# Additional Intensive Exercise

## Chapter 4A: Vector Diagrams

### *Questions*

**Q1**

A 500 N object is suspended at the mid-point of the cable ABC. By using a suitable scale drawing, find the tension present in the cable AB and BC.

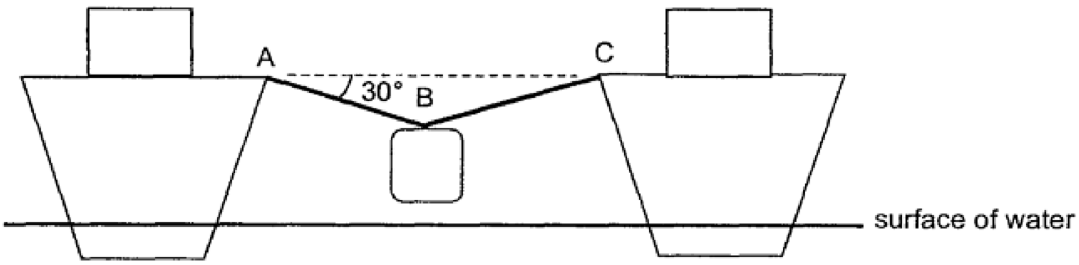



**Fig. 1.1 (not drawn to scale)**

tension in AB= ..........................

tension in BC = ........................ [4]

**Q2**

A climber of weight 720 N is rappelling down a cliff. At the instant shown in Fig. 2.1, he is stationary and in a state of equilibrium.

The rope makes an angle of $\theta$ with the vertical, and the cliff exerts a force $F$ of 300 N on the feet of the climber. This force $F$ is directed at 22° above the horizontal.

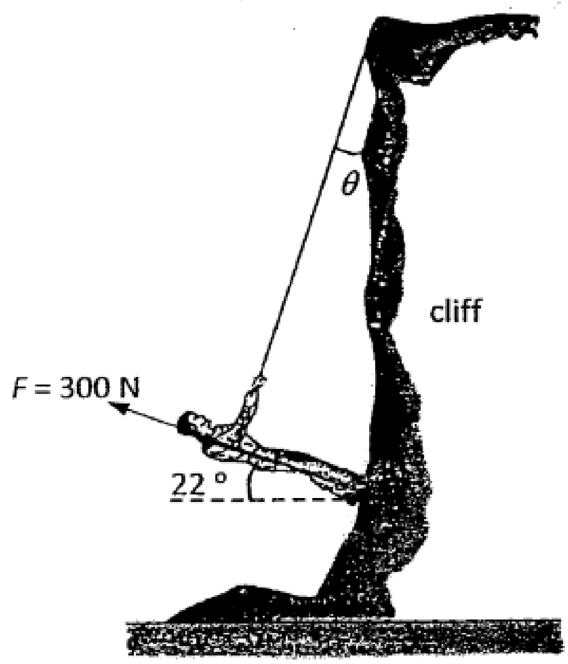



**Fig. 2.1**

In the space below, draw a scaled diagram to show the forces acting on the climber.

Determine the magnitude of the tension in the rope, and the angle $\theta$ it makes with the vertical.

tension = ..................................................................

$\theta$ = ..................................................................

[3]

**Q3**

When the skier is in an equilibrium position, the normal reaction force, **R** exerted by the skis on him, is 400N, at an angle of 40° to the vertical.

Two forces experienced by the skier, **R** and **W**, are indicated in Fig. 2.2.

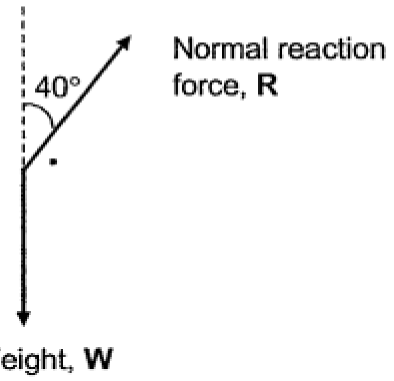



**Fig. 2.2**

Using a labelled vector diagram, determine the magnitude and direction of the air resistance experienced by the skier.

Your vector diagram should show forces in the same orientation as Fig. 2.2. (i.e. **W** must be vertically downward).

air resistance =………….. [4]

**Q4** **Difficult!**

In a pool game, ball A moves horizontally and simultaneously collides with ball B and ball C as shown in Fig 2.1. Upon collision, ball A exerts a 0.50 N force on ball C at an angle of 30° to the horizontal as shown in Fig 2.2. The resultant force acting on ball A is 0.80 N at an angle of 25° to the horizontal as shown in Fig 2.3.

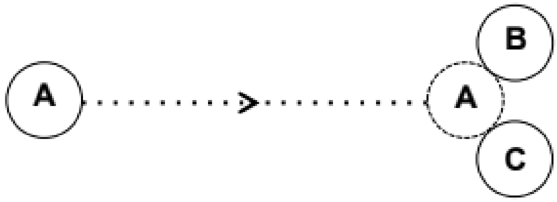



Fig 2.1

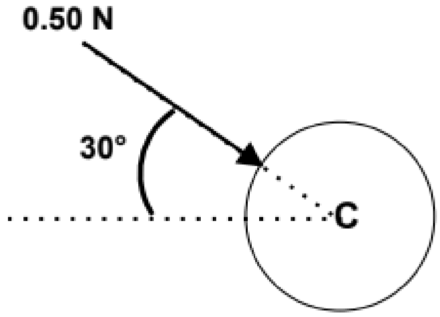



Fig 2.2

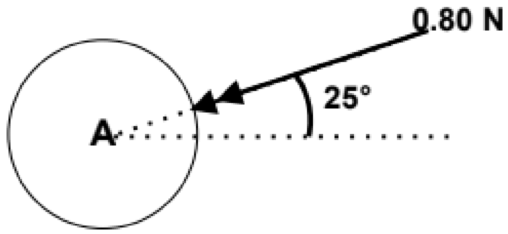
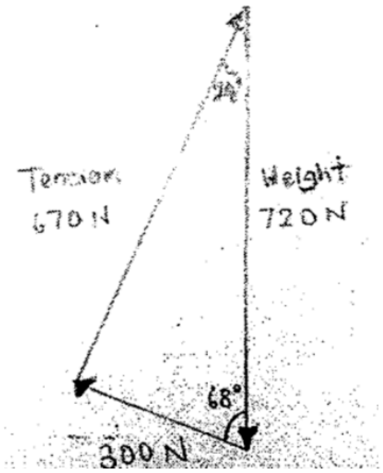


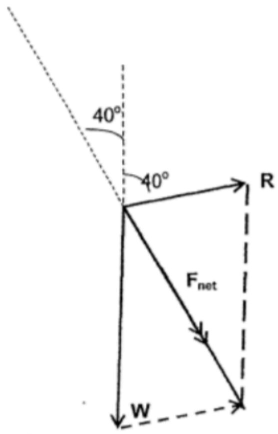
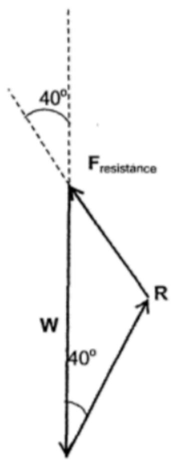

Fig 2.3

In the space below, draw a labelled diagram to show the resultant force acting on ball A due to the forces that ball B and ball C exert on ball A during the collision. Determine the magnitude of the force that ball B exerts on ball A.

force = ........................................ [3]

## *Answers*

| | | | |
|---|---|---|---|
| **Q1** | Scale: 1 cm : 50N (490N – 510N)<br>or 1cm: 100N (480N to 520N)<br>Correct shape<br>Correct direction of arrows<br>Tension = 500 N<br><br><u>Comments:</u><br>Scale must be mentioned and not inferred from the vector diagram. | B1<br>B1<br>B1<br>B1 | Students made common mistakes in the identification of the direction of the tensional forces. Most students make the mistake of pointing the tensional forces towards the weight.<br>Most students have trouble in identifying that the two tensional forces will act to have a resultant upwards force.<br>Students could properly identify a proper scale. |
| **Q2** |   | Scale<br>1.0 cm : 100 N<br><br>Tension = 670 N<br>$\Theta = 24°$ | |

| | |
|---|---|
| **Q3** | Method 1: Parallelogram of forces (not drawn to scale)<br>Suggested scale is 1 cm: 100 N (or smaller)<br><br><br>• suitable scale [B1]<br>• appropriate labels for given forces and the resultant force [B1]<br>• Inference from the parallelogram of forces that the magnitude of air resistance = magnitude of resultant force = 390 N, together with appropriate label for the force; reasoning in words is expected [A1].<br>**Remark:** As the skier is in equilibrium, a vector that has the magnitude of the resultant force but is directed in the opposite direction. *A parallelogram can be used to find the resultant force*<br>• The direction of air resistance is 40° from the vertical/N40°W [A1].<br>• No mark is awarded for giving the direction of air resistance without a reference direction.<br>• Deduct ½ mark for missing arrows to show vectors or vector **W** not directed vertically.<br>Method 2: Triangle of forces (not drawn to scale)<br><br><br>**Remark**<br>A triangle of forces modelling the skier in equilibrium must show vectors that are directed in such a way that the tip of one vector touches the tail of the next vector sequentially as shown above. |
| **Q4** | • 0. 66 N ± 0.06 N.<br>• Correct arrow direction<br>• Correct diagram |

# Chapter 4B: Newton's Laws of Motion

## *Questions*

**A1**

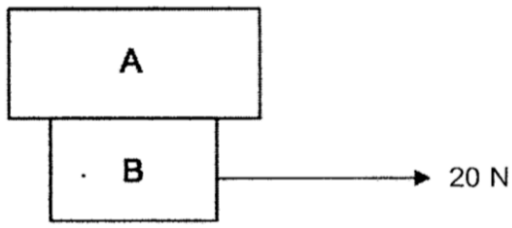
A 40 kg mass is moving across a horizontal surface at 5 m/s.

What is the magnitude of the uniform net force required to bring the mass to a stop in 8.0 s?

**A** 1 N
**B** 5 N
**C** 25 N
**D** 40 N

**A2**

Two objects, A (mass 6 kg) and B (mass 4 kg), are stacked one on top of the other as shown.




B is pulled by a force of 20 N and all surfaces are frictionless.

What is the acceleration of A?

**A** 0 m/s$^2$
**B** 2 m/s$^2$
**C** 3.3 m/s$^2$
**D** 5 m/s$^2$

**A3**

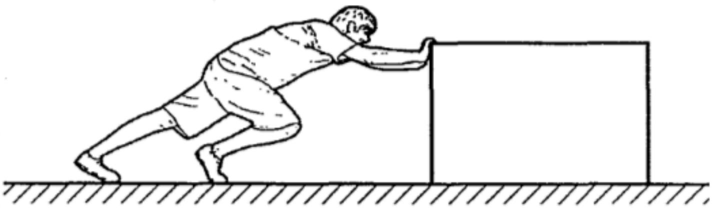
When a horizontal force of 5.0 N is applied to a wooden block of mass 3.0 kg on a horizontal surface, the block moves with a constant velocity.

If the force is increased to 12 N, what is the acceleration of the block?

**A** 1.7 m/s$^2$ **B** 2.3 m/s$^2$ **C** 4.0 m/s$^2$ **D** 5.7 m/s$^2$

**A4**

A man pushes a heavy box along the ground.



A force acts between the man's hands and the box. Another force acts between the man's feet and the floor.

In which directions do these forces act on the man?

| | force on man's hands | force on man's feet |
|---|---|---|
| **A** | towards the left | towards the left |
| **B** | towards the left | towards the right |
| **C** | towards the right | towards the left |
| **D** | towards the right | towards the right |

**A5**

A car of mass 1500 kg is towing a trailer of mass 1100 kg along a level road. The acceleration of the car is 1.30 m $s^{-2}$.

Ignoring friction and air resistance, what is the driving force on the car?

**A** 1430 N **B** 1950 N **C** 2000 N **D** 3380 N

**A6**

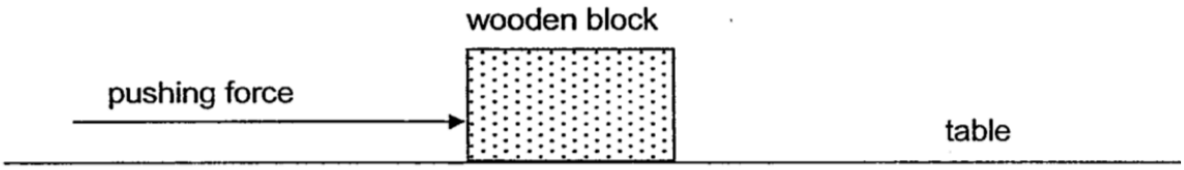
A hard stone hits the ground and comes to rest almost immediately.

As the stone hits the ground, what is the direction and the size of the force acting on the ground?

**A** downwards and equal to the weight of the stone
**B** downwards and larger than the weight of the stone
**C** upwards and equal to the weight of the stone
**D** upwards and larger than the weight of the stone

**A7**

A wooden block is pushed across a table at constant speed.



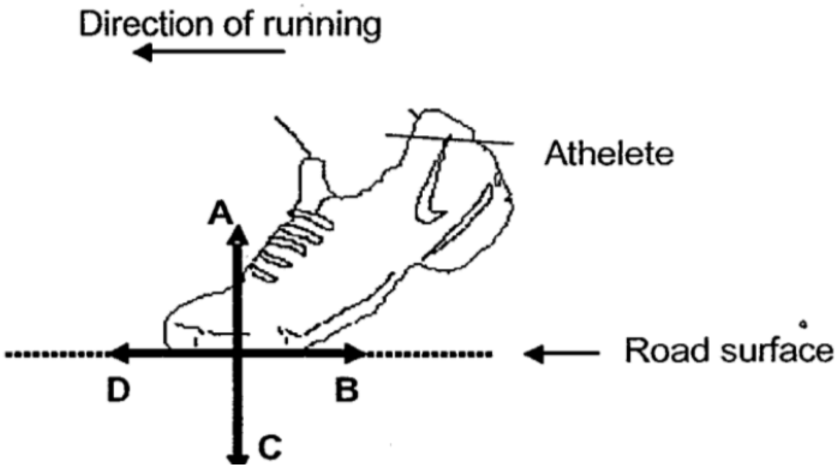

Which statement is correct?

**A** The frictional force increases as the block moves.
**B** The frictional force is equal and opposite to the pushing force.
**C** The frictional force is less than the pushing force.
**D** The frictional force is more than the pushing force.

**A8**

The figure below shows the foot of an athlete as he is about to start running.

In which direction does the frictional force act on the sole of his shoe?



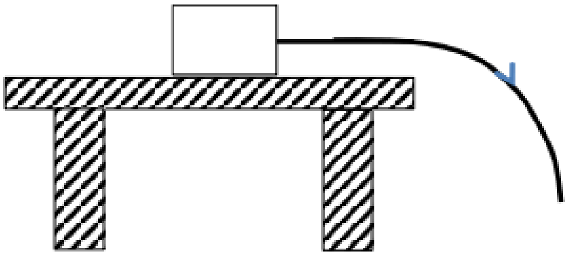

**A9**

A crane lifts a 20 kg object from rest. The object moves upward at a constant acceleration of 4.0 $m/s^2$. What is the tension of the crane acting on the object?

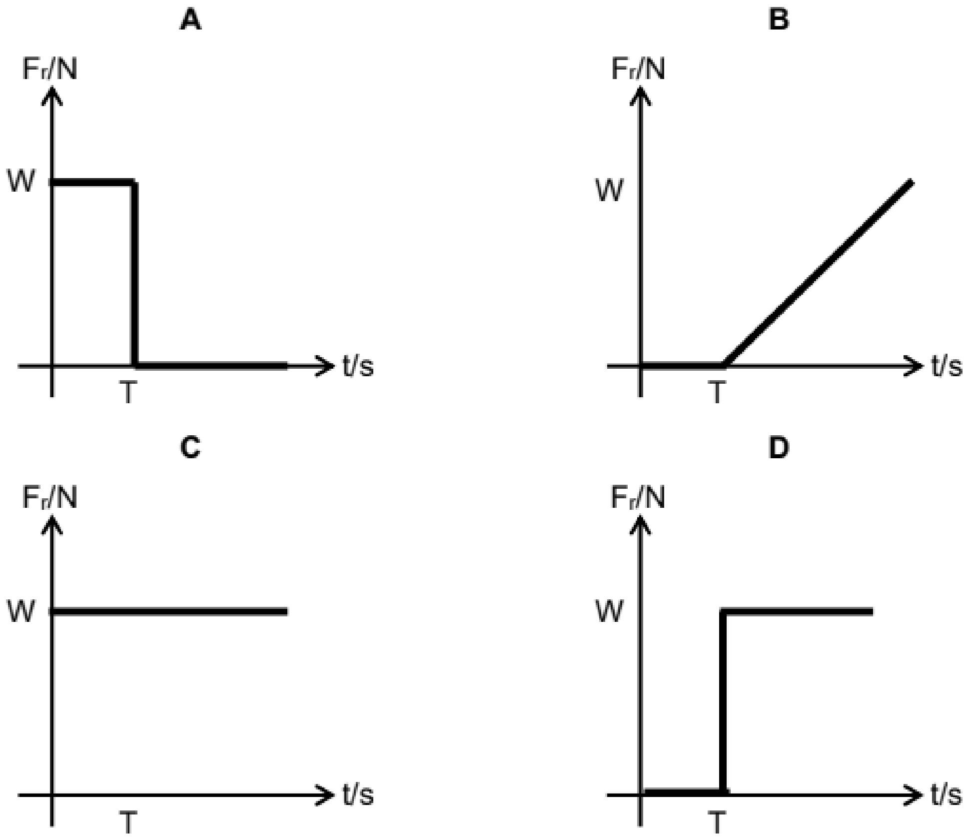
**A** 80 N **B** 120 N **C** 200N **D** 280 N

**A10**

A book of weight, W slides along a smooth table-top until it falls off from the edge of the table at time, T. The figure below shows the path of the book.



Which graph shows how the resultant force acting on the book changes with time? Neglect air resistance.



**B1**

Fig. 3.1 shows a magnet picking up an iron coin.

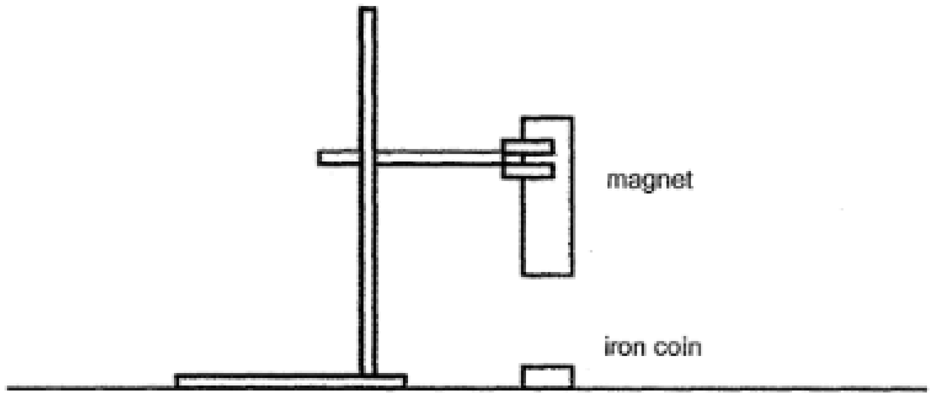



**Fig. 3.1**

The coin has a mass of 0.02 kg.
The initial attractive force on the iron coin by the magnet was 0.3 N.

Calculate

**(i)** the initial resultant force acting on the coin,

resultant force = ..................................... [2]

**(ii)** the initial acceleration of the coin.

acceleration = ................................ [2]

**B2**

**Fig. 1.1** shows a sealed long cylinder that demonstrates how two similar objects **A** and **B** falls under gravity on Earth.

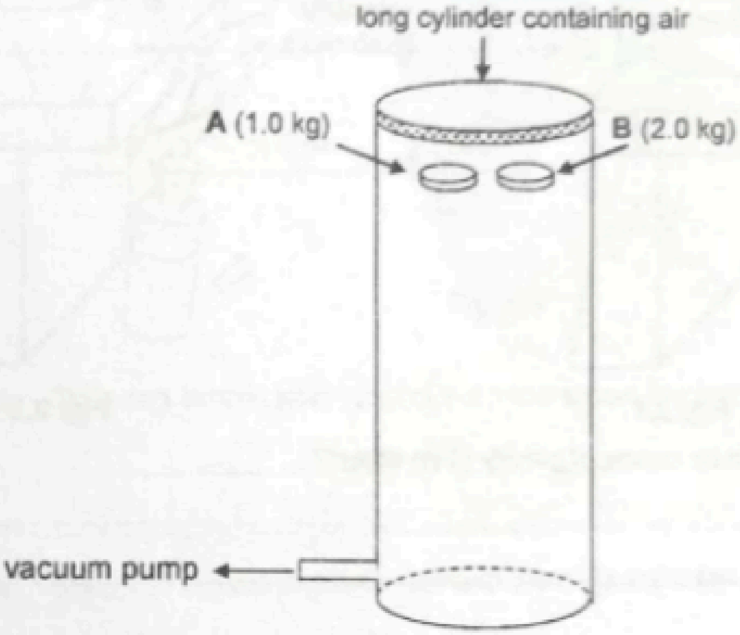



**Fig. 1.1**

**(a)** **(i)** Objects **A** and **B** are released from rest simultaneously from the top of the cylinder.
State which object will first reach the bottom of the cylinder. [1]

______________________________________________________________

**(ii)** Explain using forces why the object reaches first the bottom of the cylinder. [2]

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**(b)** A vacuum pump is connected to cylinder and the air is removed. The experiment is first repeated on Earth and then on the moon where **A** and **B** are released from the top of the cylinder.
State two differences in the two experiments. [2]

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**B3**

Fig. 1.1 shows how the speed of a rocket SpaceX varies with time as it enters the gravitational field of a new Planet Y with negligible atmosphere. SpaceX has a total mass of $1.8 \times 10^6$ kg. Once it enters the atmosphere of Planet Y, it undergoes free fall for 8.0 s before its engine fires a continuous thrust to bring it to a gentle upright landing on the surface of Planet Y.

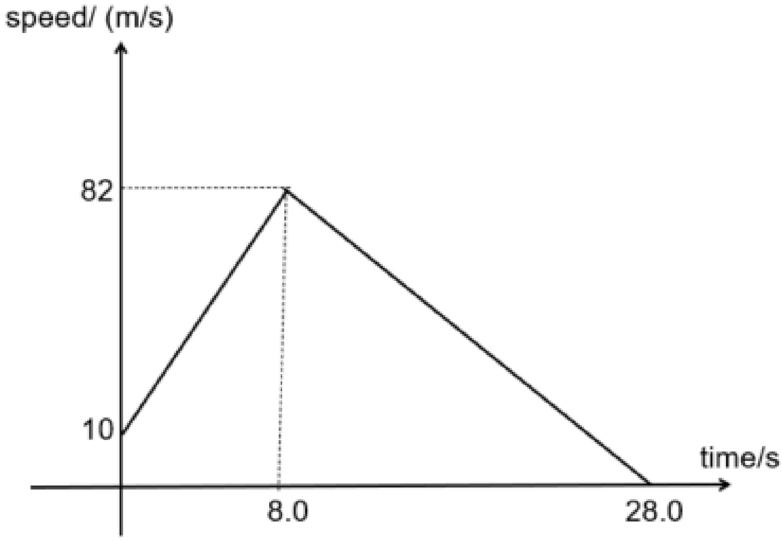


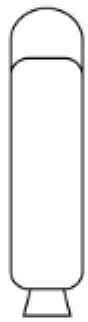

**Fig 1.1**

**(a)** Calculate the weight of Space X on Planet Y.

weight = ……………………..[2]

**(b)** At 8.0 s, significant amount of liquid Oxygen fuel undergoes combustion in the rocket engine to produce a constant thrust, *T* to decrease rocket's speed of descent.

**(i)** On Fig. 1.2, draw and label all the forces acting on SpaceX during its descent. You may ignore air resistance.



[1]

**Fig. 1.2**

**(ii)** Hence, calculate the magnitude of the thrust, *T*.

*T* = ………………….. [2]

**(iii)** With reference to the forces acting on SpaceX, explain why the deceleration from t = 8.0 s to t = 28.0 s increases in reality.

Assume that the thrust produced by the engine is uniform throughout the descent.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………[1]

B4

Fig. 1.1 shows a modern Formula One car. It is a single-seat and open cockpit race car with substantial front and rear wings, and its engine is positioned behind the driver.

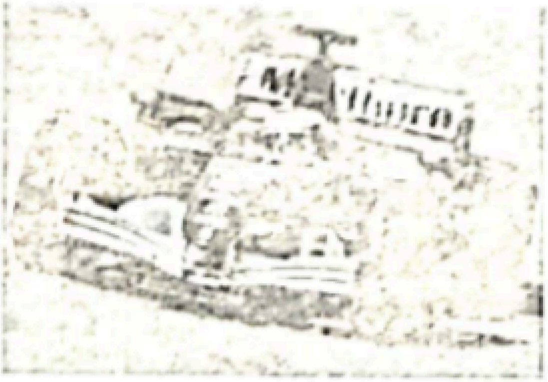


Fig. 1.1

An average F1 car with a mass of 600 kg can decelerate from 100 to 0 km/h in about 17 m.

A Formula One race car is defined as much by its aerodynamics as it is by its powerful engine. That is because any vehicle traveling at high speed must be able to do two things well: reduce air resistance and increase downforce. Airplane wings create lift, but the wings on a Formula One car produce downforce, which holds the car onto the track, especially during cornering.

(a) Find the time needed for the car to come to a complete stop.

time = ............................[3]

(b) Calculate the deceleration of the car.

deceleration = ..............................[2]

(c) Hence calculate the forward force which the driver experiences if the total mass is 680 kg. Assume that frictional force is negligible.

forward force = ..............................[1]

**B5**

Fig 10.1 shows the design of a bullet. When the gun powder is ignited, high speed gas will be emitted out through the end of the cartridge and moves the bullet forward to the right.

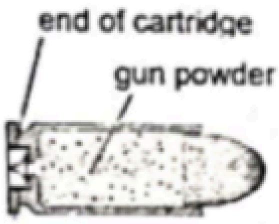



Fig 10.1

(a) Using relevant Newton's law of motion, explain why the bullet moves forward to the right.

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..............................................................................................................................[2]

Fig 10.2 shows a gun is used to test the efficiency of a bullet by measuring the depth of the penetration made by the bullet when it hits the wooden block. Bullets containing different amount of gun powder are used for each test. The wooden block is placed 5.0 metre away from the tip of the gun.

Fig 10.3 shows the bullet hitting the wooden block and is stopped by the block subsequently. The penetration depth is the distance travelled by the bullet from surface A of the block before it comes to a stop in the block.

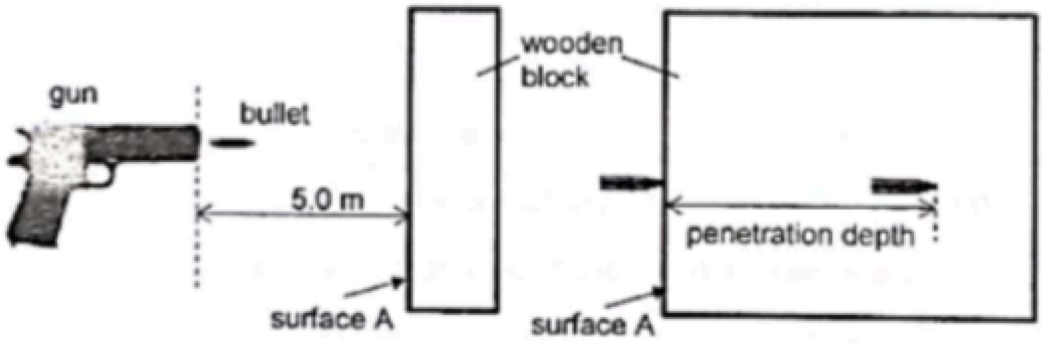


Fig 10.2 Fig 10.3

Table 10.4 shows the relationship between the amount of gun powder in the bullet and the penetration depth.

| Mass of gun powder / g | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 |
|---|---|---|---|---|---|
| Penetration Depth / cm | 12.5 | 18.0 | 24.5 | 32.0 | 40.5 |

Table 10.4

**(b)** Explain, using the ideas of force and motion, the trend in Table 10.4.

..........................................................................................................................................

..........................................................................................................................................

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..........................................................................................................................................

..........................................................................................................................................[2]

**(c)** The speed of the bullet just after leaving the tip of the gun and the speed of the bullet before hitting the wooden block is approximately constant. The bullet can be assumed to be traveling along a straight horizontal path.

Explain, using the concept of force, why this is so.

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..........................................................................................................................................[2]

**(d)** When the mass of the gun powder used is 8.0 g, the total initial mass of the bullet is 28.0 g. The bullet does not contain any gun powder after it leaves the tip of the gun.

The speed of the bullet just before hitting the wooden block is 160 m $s^{-1}$.

State the mass of the bullet (in kg) just before hitting the wooden block.

mass = …………..kg **[1]**

# *Answers*

<table>
<tr><td>A1</td><td>C</td></tr>
<tr><td>A2</td><td>A</td></tr>
<tr><td>A3</td><td>B</td></tr>
<tr><td>A4</td><td>B</td></tr>
<tr><td>A5</td><td>D</td></tr>
<tr><td>A6</td><td>B</td></tr>
<tr><td>A7</td><td>B</td></tr>
<tr><td>A8</td><td>D</td></tr>
<tr><td>A9</td><td>D</td></tr>
<tr><td>A10</td><td>D</td></tr>
<tr><td>B1</td><td>
<table>
<tr><td>(i)</td><td>F = 0.3 – (0.02 x 10)<br>= 0.1 N</td><td>M1<br>A1</td><td>Some students were unable to identify that the attractive force and weight acted in opposite direction.</td></tr>
<tr><td>(ii)</td><td>F = ma<br>= 0.1 / 0.02<br>= 5m/s^2</td><td><br>M1<br>A1</td><td>Most were able to get this question correct due to ecf</td></tr>
</table>
</td></tr>
<tr><td>B2</td><td>
<table>
<tr><td>(ai)</td><td>>B</td><td>B1</td></tr>
<tr><td>(aii)</td><td>> Weight of B is greater than weight of A and when A reaches terminal velocity where its air resistance = weight = 10 N, the air resistance of B is still smaller than Weight of B (20 N)<br>>The net force on B causes B to increase its acceleration and velocity more than the terminal velocity of A.</td><td>B1<br>A1</td></tr>
<tr><td>(b)</td><td>>On the moon, A and B takes more time to reach the ground (due to smaller gravitational field strength compared to earth, $g_{moon}$=1/6($g_{earth}$)).<br>>On the moon, velocity of A and B on impact is smaller than that on Earth.<br>>Acceleration on the moon is smaller than that on Earth.<br>Note: There is no terminal velocity as air resistance is not present in vacuum and both reach ground together.</td><td>B1<br>B1</td></tr>
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**B3**

Fig. 1.1 shows how the speed of SpaceX, a rocket varies with time as it enters the gravitational field of a new Planet Y with negligible atmosphere. SpaceX has a total mass of $1.8 \times 10^6$ kg. Once it enters the atmosphere of Planet Y, it undergoes free fall for 8.0 s before its engine fires a continuous thrust to bring it to a gentle upright landing on the surface of Planet Y.

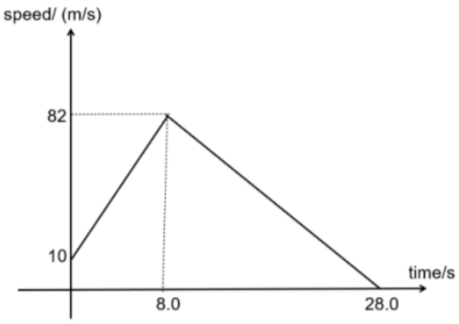



**Fig 1.1**

**(a)** Calculate the weight of Space X on Planet Y.

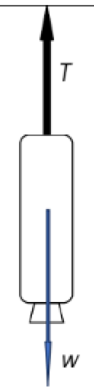
a=(v-u)/t
= (82-10)/8 = 9.0 $m/s^2$

W=mxg = $1.8 \times 10^6$ kg x 9.0 N/kg
=$1.62 \times 10^7$ N

weight = ……………………..[2]

**(b)** At 8.0 s, significant amount of liquid Oxygen fuel undergoes combustion in the rocket engine to produce a constant thrust, *T* to decrease space X's speed of descent.

**(i)** On Fig. 1.2, draw and label all the forces acting on SpaceX during its descent. You may ignore air resistance.




[1]

**Fig. 1.2**

**(ii)** Hence, calculate the magnitude of the thrust, *T*.

Taking upward as the positive direction
$F_{resultant} = T - W$
$1.8 \times 10^6$ kg x 4.1 N/kg = T – ($1.62 \times 10^7$N)
R =$23.58 \times 10^6$ N
= 2.36 or $2.4 \times 10^7$ N

ecf allowed from (a) for W

*T* = ………………….. [2]

**(iii)** In reality, from t = 8.0 s to t = 28.0 s, the deceleration of SpaceX is increasing. Assuming that the thrust produced by the engine is uniform, explain in terms of forces why this is so.

As the shuttle lands, its mass/weight decreases due to the burning of fuel, hence the upright resultant force is increasing (as thrust is constant) and deceleration is increasing

………………………………………………………………………………[1]

| | |
|---|---|
| **B4** | (a) 100 km/h = 28 m/s — 1<br>½ x t x 28 = 17 — 1<br>t = 1.21 s — 1<br><br>b) a = (0 – 28) / 1.21<br>= -23.1 m/s² — 1<br>deceleration = 23.1 m/s² — 1<br><br>c) F = ma = 680 x 23.1 = 15708 N = 15700 N — 1 |

**B5**

| Qn | Solution |
|---|---|
| 10(a) | The gas emitted out exerts a force to the left on the surrounding air.<br><br>By Newton's 3rd Law, the surrounding air exerts a force to the right on the gas and hence a force to the right on the bullet and the bullet move forward to the right. |
| (b) | The larger the amount of the gun powder, the more the gas will be produced and hence the larger the amount of force exerted on the bullet to move to the right. The bullet will travel with a larger speed.<br><br>With a larger speed and assuming a constant deceleration on the bullet as it strikes the wall, the bullet will have to travel a longer distance before it comes to a stop. Hence, there is a larger penetration depth. |
| (c) | The air resistance acting on the bullet can be considered negligible as the surface area of the bullet opposing the motion is small.<br><br>Thus, there is no resultant force acting on the bullet. By Newton's 1st law, the bullet will travel with a constant speed along a straight line. |
| (d)(i) | Mass of bullet<br>= 28.0 – 8.0<br>= 20.0 g<br>= 0.0200 kg (4 dp)<br><br>Note: Precision of measuring instrument is one d.p in terms of gram. Hence, in terms of kilogram, it will be 4 d.p. |