2]

(As speed increases, drag force increases. At terminal speed, its drag force and weight are balanced.)

(c) Explain why the top rubber band is not placed close to the surface of the oil.

To ensure all the spheres have enough time to reach terminal speed.

..... [1]

(d) The student repeats the procedure using steel spheres of different diameters d and plots a graph of terminal speed v against d^2, as shown in Fig. 4.2.

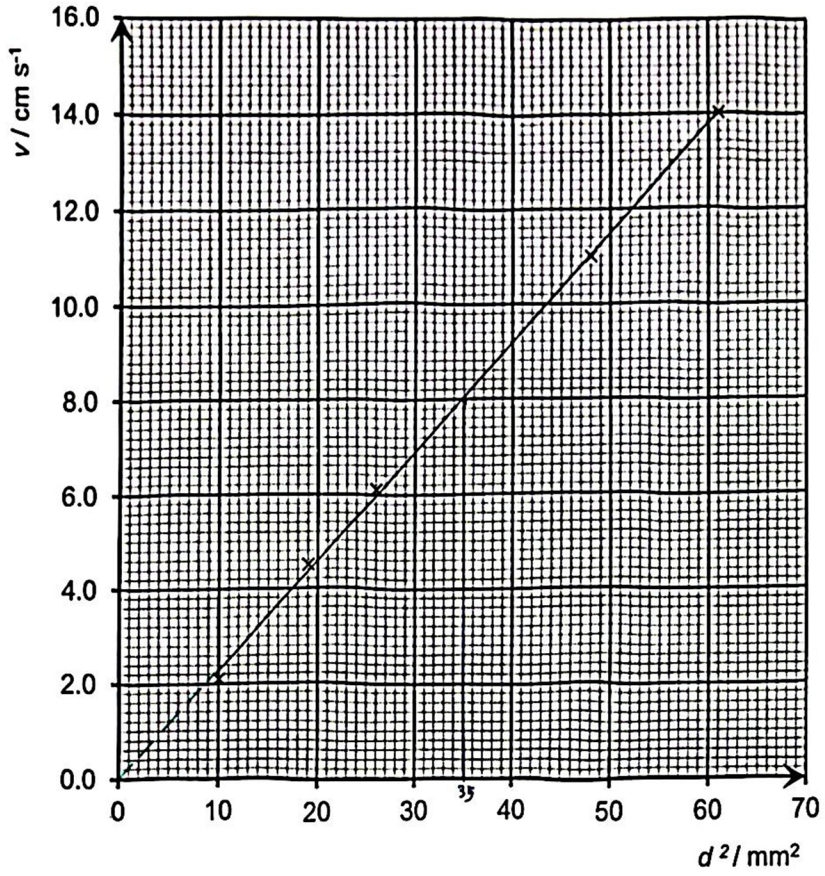


Fig. 4.2

(i) Using Fig. 4.2, describe the relationship between v and d^2.

replurase properly.

0+1

As d^2 increases, v increases in a linear way. [1]

(v is directly proportional to d^2.) linearly.

(ii) Using Fig. 4.2, determine the diameter of the sphere with a terminal speed of 8.0 cm s^{-1} in oil.

$d^2 = 35$

$d = 5.9$ (2 s.f.)

diameter = 5.9 mm [1]

[Total: 8]

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