Name	Register Number	Class

GREENRIDGE SECONDARY SCHOOL
MID-YEAR EXAMINATION 2019
Secondary 3 Express

PHYSICS **6091**

9 May 2019
Thursday

2 hours
0800 – 1000

Additional Materials: 1 Sheet of OTAS

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READ THESE INSTRUCTIONS FIRST

Write your name, register number and class on this cover and all the work you hand in.
Write in blue pen or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.
The use of an approved scientific calculator is expected, where appropriate.
You may assume g = 10 m/s^2 whenever necessary, unless otherwise stated.

Section A
Answer **all** questions in soft pencil on the OTAS.

Section B
Answer **all** questions in the spaces provided.

Section C
Answer **all** questions in the spaces provided.

At the end of the examination, hand in the OTAS separately.

The number of marks is given in brackets [ ]
at the end of each question or part question.

For Examiner's Use	
Section A	/ 25
Section B	/ 45
Section C	/ 20
Total	/ 90

This paper consists of 22 printed pages, including this cover page.

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Section A

This section carries 25 marks.
Answer **all** questions in soft pencil on the OTAS.

1 A student measured the diameter of a marble using different instruments. The readings are tabulated below.

Instrument used	*Diameter*
X	0.0112 m
Y	1.124 cm
Z	11 mm

Which of the following correctly lists the instruments used?

	X	*Y*	*Z*
A	Metre rule	Micrometer	Vernier calipers
B	Metre rule	Vernier calipers	Micrometer
C	Micrometer	Vernier calipers	Metre rule
D	Vernier calipers	Micrometer	Metre rule

2 Fig. P shows the reading of a micrometer screw gauge when the spindle is totally closed. Fig. Q shows the reading when it measures the external diameter of a pipe.

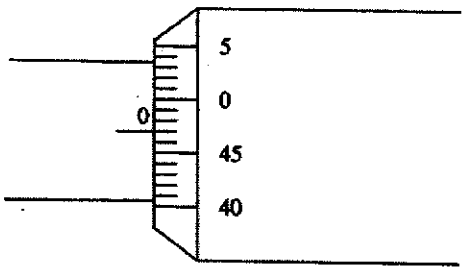


Fig. P

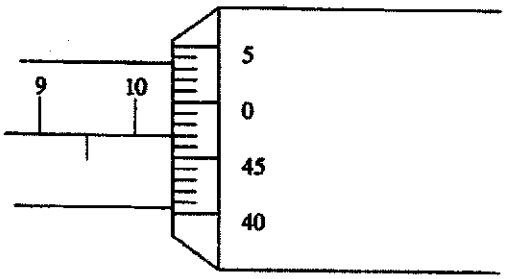


Fig. Q

What is the external diameter of the pipe?

A	10.44 mm	**B**	10.47 mm
C	10.48 mm	**D**	10.50 mm

3 Which of the following is an example of motion with non-zero acceleration?

A A helicopter hovering at constant height.
B An ice-skater moving at constant speed in a straight line.
C A ball tied to a string moving in a circle with constant speed.
D A man with an open parachute falling at terminal velocity while skydiving.

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4 A student recorded the data of three pendulums *P*, *Q* and *R* in the table below.

	Mass / g	*Volume / cm³*	*Length / cm*
P	20.2	5.0	90.0
Q	42.5	5.0	30.0
R	61.4	5.0	50.0

Which statement is true about their periods?

A All three pendulums have the same period.
B Period of P is longer than period of Q.
C Period of Q is longer than period of R.
D Period of R is longer than period of P.

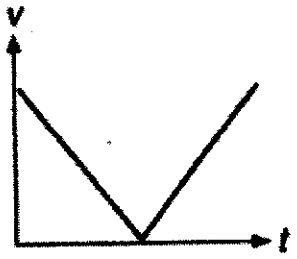
5 The velocity of a moving object is given by the

A area below a velocity-time graph.
B area below a displacement-time graph.
C gradient of a velocity-time graph.
D gradient of a displacement-time graph.

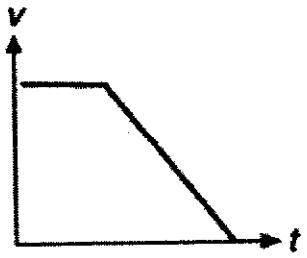
6 A man throws a soft ball vertically upwards. The ball eventually returns to the thrower after reaching a certain height. The initial speed of the ball is 20 m/s.

Neglecting air resistance, which of the speed-time graphs (**A**, **B**, **C** or **D**) best represents the motion of the ball?

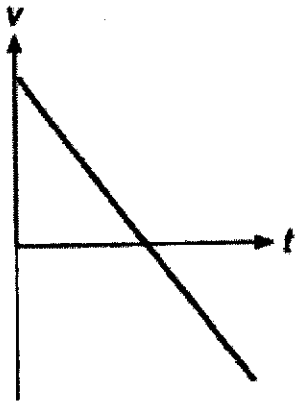
A



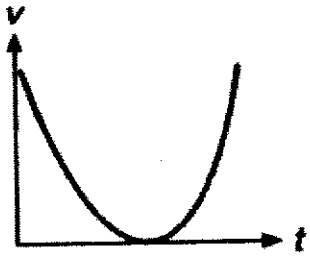
B



C



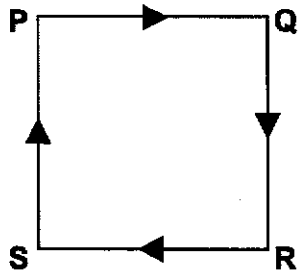
D



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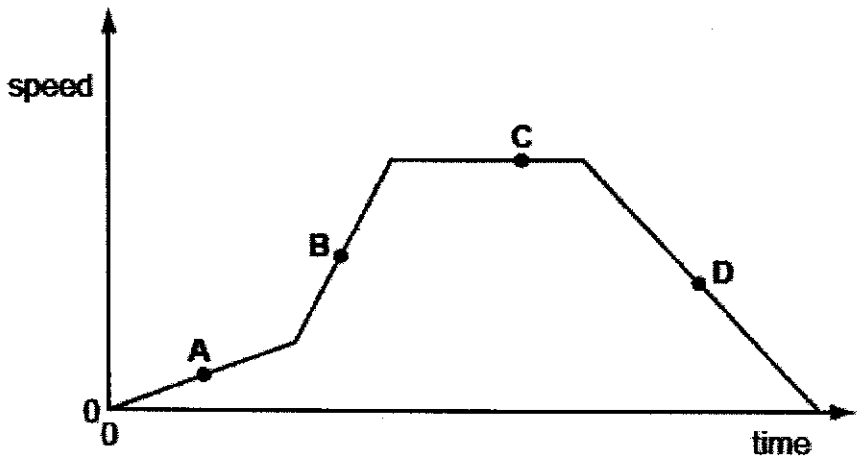
7 A student walks along the sides of a square PQRS with length 5 m as shown below. He starts at and returns to P in 20 s.



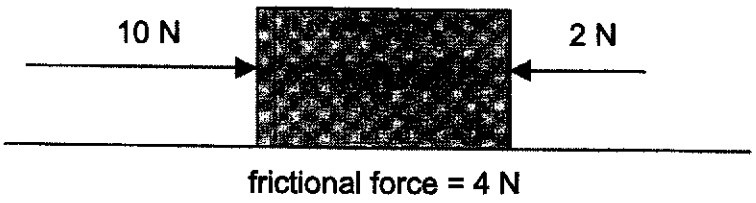
What is his average velocity?

A 0 m/s **B** 1 m/s **C** 2 m/s **D** 4 m/s

8 The speed-time graph shows the journey of a train. At which point (**A**, **B**, **C** or **D**) is the resultant force acting on the train at its maximum?



9 A boy pushes a box of mass 2 kg horizontally on a rough surface with a 10 N force. At the same time, a girl pushes the box with an opposing force of 2 N.



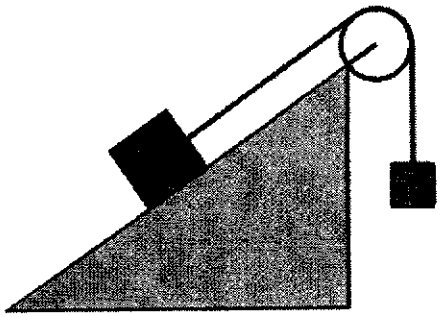
If the frictional force is 4 N, what is the acceleration of the box?

A 2 m/s^2 **B** 4 m/s^2 **C** 6 m/s^2 **D** 7 m/s^2

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10 Two boxes X and Y are connected by a string over a pulley on a slope, and they are at rest.



A student stated that the following forces may be acting on box Y.

- weight
- friction
- thrust
- tension
- normal reaction force

How many of the forces are in the free-body diagram for box Y?

A 1 **B** 2 **C** 3 **D** 4

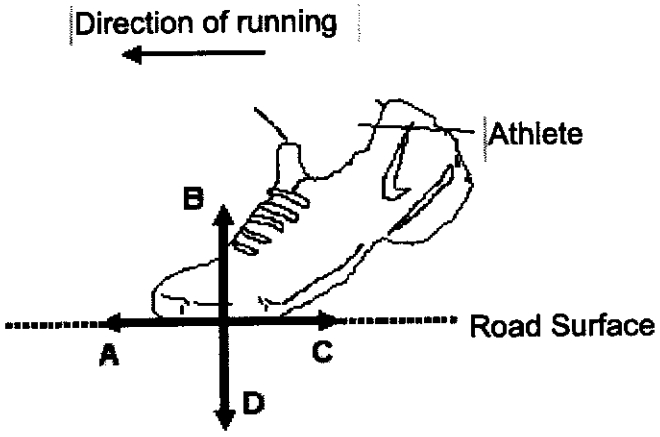
11 A body is moving in a straight line under the action of a constant resultant force.

Which of the following changes during its motion?

A acceleration **B** inertia

C mass **D** kinetic energy

12 The diagram below shows the foot of an athlete when he is about to run.

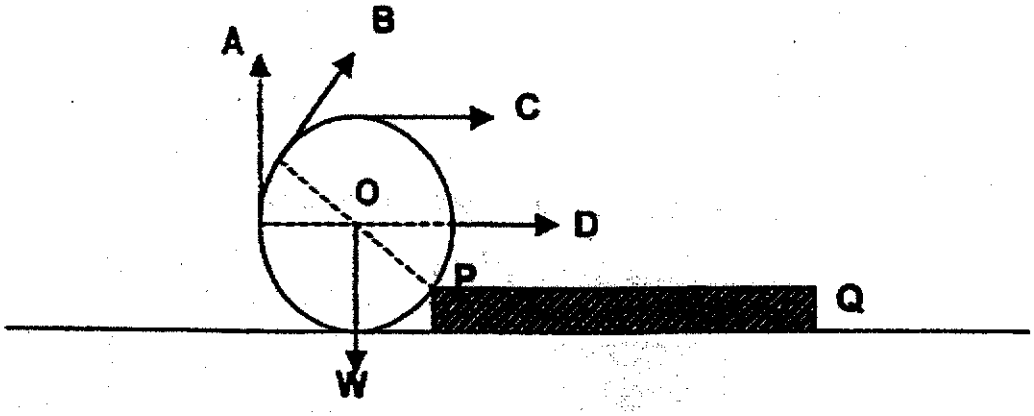


Which direction (**A**, **B**, **C** or **D**) does the frictional force act on the sole of his shoe?

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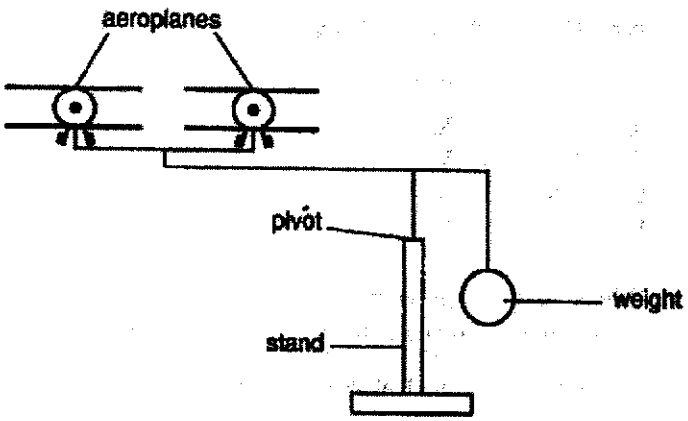
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13 The diagram below shows a heavy roller with weight W and its central axle at O, which is to be pulled onto a pavement PQ.



Which of the forces (**A**, **B**, **C** or **D**) is the smallest one to turn the roller up the pavement at point P?

14 The diagram shows a balancing toy pivoted on a stand. If the toy is tilted slightly, it does not overbalance but returns to its orginal position.



This is because the centre of gravity of the toy is

A below the pivot.
B between the aeroplanes.
C exactly at the pivot.
D inside the weight.

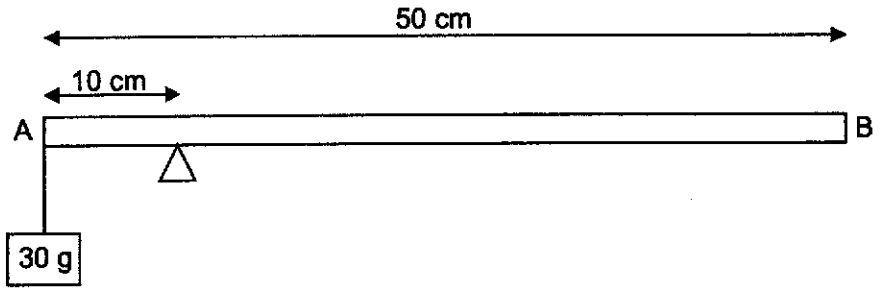
15 On Earth, a spring balance reads 6 N and a lever balance requires 6 discs to balance an object. Given that the gravitational field on Moon is 1/6 of its value on Earth, which of the following results are correct if the measurements are to be repeated on Moon?

	Spring balance reading / N	Number of discs to balance
A	1	1
B	6	1
C	1	6
D	6	6

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16 A uniform half-metre rule AB is balanced horizontally across a knife-edge placed 10 cm from A as shown in the diagram below. A mass of 30 g is hung from the end A.



What is the weight of the ruler?

A 0.20 g **B** 0.12 g **C** 0.20 N **D** 0.12 N

17 It is known that an object has very high inertia. This means that

A both starting and stopping the motion of the object are very difficult.
B both starting and stopping the motion of the object are very easy.
C it is easier to stop the motion of the object than to start the object moving.
D it is easier to start the object moving than to stop the motion of the object.

18 Five identical iron balls, each of mass 25 g, are immersed in a measuring cylinder containing 30 cm^3 of water. The reading of the water level rises to 50 cm^3.

What is the density of the iron (in g/cm^3)?

A 0.50 **B** 1.25 **C** 5.00 **D** 6.25

19 The table below shows the weights of some masses on the surface of four different planets. Which planet (**A**, **B**, **C** or **D**) has the greatest gravitational field strength, *g*?

	Mass / kg	**Weight / N**
A	2.0	24
B	3.0	30
C	5.0	35
D	8.0	40

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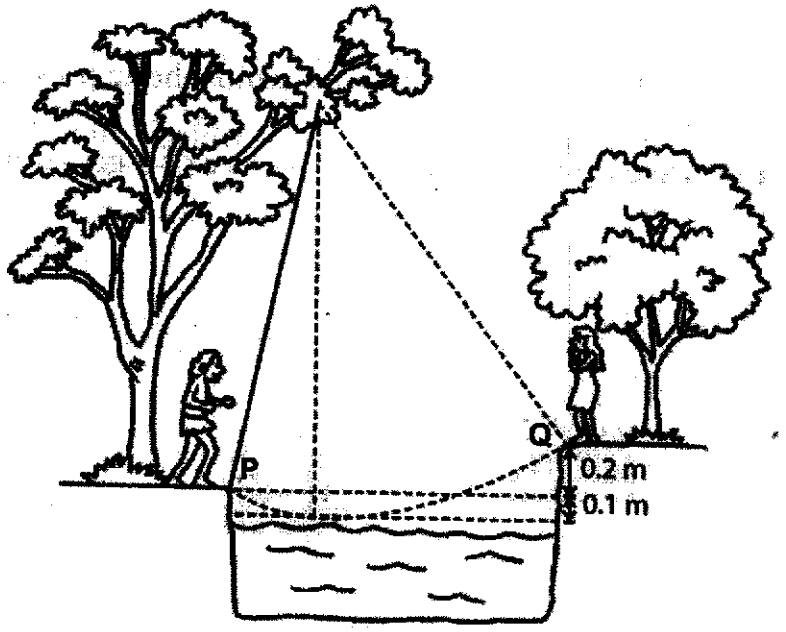
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20 A worker is lifting boxes of identical weight from the ground onto a moving belt. At first, it takes him 2.0 s to lift each box. Later in the day, it takes him 3.0 s.

Which of the following statements is correct?

A Later in the day, less work is done in lifting each box.
B Later in the day, less power is developed in lifting each box.
C Later in the day, more work is done in lifting each box.
D Later in the day, more power is developed in lifting each box.

21 Tarzan, whose mass is 85 kg, needs to swing across a piranha-infected river to save Jane from danger as shown below.



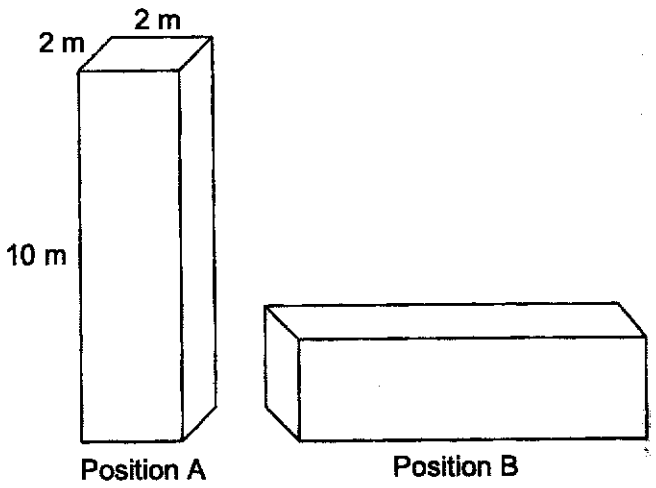
What is the minimum speed (in m/s) at which Tarzan must swing at P in order to reach Jane at Q?

A 1.41 **B** 2.00 **C** 2.45 **D** 4.00

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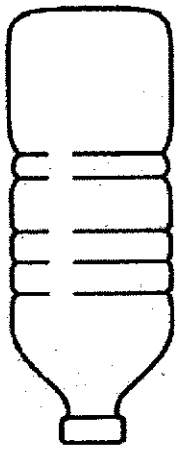
22 A steel block with density 8000 kg/m^3 falls from position A to position B as shown.



By considering the distance moved by its centre of gravity, how much gravitational potential energy is lost during the process?

A 12.8 MJ **B** 16.0 MJ **C** 25.6 MJ **D** 32.0 MJ

23 A bottle is filled with water. A cap is put on the bottle and it is turned upside down. There is no air inside the bottle. The area of the cap in contact with the water is 4.0×10^{-4} m^2, and the pressure that the water exerts on the cap is 3 kPa.



What is the mass of the water?

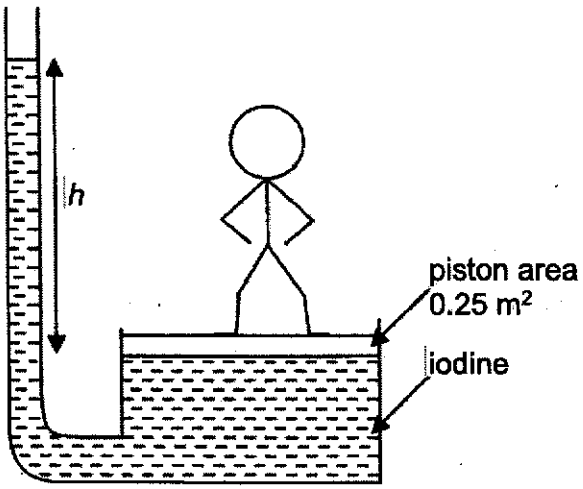
A 0.075 kg **B** 0.12 kg **C** 1.2 kg **D** 12 kg

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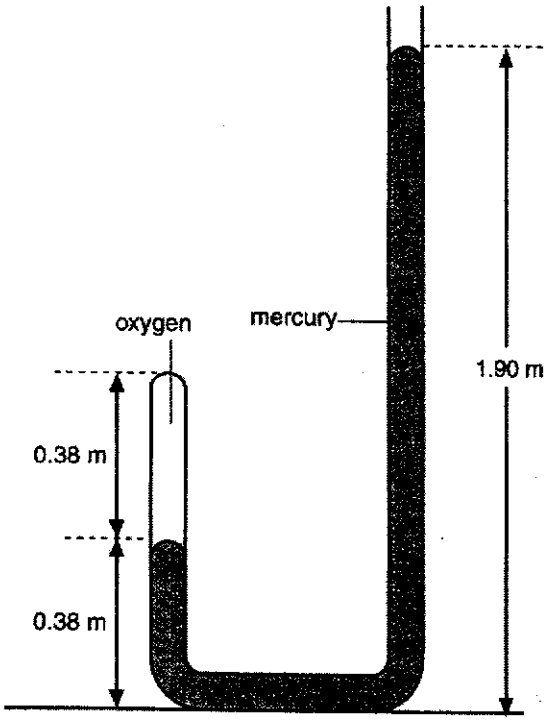
24 In an arrangement shown in the diagram below, a person of mass 50 kg stands on a platform over a piston of area 0.25 m^2. The diagram is **not** drawn to scale.



Given that the liquid is iodine with density 5000 kg/m^3, what will the height *h* be?

A 4 cm **B** 20 cm **C** 25 cm **D** 204 cm

25 Oxygen is compressed in the sealed end of a long J-tube by means of a column of mercury open to the atmosphere as shown.



Mercury has a density of 1.36×10^4 kg/m^3, and the atmospheric pressure is 1.0×10^5 Pa. What is the pressure of the oxygen in Pa?

A 1.5×10^5 **B** 2.0×10^5 **C** 2.5×10^5 **D** 3.0×10^5

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Section B

This section carries 45 marks.
Answer **all** questions in the spaces provided.

1 A window cleaner drops a sponge from a window at time $t = 0$ s. Fig. 1.1 shows the velocity-time graph for the motion of the sponge.

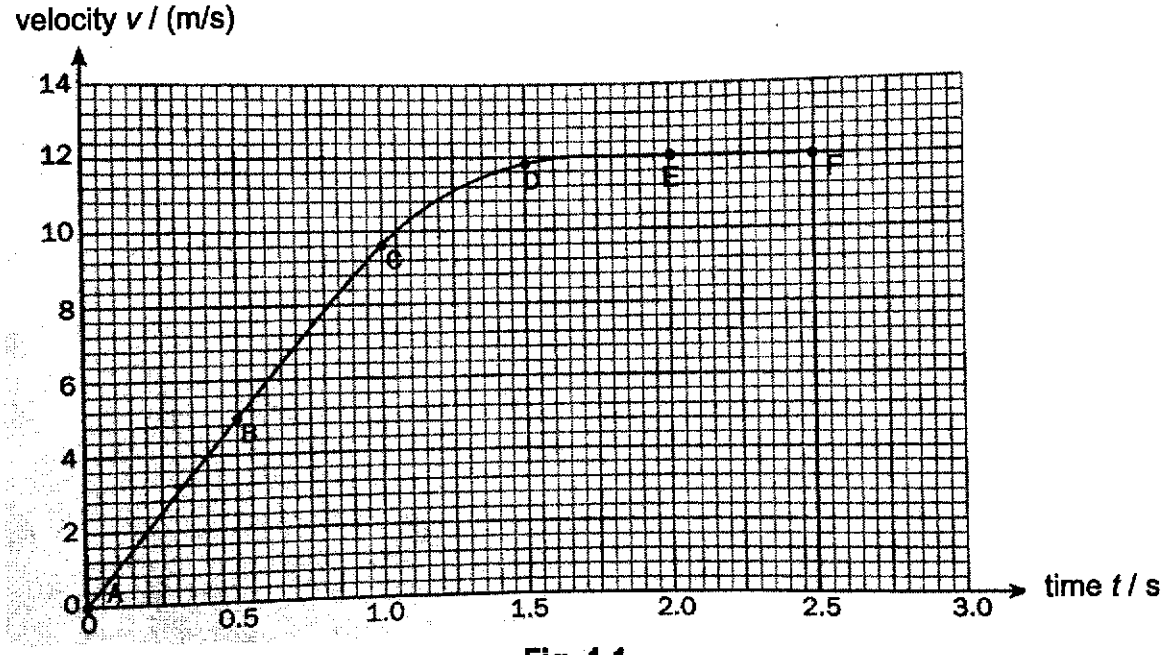


Fig. 1.1

(a) Describe and explain the **acceleration** of the sponge during the following time intervals.

(i) A to B: .....

.....

.....

.....

..... [2]

(ii) C to D: .....

.....

.....

.....

..... [2]

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(iii) E to F: .....

.....

.....

.....

..... [2]

(b) Estimate the height of the window from the ground below.

height = ... [2]

2 A kite of mass 5.0 kg is flying in the sky at a constant speed of 2.5 m/s on a windy day. The force of the wind can be seen as a single force of 80 N acting at an angle of 20° to the horizontal, as shown in Fig. 2.1. There is negligible tension force in the string as the string is loose.

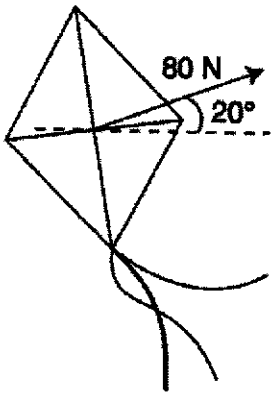


Fig. 2.1

(a) Explain why the resultant force on the kite is zero.

.....

..... [2]

(b) Calculate the weight of the kite.

weight = ... [1]

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(c) By means of a scale diagram, find the magnitude and direction of the lift force acting on the kite.

magnitude = ... [4]

direction = ... [1]

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3 Fig. 3.1 shows a helicopter stationary in the air. Vertical forces are produced by the front rotor and by the back rotor. The weight of the helicopter is 150 kN. Horizontal distances are marked on Fig. 3.1.

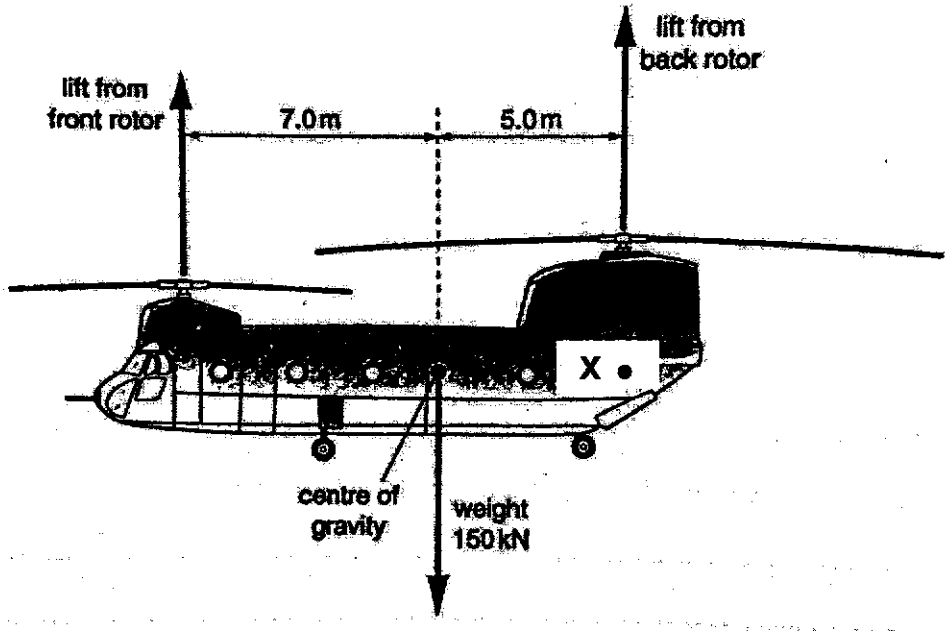


Fig. 3.1

(a) (i) Describe **two** differences between mass and weight.

.....

.....

.....

.....

..... [2]

(ii) Determine the mass of the helicopter.

mass = ... [1]

(b) (i) By taking moments about point X, calculate the lift force from the front rotor.

lift force = ... [2]

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(ii) Calculate the lift force from the back rotor.

lift force = ... [2]

(c) The helicopter pilot adjusts the lift forces at the front and back of the helicopter. The front of the helicopter tilts down, whilst the centre of gravity of the helicopter stays at the same height. State and explain how the lift forces from the rotors are adjusted to achieve this effect.

.....

.....

.....

.....

..... [2]

4 A marble of mass 5 g which is initially at rest is released from the top of a track as shown in Fig. 4.1. The marble moves round the perfectly smooth loop ABCD and then along a rough horizontal track DE.

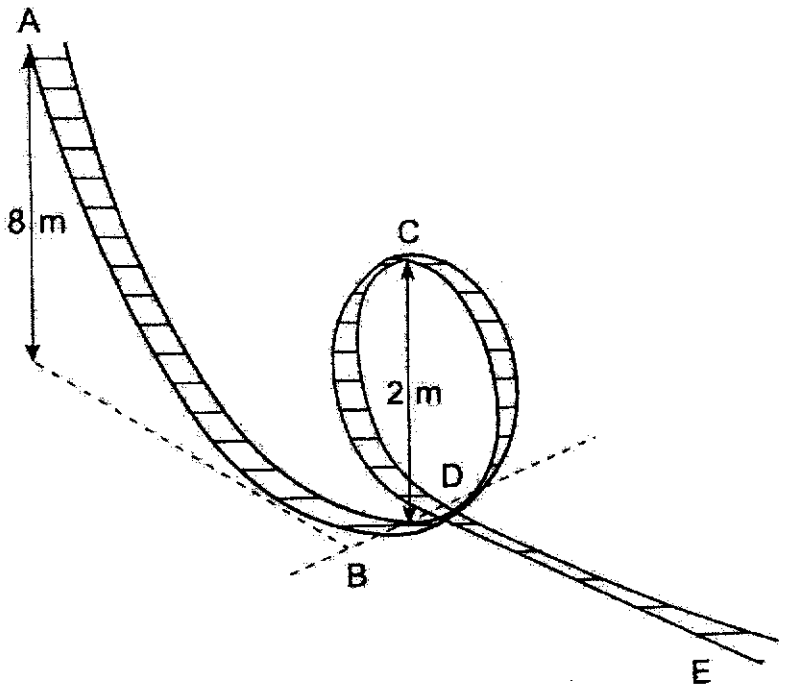


Fig. 4.1

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(a) Calculate the speed of the marble at C.

speed = ... [3]

(b) State and explain the kinetic energy of the marble at D.

.....

.....

.....

.....

.....

.....

..... [3]

(c) Given that the marble comes to a complete stop at E, find the constant frictional force acting on the marble along the track DE if track DE is 4 m long.

frictional force = ... [2]

(d) It is found that the marble cannot move round the loop if the speed at C is less than 2.56 m/s. Find the minimum height above B from which the marble has to be released for it to go round the loop.

height = ... [2]

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5 A uniform cylinder of cross section 0.75 cm^2 contains a column of liquid of length 38.5 cm as shown in Fig. 5.1.

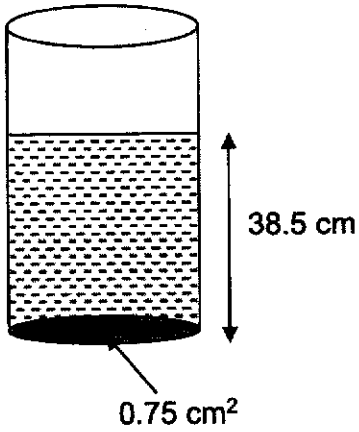


Fig. 5.1

Given that the density of the liquid is 1.65 g/cm^3, calculate

(a) the mass of liquid inside the cylinder,

mass = ...[2]

(b) the weight of liquid inside the metal cylinder.

weight = ...[1]

(c) the pressure exerted on the base of the metal cylinder, in N/cm^2.

pressure = ...[1]

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6 A student arranged a tube in a beaker of liquid as shown in Fig. 6.1. The tube was first filled with liquid. Then, closing end B with his finger, he dipped the other end into the beaker of liquid. He placed the tube such that point A is 60 mm above the free surface of the liquid and B is 20 mm below it.

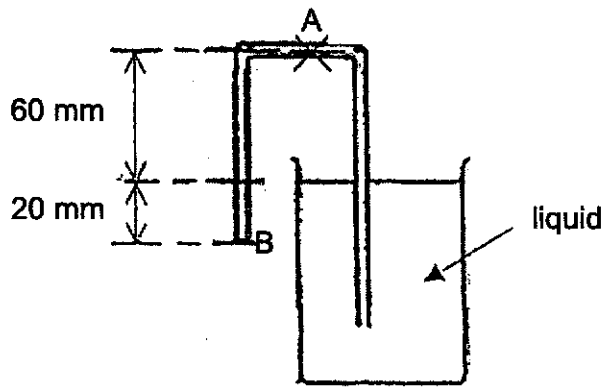


Fig. 6.1

(a) Find the pressure at A and B given that the atmospheric pressure is 1.0×10^5 Pa and the density of the liquid is 900 kg/m^3.

pressure at A = ... [2]

pressure at B = ... [2]

(b) When the student removed his finger from B, the liquid ran out.

(i) Explain why.

.....

.....

..... [1]

(ii) Describe the liquid level in the beaker when the liquid stops flowing.

.....

.....

..... [1]

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Section C

This section carries 20 marks.
Answer **all** questions in the spaces provided.

7 Fig. 7.1 shows a small ball bearing of mass 50 g being released at the top of a fluid of height 125 cm inside a tank. The ball bearing moves down and reaches the bottom of the tank in 6.0 seconds.

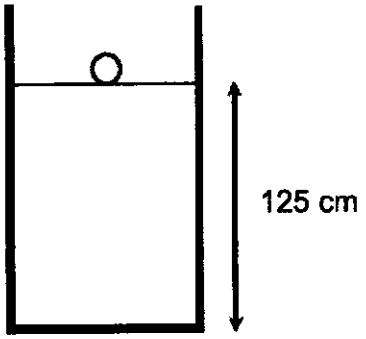


Fig. 7.1

The speed-time graph of the ball bearing is shown in Fig. 7.2.

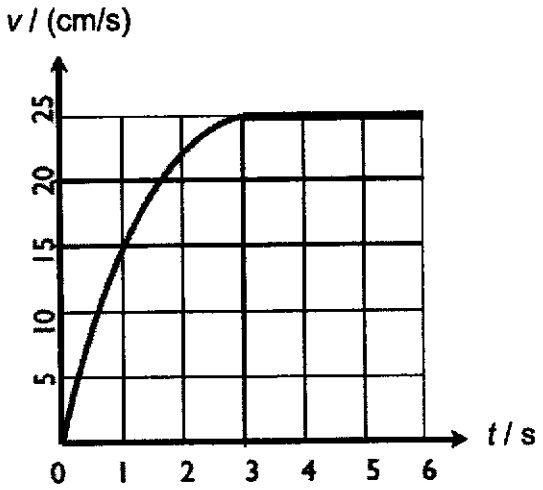


Fig. 7.2

(a) On Fig. 7.2, indicate the position in which the ball bearing has the maximum acceleration. Label this point A. [1]

(b) Calculate the gravitational potential energy at time $t = 0$ s.

energy = ... [1]

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(c) Calculate the kinetic energy at time $t = 5.0$ s.

energy = ... [1]

(d) Explain why the two values in **(b)** and **(c)** are different.

.....

.....

..... [1]

(e) Calculate the average speed of the ball bearing during the first 3 seconds.

average speed = ... [2]

(f) Calculate the fluid resistance experienced by the ball bearing at $t = 4.0$ s.

water resistance = ... [1]

(g) Complete the free body diagrams in Fig. 7.3 by drawing arrows to represent the forces acting on the ball bearing at the following times. Label all the forces clearly, and use the length of the arrows to roughly compare the magnitude of the forces. [3]



At t = 0 s ***At t = 2.0 s*** ***At t = 4.0 s***

Fig. 7.3

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8 When a train is moving, many forces resist its movement. In Fig. 8.1, graph X shows the total resistive force on the train at different speeds when it runs along a straight and horizontal track. Graph Y shows the force which the train engine can exert at various speeds.

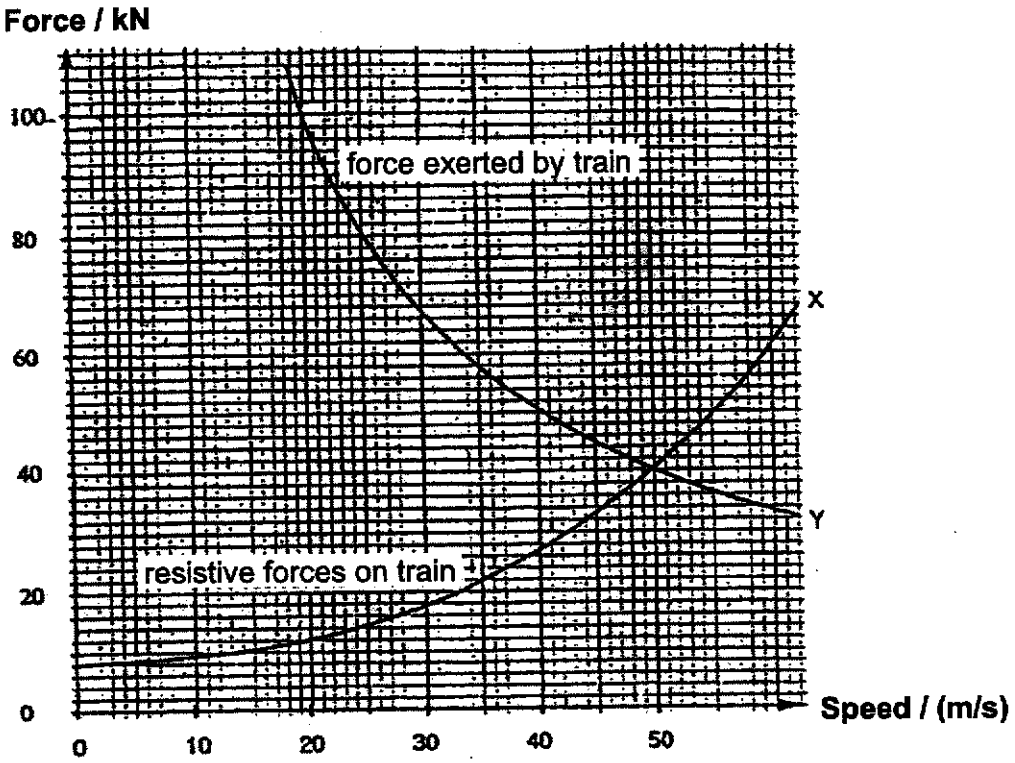


Fig. 8.1

(a) *When a train is moving, many forces resist its movement.* State **two** examples of such resistive forces.

..... [2]

(b) Using the information on Fig. 8.1 and the Newton's second law of motion, explain why the acceleration of the train decreases when its speed increases.

.....

.....

.....

.....

.....

.....

..... [3]

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(c) The train has a mass of 4.0×10^5 kg. Calculate the acceleration of the train when its speed is 20 m/s.

acceleration = ... [2]

(d) State the maximum speed of the train. Explain how you got your answer.

.....

.....

.....

.....

.....

.....

..... [3]

END OF PAPER

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GREENRIDGE SECONDARY SCHOOL
MID-YEAR EXAMINATION 2019
3E PHYSICS 6091
ANSWER SCHEME

Section A [25 marks; 1 mark each]

Qn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Ans	D	D	C	B	D	A	A	B	A	B	D	A	B	A	C	C	A	D	A	B	B	A	B	A	D

Section B [45 marks]

Qn	Answer	Mark
1 (a)(i)	Constant acceleration.	1
	When the sponge is just released, the only force acting on it is its weight, and the sponge falls with a constant acceleration due to gravity of 10 m/s^2.	1
(ii)	Decreasing acceleration.	1
	When the sponge falls freely due to gravity, its speed increases and air resistances increases, so resultant force on the sponge decreases. Since F_R = ma, acceleration a decreases.	1
(iii)	Zero acceleration.	1
	Air resistance is equal and opposite to the weight, so resultant force is zero. Since F_R = ma, acceleration a is zero.	1
(b)	Distance AC = ½ (1)(9.6) = 4.8 m	1
	Distance CD = ½ (0.5)(10+12) = 5.5 m Distance after D = (12)(1) = 12 m	
	Height = 4.8 + 5.5 + 12 = 22.3 m	1
2 (a)	As the kite is travelling at constant speed, the acceleration is zero.	1
	Since Resultant Force = mass x acceleration, the resultant force must be zero.	1
(b)	W = mg = (5)(10) = 50 N	1
(c)	(Drawing of downward weight)	1
	(Drawing of parallelogram with resultant)	1
	(All directions indicated and forces clearly labelled)	1
	Magnitude = 78.5 N (accept +/- 10%)	1
	Direction = 17° below the horizontal, or 37° clockwise from 80 N force	1
3 (a)(i)	Mass is the amount of matter in a substance but weight is the amount of gravitational force acting on it.	1
	Mass is a scalar but weight is a vector.	1
(ii)	W = mg 150000 = (m)(10)	
	m = 15000 kg	1
(b)(i)	Taking moments about X, ACW = CW	
	(150)(5) = (F)(12)	1
	F = 62.5 kN	1
(ii)	Sum of Upward Forces = Sum of Downward Forces 62.5 + B = 150	1
	B = 87.5 kN	1
(c)	The lift force from the front rotor is decreased while the lift force from the back rotor is unchanged / increased.	1
	This will produce an anticlockwise moment to cause the front of the helicopter to tilt downwards.	1
4 (a)	$TE_A = TE_C$ $GPE_A = GPE_C + KE_C$	
	$(0.005)(10)(8) = (0.005)(10)(2) + ½ (0.005)(v^2)$	1
	$0.4 = 0.1 + 0.0025v^2$	1
	v = 11.0 m/s	1
(b)	The kinetic energy of the marble at D is 0.4 J.	1
	By Principle of Conservation of Energy,	1
	all the gravitational potential energy at A has been converted to kinetic energy at D.	1
(c)	W.D. = F × d 0.4 = (F)(4)	1
	F = 0.1 N	1
(d)	$TE_X = TE_C$	

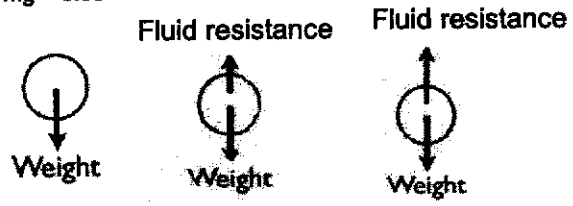
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Qn	Answer	Mark
	$GPE_X = GPE_C + KE_C$	
	$(0.005)(10)(x) = (0.005)(10)(2) + ½ (0.005)(2.56^2)$	1
	$x = 2.33$ m	1
5 (a)	Mass = density x volume	
	= 1.65 x 38.5 x 0.75	1
	= 47.6 g	1
(b)	Weight = m x g	
	= (47.6 /1000) x 10	
	= 0.476 N	1
(c)	Pressure = Force / Area	
	= 0.476 / 0.75	
	= 0.635 N / cm^2	1
6 (a)	$P_A = P_{atm} - h\rho g = (1 \times 10^5) - (0.060 \times 900 \times 10)$	1
	$= 100000 - 540 = 99460$ Pa	1
	$P_B = P_{atm} + h\rho g = (1 \times 10^5) + (0.020 \times 900 \times 10)$	1
	$= 100000 + 180 = 100180$ Pa	1
(b)(i)	Downward pressure at B is larger than the upward atmospheric pressure.	1
(ii)	The level of liquid in the beaker is at the same level as end B.	1

Section C [20 marks]

Qn	Answer	Mark
7 (a)	(Label at t = 0 s)	1
(b)	GPE = mgh = 0.05 × 10 × 1.25 = 0.625 J	1
(c)	KE = ½ mv^2 = ½ × 0.05 × $(0.25)^2$ = 0.00156 J	1
(d)	Part of the GPE has been converted to work done against fluid resistance.	1
(e)	Total distance = 125 cm	
	Distance travelled in last 3 seconds = 3 × 25 = 75 cm	1
	Distance travelled in first 3 seconds = 125 – 75 = 50 cm	
	Average speed = 50/3 = 16.7 cm/s	1
(f)	Water resistance = Weight	
	= mg = 0.05 × 10 = 0.5 N	1
(g)		
	(Show Weight in all diagrams)	1
	(Show Fluid Resistance in last 2 diagrams)	1
	(Show that Weight = Fluid Resistance at 3rd diagram and Weight > Fluid Resistance at 2nd diagram)	1
8 (a)	Air resistance	1
	Friction	1
(b)	From the graphs, when speed increases, force exerted by the train decreases and resistive force increases,	1
	thus resultant force decreases.	1
	Since $F_R = ma$, a decreasing resultant force causes a decreasing acceleration.	1
(c)	Engine force = 100 kN, Resistive force = 12 kN	
	$F_R = 100 - 12 = 88$ kN	1
	$a = F/m = (88 \times 10^3) / (4 \times 10^5) = 0.22$ m/s^2	1
(d)	50 m/s	1
	According to the graphs, resultant force is zero at 50 m/s, meaning no acceleration and there is no more change in speed.	1

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GREENRIDGE SECONDARY
FEEDBACK FOR LEARNING *from* MID-YEAR EXAMINATION 2019
SECONDARY 3 EXPRESS
PHYSICS 6091

Qn	Common Error or Misconception	Scientific Conception
1 (a)	Many students thought that "increasing velocity" meant "increasing acceleration".	When velocity increases at a constant rate, it is a constant acceleration.
1 (b)	Some students used "distance = speed x time" to estimate the height required.	"Distance = speed x time" only applies when speed is constant. Since speed varies, the distance moved can only be calculated by finding the area under the v-t graph.
2 (c)	Some students did not include the weight (50 N) in the diagram, or did not show this weight to be a vertically downward force. Some did not indicate the direction of the forces. All these led to students drawing the wrong diagonal to find the resultant force wrongly.	Follow the original diagram as closely as possible, with the weight being a vertically downward force, in order to avoid unnecessary mistakes in correctly drawing the diagonal to find the resultant force.
3 (b)	Some students ignored the prefix for 150 kN and treated it as 150 N.	Be mindful of prefixes, e.g., k represents kilo (10^3).
3 (c)	Many students did not mention "moments" in explaining how the helicopter can rotate.	In "Explain" or "Describe" questions that involve turning effects, "moment" is a crucial keyword. Key phrases can include, clockwise moments, anticlockwise moments, principle of moments.
4 (b)	Many students did not mention "principle of conservation of energy" in the explanation.	In "Explain" or "Describe" questions that involve conversion of energy, "principle of conservation of energy" is a key concept.
4 (c)	Most students failed to apply $W.D. = F \times d$ to find the frictional force along the track.	Work done against friction = (friction force) x (distance along where friction applies)
5 (b)	Many students failed to use S.I. units when applying the formula $W = mg$. m should be in kg but many left it in g.	Be mindful to use S.I. units when applying all physics formulae. The S.I. unit for mass is kilogram (kg).
6 (a)	Most students could not apply their knowledge to the unfamiliar situation, where pressure is higher as we go lower from the atmospheric pressure level, and lower as we go higher from the atmospheric pressure level.	Pressure at the same liquid level is the same. Pressure increases with depth, and decreases when going up.
6 (a)	Some students added pressure in terms of liquid length to pressure in terms of Pa directly.	To add two values for any physical quantity, they must be in the same unit. Convert both pressures to Pa (S.I. unit) before adding them.
7 (a)	No student could identify the point of maximum acceleration on the *v-t* graph.	On the *v-t* graph, gradient represents the acceleration. For maximum acceleration, it is the point where gradient is the largest (steepest). For this question, that is at $t = 0$ s.
7 (e)	Most students did not make use of the graph to deduce the fluid resistance at $t = 4.0$ s.	When acceleration is zero, resultant force is zero. In this question, that happens when downward weight is equal to the upward fluid resistance.
7 (g)	Most students could not draw the free-body diagram for an object that is free-falling.	At moment of release, an object only experiences a downward weight force. As it falls, it accelerates due to gravity. Since speed increases, the upward fluid resistance force increases, until it is equal to its weight. Resultant force would be zero, so acceleration is zero, and the object would continue to move in the same direction at a constant speed.
8 (b)	Many students did not make use of Newton's Second Law in the explanation.	State the Newton's Second Law ($F_R = ma$) and explain how it is applicable or related to this question.
8 (d)	Many students could not state the correct maximum speed.	Maximum speed occurs when acceleration is zero. This is when resultant force is zero, i.e. forward force = resistive force.

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