SERANGOON JUNIOR COLLEGE
JC1 MID YEAR EXAMINATION
General Certificate of Education Advanced Level
Higher 2

H2 - SOLUTIONS

CANDIDATE NAME

CIVICS GROUP | 1 | S | R | | |

INDEX NUMBER

12345678

PHYSICS

9646

Multiple Choice and Structured Questions

27 May 2013

2 hours

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Civics Group and index number on the Answer Sheet in the spaces provided.

Section A
There are **twenty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the OMS.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

Section B
Answer **all** questions.
Show all your workings clearly on the question paper.

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

For Examiners' Use	
MCQ	/ 20
Q1	/ 4
Q2	/ 10
Q3	/ 7
Q4	/ 9
Q5	/ 6
Q6	/ 6
Q7	/ 8
Total marks	/ 70

This document consists of **24** printed pages and **0** blank page.

DATA AND FORMULAE

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
			$(1 / (36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos\omega t$
	v	=	$\pm\omega\sqrt{\left(x_0^2 - x^2\right)}$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$Q / 4\pi\varepsilon_o r$
alternating current/voltage,	x	=	$x_0 \sin\omega t$
transmission coefficient,	T	$\propto$	$\exp(-2kd)$
			where $k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{0.693}{t_{\frac{1}{2}}}$

Section A

1 Which of the following estimates is unrealistic?

A The kinetic energy of a man running in an Olympic 100-metre dash is 20 000 J.

B The time taken to drive from the East to the West of Singapore by the expressway is half an hour.

C The time taken to mow a school field with a mower that is 0.5 m wide and moves with a speed of 1 km h^{-1} is 10 h.

D The height of a 10-storey building is 35 m.

Ans: A

Estimated kinetic energy of a man running in an Olympic 100-m dash

$$=\frac{1}{2}(60)(10)^2 = 3000\ J$$

Estimated time taken to drive from the East to the West of Singapore = $\frac{40\ km}{100\ km\ h^{-1}} = 0.4\ h$

Estimated time taken to mow a school field:

Field size estimated at 100 *m* x 50 *m*.

Since mower is 0.5 *m* wide, there are about 50/0.5 = 100 rows to mow.

Time taken = $\frac{100}{1000}\times 100 = 10\ h$

Estimated height of a 10-storey building = 10 x 3.5 *m* = 35 *m*

2 In an experiment to determine the specific heat capacity of a liquid, *c*, each of four students made a series of measurements. The results are as shown in the given table. If the true specific heat capacity of the liquid is 2100 J kg^{-1} K^{-1}, which of the students obtained the most precise results?

Student	Results / J kg^{-1} K^{-1}			
A	2097	2102	2101	2102
B	2110	2097	2095	2094
C	2095	2097	2096	2097
D	2105	2110	2103	2100

Ans: C

3 Which of the following statements about the accuracy of measurements is false?

A Accuracy is a measure of the correctness of results rather than their reproducibility.

B The accuracy of measurements can be improved by taking the average of repeated readings.

C The accuracy of measurements can be improved by ensuring that the measuring instrument is properly calibrated.

D Good accuracy is associated with small systematic errors.

Ans: B

4 A car undergoes several gear changes, and accelerates with the following acceleration values:

4.0 m s^{-2} for 15 s

3.0 m s^{-2} for 30 s

2.0 m s^{-2} for 45 s

What is the average acceleration of the car?

A 0.1 m s^{-2}

B 2.7 m s^{-2}

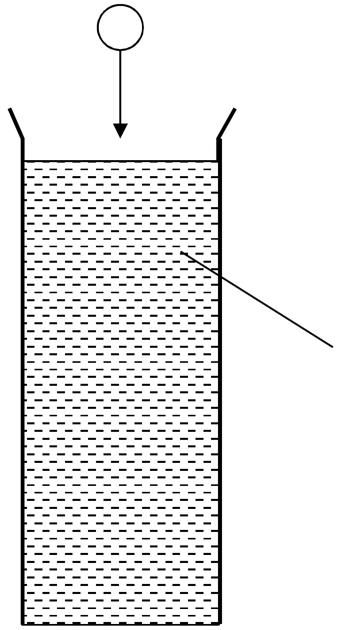
C 3.0 m s^{-2}

D 3.5 m s^{-2}

Ans: B

$$\text{average acc} = \frac{\text{change in velocity}}{\text{time}}$$
$$= \frac{4(15)+3(30)+2(45)}{15+30+45}$$
$$= 2.7$$

5 In the diagram below, a ball enters a deep tank of viscous fluid with a non-zero velocity, and eventually achieves terminal velocity.



Which of the following statement(s) is/ are true about the motion of the ball?

(i) The ball will definitely slow down.

(ii) The ball will definitely experience a drag force directed upwards.

(iii) The ball will eventually experience a zero net force.

A (i) only

B (i) and (ii) only

C (ii) and (iii) only

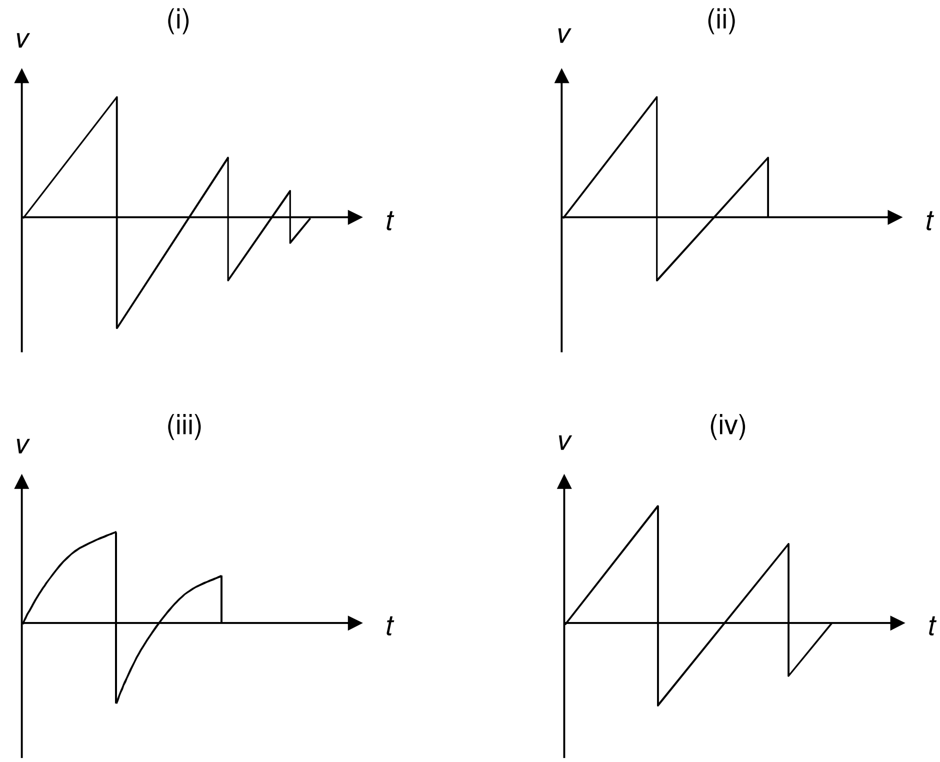
D (i), (ii) and (iii)

Ans: C
If the ball enters the ball at low speed, it will initially experience a net downward force, and speeds up. As the magnitude of drag force (directed upwards opp to motion) experienced increases, the net force eventually reduces to zero, hence achieving terminal velocity.

Conversely, if the ball enters the ball at high speed, it will initially experience a net upward force, and slows up. As the magnitude of drag force (directed upwards opp to motion) experienced decreases, the net force eventually reduces to zero, hence achieving terminal velocity.

For Examiner's Use

6 In an experiment to investigate the bouncing motion of a ball, a ball is dropped from a given height and allowed to bounce. The experiment is conducted several times, in both vacuum and non-vacuum environments.



In each experiment, the velocity time graph of the ball depicts the motion from the moment of release, until the ball comes to a complete rest. Which of the following graphs are **not** possible velocity-time graphs?

A (i) and (ii) only

B (ii) and (iii) only

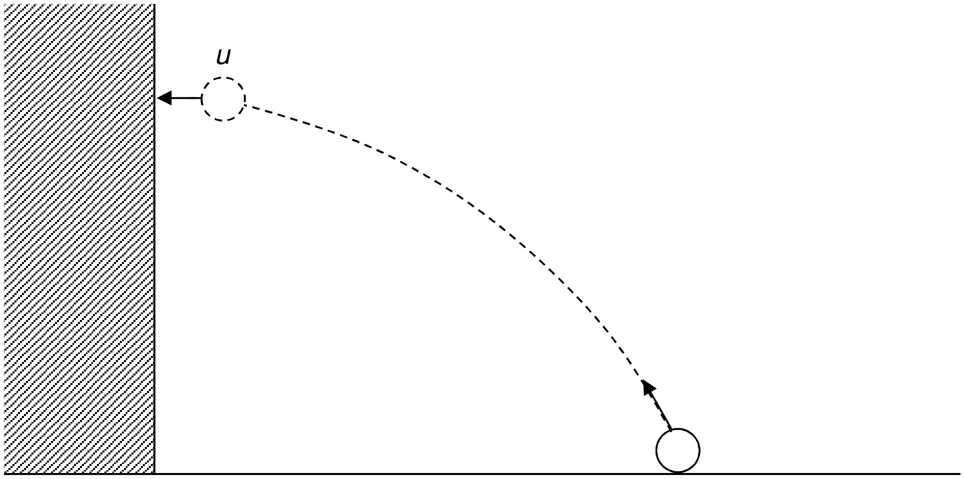
C (iii) and (iv) only

D (i) and (iv) only

Ans: D
Graph (i) is not possible because the 2nd and 3rd triangles should have the same areas under the graph since the rebound height and falling height should be the same in between 2 consecutive bounces.
Graph (iv) is not possible because there should always be odd number of "triangles" in this case, since the ball cannot stand still in mid air.

For Examiner's Use

7 A ball is projected from the floor at an angle to the horizontal, as shown in the diagram below. The time taken for the ball to reach the wall is *t*. Take air resistance to be negligible.



The ball hits the vertical wall perpendicularly with a speed *u*, and rebounds perpendicularly with a speed of less than *u* from the wall.

What could be deduced about the time taken for the ball to reach the ground after rebounding from the wall?

A Less than *t*

B Same as *t*

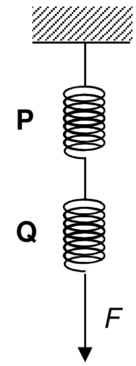
C More than *t*

D Cannot be determined

Ans: B
Consider the vertical motion of the ball.
In both the upward and downward cases, the ball experiences the same value of Δ*s*, *g*, and the horizontal speed before and after rebound is zero, ∴ the time taken from floor to wall, is the same as that from wall to floor again.
[Similar to situation where time taken for a ball thrown up is same as time taken for ball to reach original point again].

For Examiner's Use

8 Two springs are connected in series as shown in the diagram below. Springs **P** and **Q** have spring constants 3.0 N m^{-1} and 3.5 N m^{-1} respectively. A force *F* is applied to extend the springs. The extension of spring **P** is 3.80 cm.



What is the extension of spring **Q**?

A 1.75 cm **B** 2.05 cm **C** 3.26 cm **D** 6.50 cm

Ans: C

$F_P = F_Q$

$k_P x_P = k_Q x_Q$

$(3.0)(3.80) = (3.5)x_Q$

$x_Q = 3.26cm$

9 When a force of 20 N is applied, a spring extends by 2 cm. Assuming that the spring obeys Hooke's Law, what is the additional elastic potential energy stored in the spring when an additional 30 N weight is added?

A 0.45 J

B 0.5 J

C 1.05 J

D 2.10 J

Ans: C

When total weight is 20 + 30 = 50 N, spring extends by 5 cm (using proportionality).

F = kx

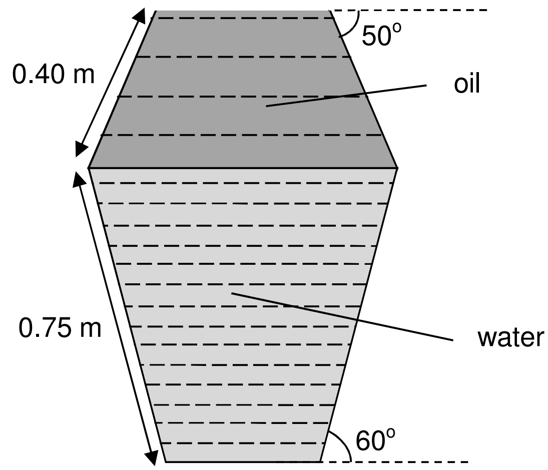
20 = k (0.02)

K = 1000 N m^{-1}

Increase in EPE = ½ k ($x_2^2 - x_1^2$) = ½ (1000) ($0.05^2 - 0.02^2$) = 1.05 J

For Examiner's Use

10 A container, filled with water and oil, has its dimensions shown in the diagram below. The densities of water and oil are 1000 kg m^{-3} and 960 kg m^{-3} respectively.



What is the pressure at the bottom of the container due to the two liquids?

A 1130 Pa

B 6100 Pa

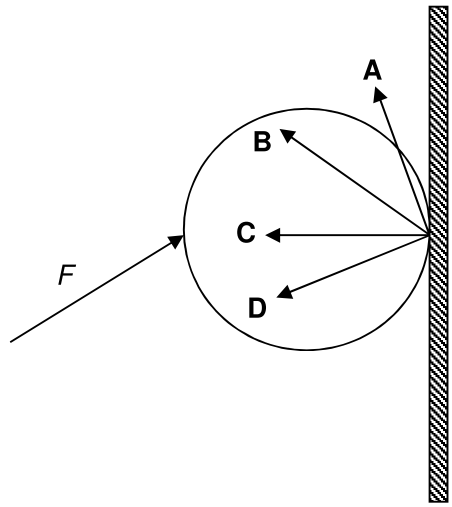
C 9260 Pa

D 11100 Pa

Ans: C

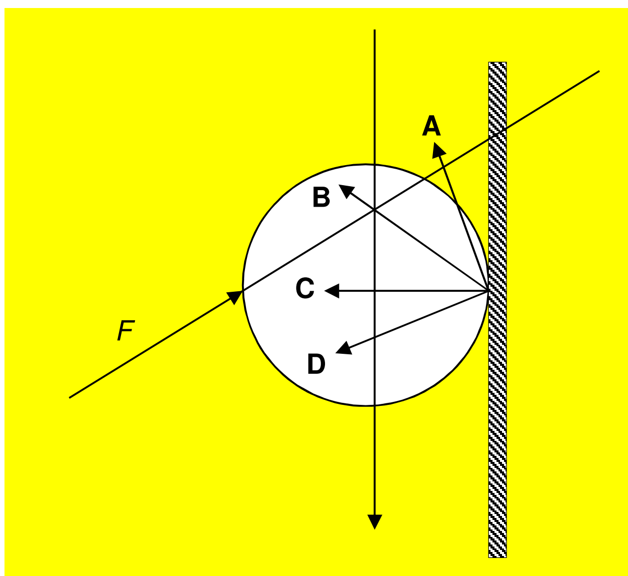
$$P = h_w \rho_w g_w + h_o \rho_o g_o$$
$$= (0.75 \sin 60^o)(1000)(9.81) + (0.40 \sin 50^o)(960)(9.81)$$
$$= 9260 Pa$$

11 John pushes a heavy uniform ball against the wall with a force *F*. Which of the following arrows correctly shows the direction of the force the wall acts on the ball?



Ans: B

Concurrent forces



For Examiner's Use

12 A box of mass 2 kg, initially at rest, is subjected to a variable force F as shown in the graph below.

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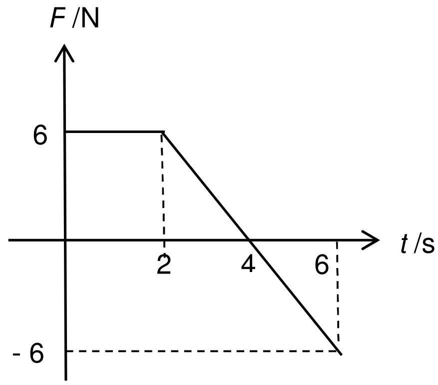


What is the maximum kinetic energy attained by the box during these 6 s ?

A 6 J **B** 9 J **C** 36 J **D** 81 J

Ans: D

Maximum speed is at t = 4 s.

m (v – u) = ½ (2+4)(6)

m (v – 0) = 18

v = 9 m s^{-1}

Therefore, max KE = ½ (2)(9)^2 = 81 J.

13 An object of mass 2 kg is hung on a spring balance from the ceiling of the lift. If the reading in the spring balance is 28 N, what is the acceleration of the lift? Take g to be 10 m s^{-2}.

A 2.8 m s^{-2} upwards

B 2.8 m s^{-2} downwards

C 4 m s^{-2} upwards

D 4 m s^{-2} downwards

Ans: C

T – mg = ma (Taking upwards to be +ve)

28 – 2(10) = ma

8 = 2a

a = 4 m s^{-2}

14 Which of the following pairs of forces is an action-reaction pair?

A Weight of a floating object and the upthrust acting on it.

B The force a ladder leaning on a wall exerts on the rough floor and the normal reaction by the floor.

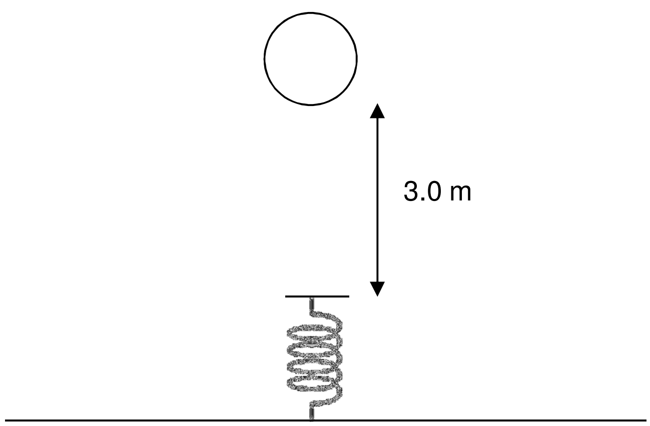
C The force a ladder leaning on a smooth wall exerts on the wall and the normal reaction force by the wall.

D Weight of a parachutist and the pull of the parachute on him when he is moving with terminal velocity.

Ans: C

Action and reaction forces must be equal in magnitude and opposite in direction as well as of the same type.

15 A ball of mass 5.0 kg is dropped from rest, from a height of 3.0 m above the top of a spring of force constant 90 N m^{-1} as shown below.



Assuming no energy loss due to dissipative forces, what is the maximum kinetic energy attained by the ball?

A 148 J **B** 161 J **C** 174 J **D** 575 J

Ans: B

At max ke, $F_{net} = 0$,

$$kx - mg = 0 \qquad \Rightarrow x = \frac{5 \times 9.81}{90} = 0.545\,\text{m}$$

By COE, Loss in GPE = Gain in KE + Gain in EPE

$$mg(h + x) = ke_{max} + \frac{1}{2}kx^2$$

$$(90)(9.81)(3.0 + x) = ke_{max} + \frac{1}{2}(90)\left(0.545^2\right)$$

$$ke_{max} = 161\text{J}$$

For Examiner's Use

16 An electric motor is required to haul a cage of mass 200 kg up a mine shaft through a vertical height of 800 m in 4.0 minutes.

What will be its electrical power required if its overall efficiency is 75%?

A 0.89 kW

B 4.9 kW

C 5.2 kW

D 8.7 kW

Ans: D

(200 x 800 x 9.81)/(4 x 60) = 75% of P

P = 8720 W

17 The drag force against the motion of an object in a liquid is proportional to the square of its speed. The engine of a motorboat delivers 30 kW to the propeller while the boat is cruising at a constant velocity of 15 m s^{-1}. When its engine failed, it is towed to the shipyard at a constant velocity of 20 m s^{-1}.

What is the tension in the towline?

A 1100 N **B** 1500 N **C** 2700 N **D** 3600 N

Ans: D

P = F v
30 000 = F (15)
F = 2 000 = k v^2 = k $(15)^2$
k = 8.89

F(drag) = 8.89 (20)2 = 3556 N
T = 3556 N

18 A hockey player is rotating his stick at 1800° per second at the instant when he hits the disc. If the tip of the stick is located 1.2 m from the axis of rotation, what is the linear speed of the tip of the stick at impact?

A 12.0 m s^{-1} **B** 18.8 m s^{-1} **C** 37.7 m s^{-1} **D** 75.4 m s^{-1}

Ans: C

1800° s^{-1} = (1800 / 180) x 3.14 = 31.4 rad s^{-1}
v = rω
= 1.2 x 31.4 = 37.7 m s^{-1}

19 A pebble of weight W is tied to a light string and is swung in a vertical circular motion. At the highest point of its path, the tension in the string is T and the centripetal force is F.

Which of the following statements is true?

A $F = T - W$

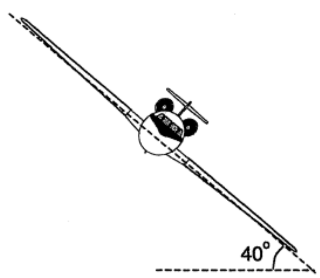
B $F = W + T$

C The net force acting upwards on the stone is $F + T + W$

D The net force acting upwards on the stone is $F - (T + W)$

Ans: B
At the highest point, both the tension and weight are pointing (downwards) towards the centre.

20 A Boeing-747 airplane flies in a horizontal circle at a speed of 130 m s^{-1}. If the wings of the plane are tilted 40° to the horizontal, what is the radius of the circle in which the plane is flying?



A 2.8 km **B** 2.5 km **C** 2.1 km **D** 1.5 km

Ans: C

L sin 50 = mg – equation 1
L cos 50 = mv^2/r – equation 2
tan 50° = rg/v^2 – equation 1 divided by equation 2
r = (tan50° x (130)^2)/(9.81) = 2053 m = 2.1 km

H2 - SOLUTIONS

For Examiner's Use

Section B

1 **(a)** The theoretical relationship of X is given by the equation $X = \sqrt{\frac{2Hke^2}{mg}}$ where k is the spring constant, m is the mass of pellet and e is the compression of the spring before firing the pellet. The following readings were obtained:

$e = (1.94 \pm 0.01) \times 10^{-3}$ m

$X = (160 \pm 2) \times 10^{-4}$ m

$H = 6.400$ m $\pm$ 6 %

Given that $k = 5.20$ N m^{-1} and $g = 9.81$ m s^{-2}, determine the value of m, expressing it with its associated uncertainty.

$$X = \sqrt{\frac{2Hke^2}{mg}}$$

$$m = \frac{2Hke^2}{X^2 g} = \frac{2 \times 6.400 \times 5.20 \times \left(1.94 \times 10^{-3}\right)^2}{\left(160 \times 10^{-4}\right)^2 \times 9.81} = 0.0997 \text{ kg}$$

$$\frac{\Delta m}{m} = \frac{\Delta H}{H} + 2\frac{\Delta e}{e} + 2\frac{\Delta X}{X}$$

$$\frac{\Delta m}{m} = 0.06 + 2\left(\frac{0.01}{1.94}\right) + 2\left(\frac{2}{160}\right)$$

$\Delta m = 0.00950 \approx 0.01\ kg$ (1 s.f.)

$m \pm \Delta m = (0.10 \pm 0.01)\ kg$

m = (………….. ± ……….) kg [3]

(b) Determine the variable which has the least impact on the reliability of m.

$$\frac{\Delta H}{H} = 0.06 \qquad \frac{\Delta X}{X} = 2\left(\frac{2}{160}\right) = 0.025 \qquad 2\left(\frac{\Delta e}{e}\right) = 2\left(\frac{0.01}{1.94}\right) = 0.0103$$

e has the smallest fractional error and hence has the least impact on the reliability of m.

………………………………………………………………………………………………………

………………………………………………………………………………………………………[1]

For Examiner's Use

2 **(a)** A motorcyclist initially at rest attempts to perform a stunt by accelerating up Ramp **A** inclined at 35°, as shown in **Fig. 2.1**, at a constant rate of 11.1 m s^{-2}. The height of Ramp **A** is 28.7 m.

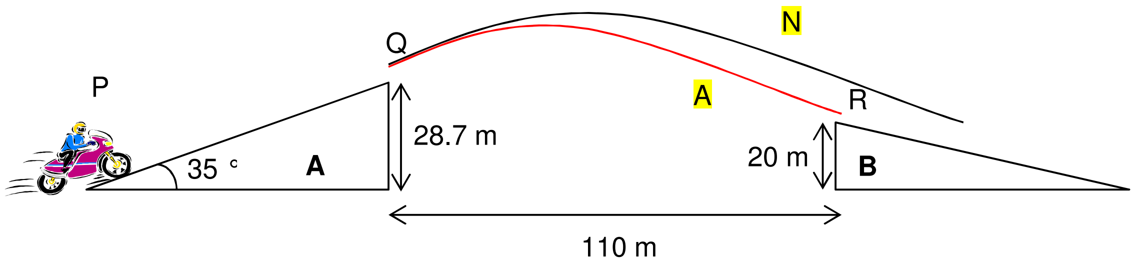


Fig. 2.1

(i) Show that the speed at which the motorcyclist takes off from Ramp **A** is 33.3 m s^{-1}. [1]

Consider path P → Q:

Let the length of ramp be *x*.

$x \sin 35° = 28.7 \Rightarrow x = 50.04$ m

$v^2 = u^2 + 2as$

$v^2 = 2(11.1)(50.04)$

$v = 33.33$ m s^{-1} (shown)

(ii) Determine if the motorcyclist is able to reach Ramp **B** that is 20 m high and is located 110 m away from Ramp **A**.

Consider path Q → R (take ↓ +ve):

$s_y = u_y t + \frac{1}{2} a_y t^2$

$8.7 = (-33.33 \sin 35°)t + \frac{1}{2}(9.81)t^2$

$t = 4.31$ s

Consider path Q → R (take → +ve):

$s_x = u_x t$

$s_x = 33.33 \cos 35° \times 4.31 = 117.7 m$

Since $s_x > 100$ m, the motorcyclist is able to reach the other ramp.

....

....[3]

For Examiner's Use

(b) Assuming air resistance is negligible,

1. sketch on **Fig. 2.1** the path of the motorcyclist and label this path **N**. [1]

2. sketch on **Fig. 2.2** a graph to show how the vertical component of the velocity v varies with time t while the motorcyclist is in the air. [1]

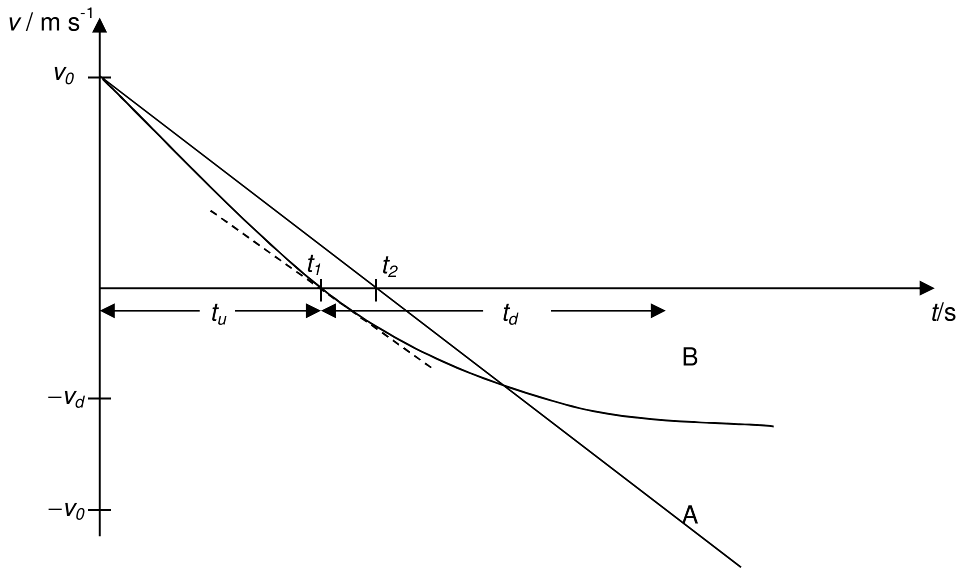


Fig. 2.2

(c) Assuming air resistance cannot be neglected,

1. sketch on **Fig. 2.1** the path of the motorcyclist and label this path **A**. [1]

2. sketch on **Fig. 2.2** a graph to show how the vertical component of the velocity v varies with time t while the motorcyclist is in the air. [1]

(d) Explain the differences, if any, between the two paths **N** and **A**.

Air resistance opposes the motion of the motorcyclist.
Vertically, the motorcyclist will decelerate more when rising because air resistance and weight acts in the same downwards direction. Hence, he will reach a lower height.

Horizontally, the motorcyclist will experience a net force backward due to air resistance, causing it to slow down and travel a shorter distance.

....[2]

For Examiner's Use

3 **(a)** State the conditions for an extended body to be in equilibrium.

1. **Resultant force must be zero (Translational Equilibrium)**
2. **Resultant moment about any point must be zero (Rotational Equilibrium)**

.... [2]

(b) **Fig. 3.1** shows a 3-metre uniform rod **XY** being hung from the centre of the rod. At the end **X**, a string is tied to a block **A** of volume 200 cm^3 submerged in a tank of water of density 1 g cm^{-3}. The density of the block is 7 g cm^{-3}. A 20.0 N weight is hung at a distance away from end **Y** of the rod. Take *g* to be 10 m s^{-2}.

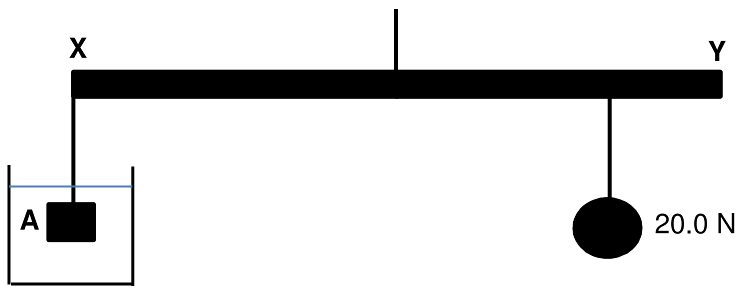


Fig. 3.1

(i) Calculate the tension in the string tied to the block **A**.

T + U = W

T + (200 x 1)/1000 x 10 = (200 x 7)/1000 x 10

T + 2.0 = 14.0

T = 12.0 N

tension = ……………….. N [2]

(ii) If the 20.0 N weight is now replaced by a 22.0 N weight placed at the same position and the setup is adjusted such that the objects are in equilibrium as shown in **Fig. 3.2**, calculate the corresponding upthrust experienced by the block **A**.

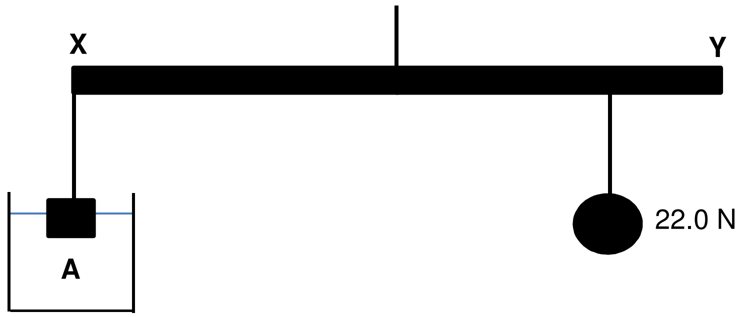


Fig. 3.2

In order for the rod to be equilibrium, net moments must be zero.

Let the distance that the weight is away from the centre of gravity be x.

12 (1.5) = 20 x

x = 0.9 m

When the 20.0 N weight is replaced by a 22.0 N weight, the additional clockwise moments created is 2 x 0.9 = 1.8 Nm. Hence the additional tension in the string must be 1.8 / 1.5 = 1.2 N

Since T' + U' = W

13.2 + U' = 14

U' = 0.8 N

upthrust = ………………….N [3]

4 (a) Define *impulse*.

Impulse the product of the average force acting on the object and the time the average force is acted on the object.

....

.... [1]

(b) An object of mass 2.0 kg is initially moving with a speed of 10 m s^{-1} as shown in **Fig. 4.1**. It is subjected to a force, *F*, as shown by the force-time graph in **Fig. 4.2**. Throughout its motion, it experiences a constant frictional force of 2.0 N.

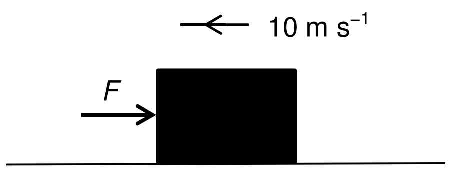


Fig. 4.1

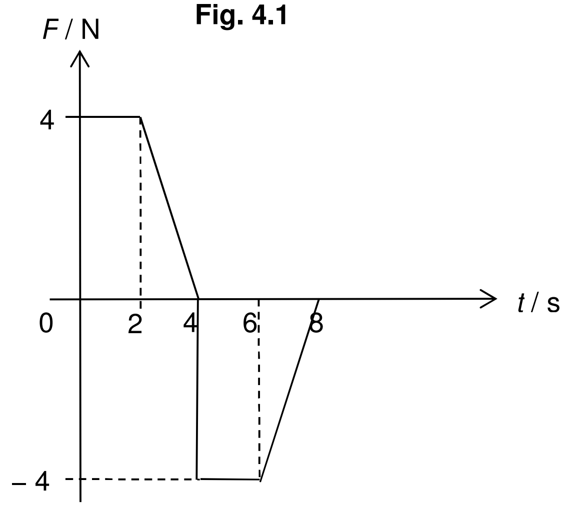


Fig. 4.2

(i) Sketch the resultant force, *R*, acting on the object from $t = 0$ to $t = 4$ s on **Fig. 4.3**. [1]

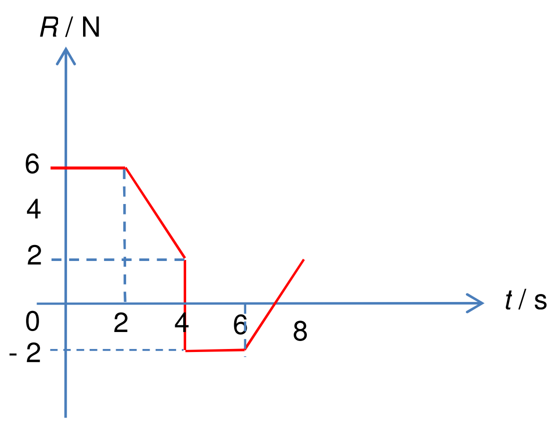


Fig. 4.3

(ii) Hence, or otherwise, show that the velocity of the object at $t = 4$ s is 0. [2]

Impulse = Area under F-t graph

= 2 x 6 +½ (2 + 6) (2) = 20 Ns

20 = 2(v_f – (-10))

V_f = 0 (shown)

(iii) From $t = 4$ s to $t = 8$ s, the force F, is now applied in the opposite direction as shown in **Fig. 4.2.** As a result, the object continues to move in the same direction as before.

(1) Sketch the resultant force, R, acting on the object from $t = 4$ to $t = 8$ s on **Fig. 4.3**. [1]

(2) Hence, or otherwise, determine the speed of the object at $t = 8$ s.

Impulse = Area under F-t graph

= - ½ (2+3)(2) + ½ (2)(1) = -4 Ns

-4 = 2(v_f – 0)

V_f = -2.0 m s^{-1}

Therefore, speed is 2.0 m s^{-1}

speed = ……………….. m s^{-1} [2]

(3) Sketch the velocity-time graph of the object from $t = 0$ to $t = 8$ s on **Fig. 4.4**. [2]

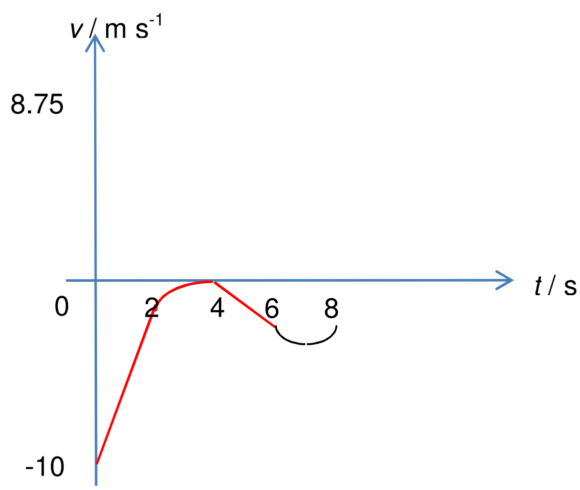
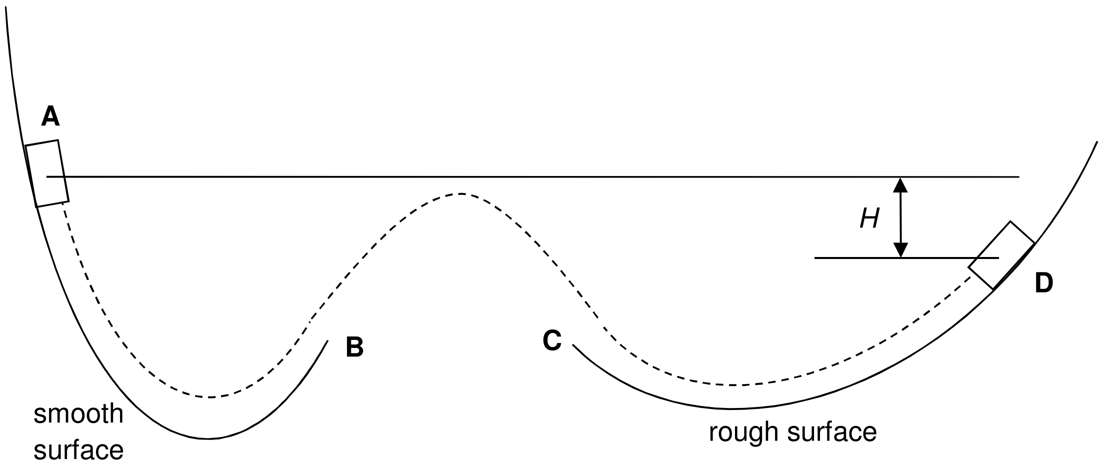


Fig. 4.4

For Examiner's Use

5 An object with a mass of 3.0 kg is released at point **A**. It slides down a smooth ramp and leaves the ramp at point **B**. It then undergoes a parabolic path and slides onto a rough surface at point **C** and comes to a rest at point **D**. Path **CD** is 2.5 m and the average frictional force acting on the block along **CD** is 2.0 N.



(a) Calculate the work done by friction on the block along **CD**.

$W = fd\cos\theta = (2.0)(2.5)\cos 180^o$

$W = -5.0J$

work done by friction = …………….. J [2]

(b) **(i)** Calculate the height *H*.

$loss \text{ in } GPE = work\ done\ against\ \ friction$

$mgH = 5.0$

$(3.0)(9.81)H = 5.0$

$H = 0.170m$

H = ……………….. m [2]

For Examiner's Use

(ii) Explain how the value of *H* changes if ramp **AB** is rough.

The value of H will be larger as more mechanical energy is lost due to frictional forces.

....

.... [1]

(c) Calculate the work done by the weight of the object as it moves from **A** to **D**.

$Work\ done\ by\ weight = -\Delta GPE = work\ done\ against\ \ friction$
$= 5.0J$

work done by weight = ... J [1]

For Examiner's Use

6 The diagram in **Fig. 6.1** shows a penguin, of weight 150 N in a large vertical cylinder. This cylinder spins about its axis fast enough that the penguin inside is held up against a rough wall without slipping. The radius of the cylinder is 6 m and it makes 2 complete revolutions in 5 s.

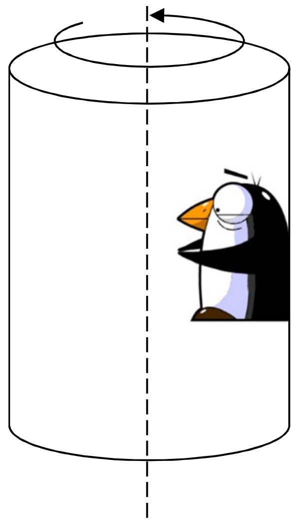


Fig 6.1

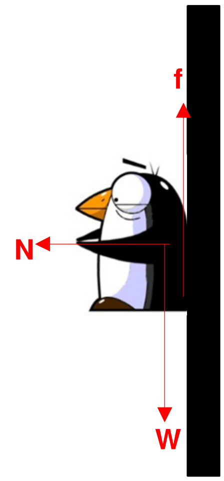


Fig 6.2

(a) In **Fig 6.2**, label t e following forces acting on the penguin:

(i) Weight of the penguin, *W*

(ii) Normal contact force, *N*

(iii) Friction exerted by the wall on the penguin, *f*

[1]

Normal force – N
Friction – f
Weight - W

(b) Calculate the centripetal force that is required to keep the penguin in circular motion.

2 revolutions in 5 s means 1 revolution in 2.5 s

Using $\omega = 2\pi / T$

$= 2\pi / 2.5$

$= 2.51 \text{ rad s}^{-1}$

By N2L, $F_{net} = ma$

$F_C = mr\omega^2$

$F_C = (150/9.81)(6)(2.51)^2$

$= 578 \text{ N}$

centripetal force = ……………..………N [2]

For Examiner's Use

(c) The normal contact force *N* is related to the friction *f* by a constant known as the coefficient of friction, *μ*. Given that $f = \mu N$, calculate the value of *μ* in this case.

Since the normal contact force provides the centripetal force to keep the penguin in circular motion,

By N2L, $F_{net} = ma$

$N = mr\omega^2$

Since there is no net vertical force acting on the penguin,

$f - mg = 0$ (acc = 0)

Since $f = \mu N$

$\mu N = mg$

$\mu (mr\omega^2) = mg$

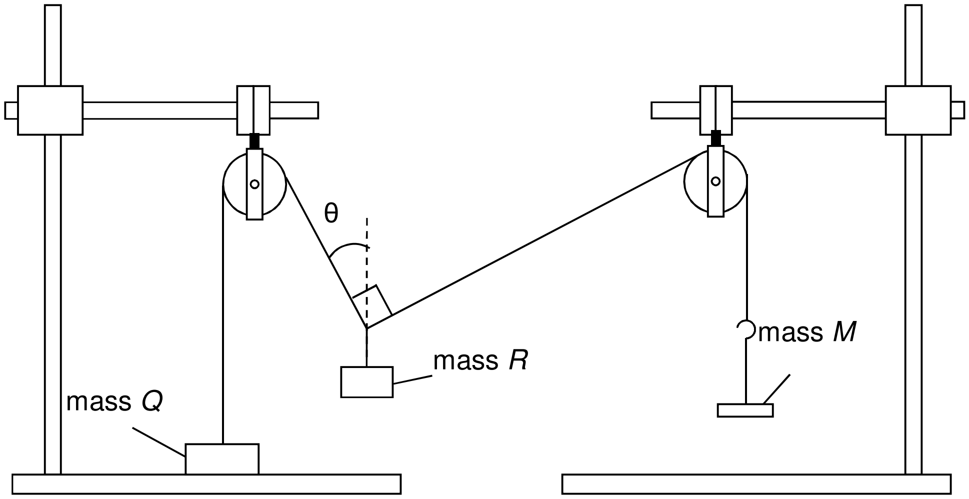
$\mu = g/r\omega^2$

$= 9.81/(6)(2.51)^2 = 0.26$

μ = …………..………. [3]

For Examiner's Use

7 In an experiment shown in the figure below, a student investigates how the angle θ between forces vary as one of the masses M is varied.



The readings for the mass M with the corresponding angles θ are shown in the table below. The student then completes the table for values of $\frac{1}{M^2}$ / kg^{-2} and $\frac{1}{\tan^2(\theta/^o)}$.

M / g	θ_1 / ° (loading)	θ_2 / ° (unloading)	θ_{avg} / °	$(1/M^2)$/ kg^{-2}	$\frac{1}{\tan^2(\theta/^o)}$
40	21	22	22	**630**	**6.1**
50	27	29	28	[redacted]	[redacted]
60	33	35	34	[redacted]	[redacted]
70	43	44	42	[redacted]	[redacted]
80	49	51	50	[redacted]	[redacted]
90	58	60	59	[redacted]	[redacted]

(a) **(i)** Fill in the blanks in the first row of the table. [1]

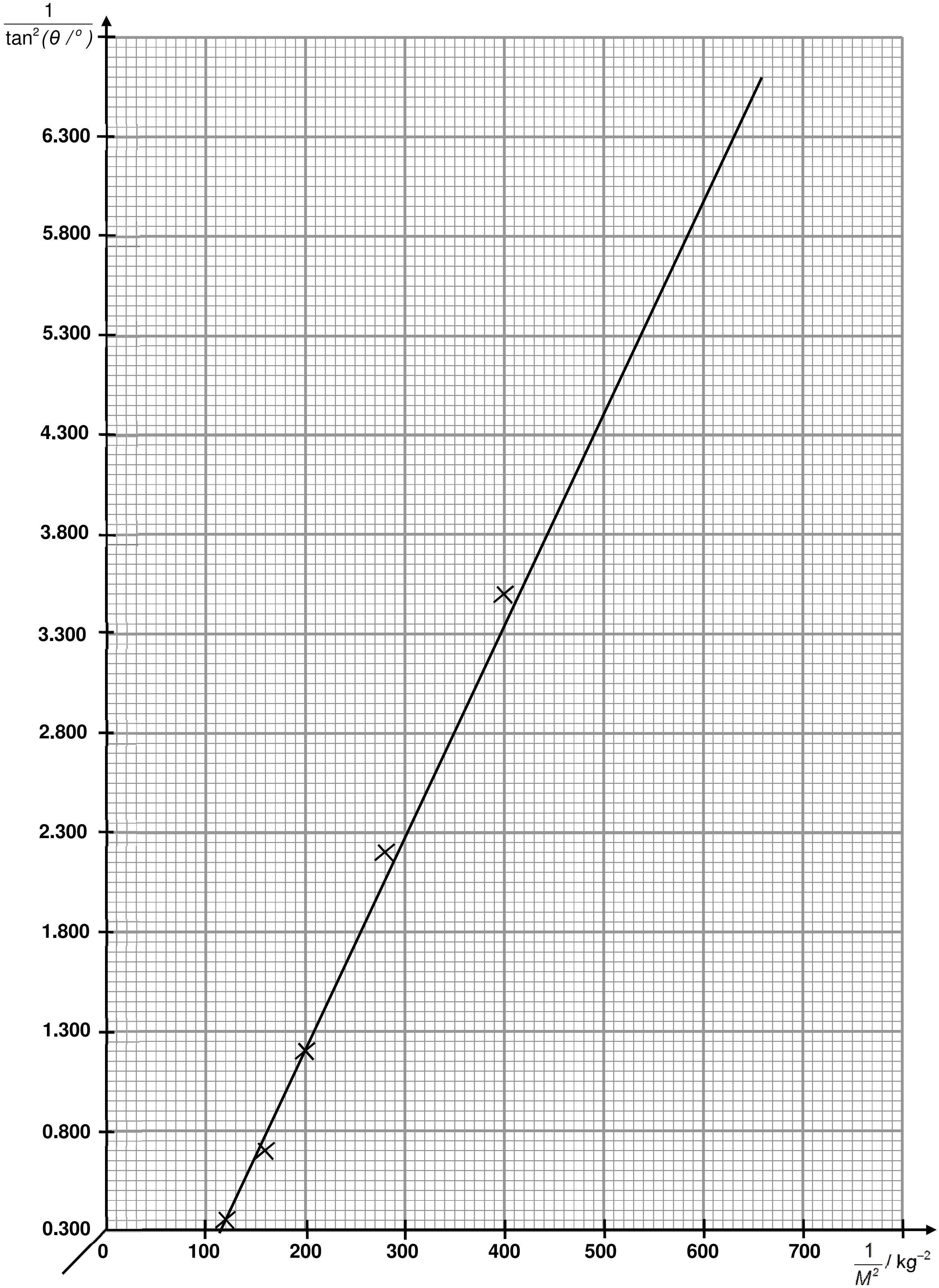
(ii) Plot the missing point found in **a(i)** on the graph. The rest of the points have been plotted for you. [1]

(b) Theory suggests that

$$\frac{1}{\tan^2\theta} = \frac{R^2}{M^2} - k \qquad \text{where } R \text{ and } k \text{ are constants}$$

A graph of $\frac{1}{\tan^2(\theta/^o)}$ against $\frac{1}{M^2}$ / kg^{-2} is plotted on the graph paper provided.

For Examiner's Use



For Examiner's Use

(i) Determine the value of *R* with its unit.

From the graph, using coordinates (640.0, 6.400) and (200.0, 1.300)

Gradient = $\frac{6.400-1.300}{640-200}=\frac{5.100}{440}=0.0116$ **(3 s.f.)**

R^2 **= 0.0116**

R **= 0.108 (3 s.f.) kg**

R = ………………….. unit: ……………. [3]

(ii) Determine the value of *k*.

$y=mx+c$

$6.400=(0.1078)(640)+c$

$c=6.400-69.0$

$c=-62.6$

$-k=-62.6$

$k=62.6$

k = …………………… [2]

(iii) Comment on any anomalous data or results that you may have obtained.
Explain your answer.

There are no anomalous points as all the points plotted are evenly distributed and bounded to the line of best fit.

....

....[1]