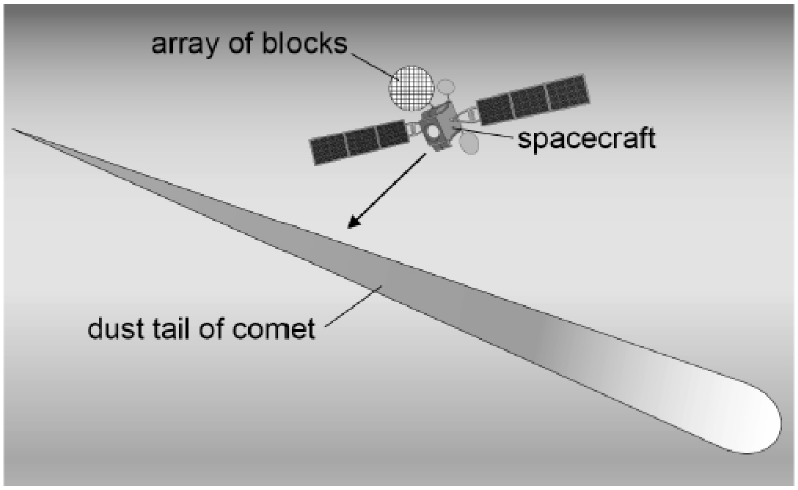
## AQA – Force, energy and momentum – AS Physics P1

**1.** June/2021/Paper_7407_01/No.03

**0 3** **Figure 5** shows a spacecraft travelling towards a comet.
The spacecraft has an array of blocks designed to capture small dust particles from the comet's tail.

**Figure 5**




To test the blocks before launch, a spherical dust particle **P** is fired at a right angle to the surface of a fixed, stationary block.
**P** has a mass of $1.1 \times 10^{-9}$ kg. It has a speed of $5.9 \times 10^{3}$ m s$^{-1}$ when it hits the surface of the block.
**P** comes to rest inside the block.

**0 3 . 1** Calculate the work done in bringing **P** to rest.

**[1 mark]**

work done = ____________________ J

**0 3 . 2** **P** travels a distance of 2.9 cm in a straight line inside the block before coming to rest.
The resultant force on **P** varies as it penetrates the block.

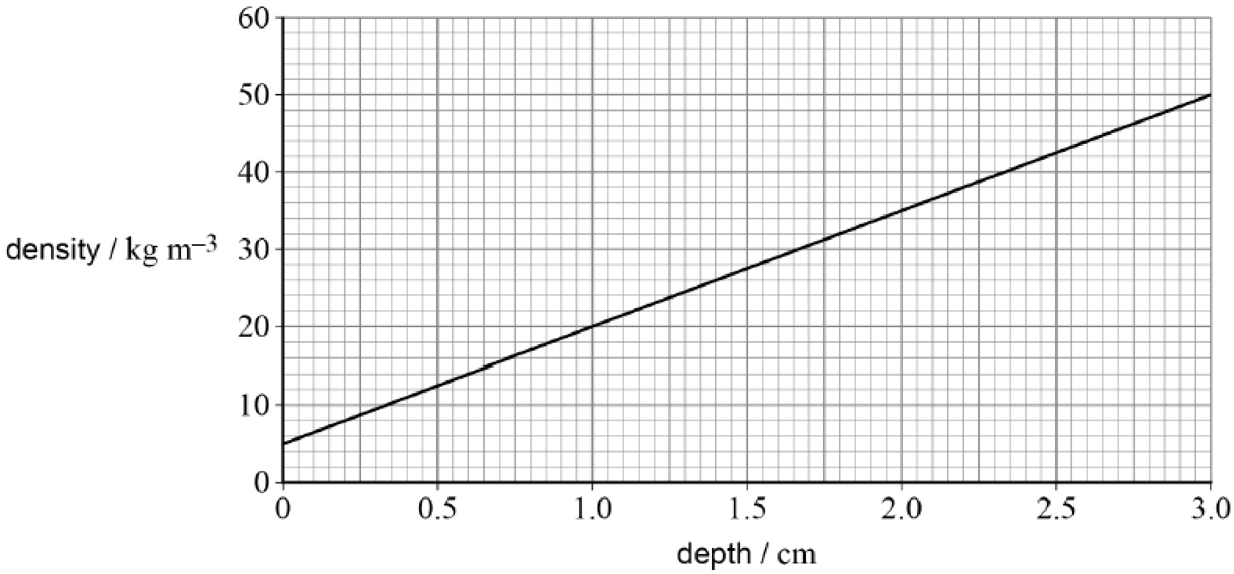
Calculate the average force acting on **P** as it is brought to rest.

**[2 marks]**

**0 3 . 3** The block is rectangular with an area of cross-section of $8.0\ cm^2$ and a thickness of $3.0\ cm$.

**Figure 6** shows how the density of the block varies with depth up to its maximum thickness.

**Figure 6**




Calculate the mass of the block.

**[4 marks]**

mass = ____________________ kg

**0 3 . 4** In another test, a spherical particle **Q** is fired at a right angle to the surface of an identical block.

**Q** has the same mass as **P** and is travelling at the same speed as **P** when it strikes the surface of the block.
**Q** is made from a less dense material than **P**.

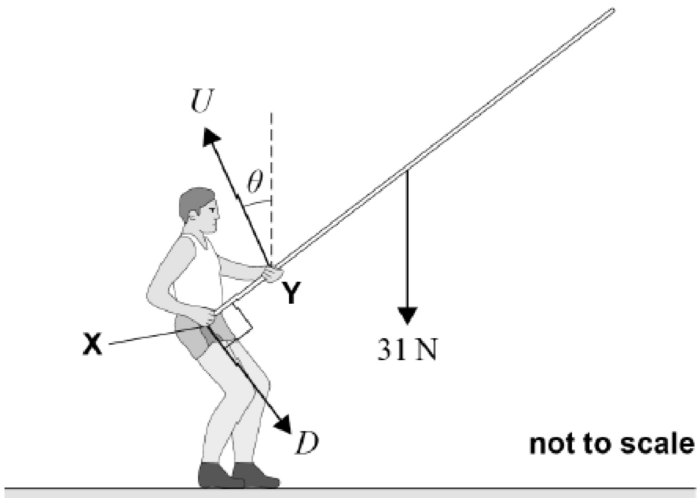
Compare the distance travelled by **Q** with that travelled by **P** as they are brought to rest.

**[3 marks]**

**2.** June/2021/Paper_7407_01/No.04

**0 4** **Figure 7** shows an athlete holding a vaulting pole at an angle of $40°$ to the horizontal.

**Figure 7**

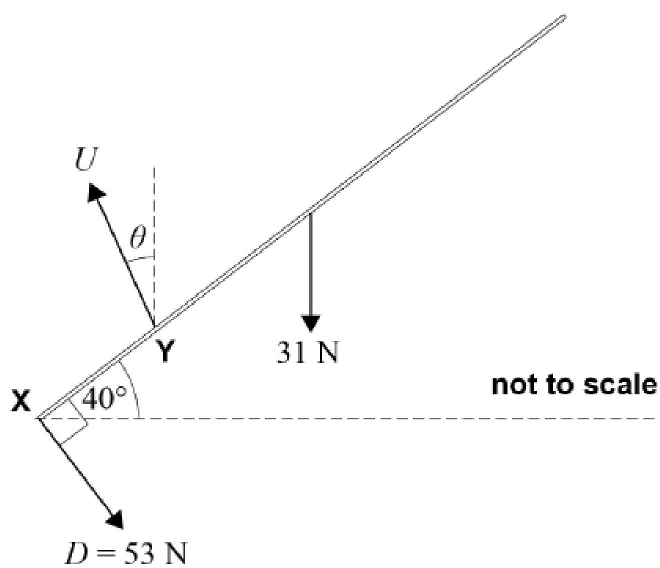



Forces $D$ and $U$ are exerted on the pole by the athlete's right and left hands respectively.
$U$ is applied at point **Y** at an angle $\theta$ to the vertical.
The magnitude of $D$ is $53\ \text{N}$ and is applied at $90°$ to the pole at **X**.

The uniform pole is in equilibrium. It has a weight of $31\ \text{N}$.

**Figure 8** shows the forces acting on the pole.

**Figure 8**



**0 4 . 1** Determine, using a scale diagram, $\theta$ and the magnitude of $U$.

**[4 marks]**

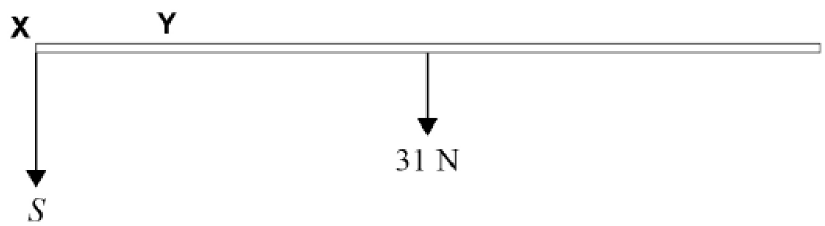
$\theta =$ ______________________ $^\circ$

magnitude of $U =$ ______________________ N

**0 4 . 2** The athlete now moves the pole to a horizontal position. The pole is held stationary in this position.
The athlete's right hand applies a force $S$ vertically downwards at **X** as shown in **Figure 9**. The athlete's left hand applies a force $V$ at **Y**.

**Figure 9**

**not to scale**



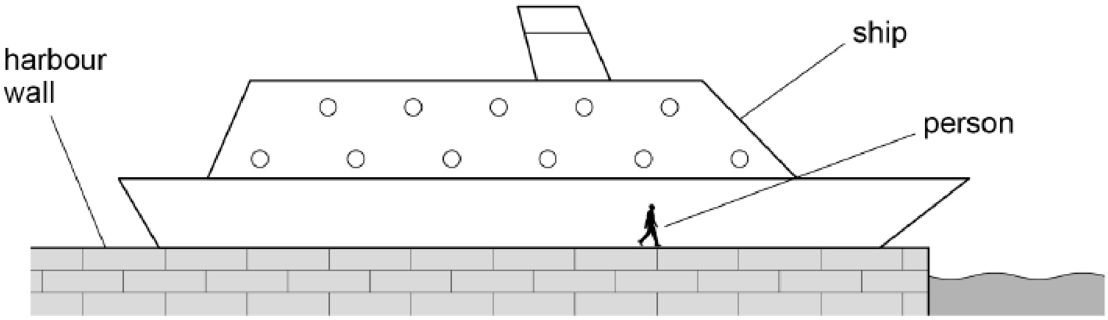

Discuss the differences between the magnitudes and directions of force $U$ in **Figure 7** and force $V$ applied at **Y** in **Figure 9**.

**[3 marks]**

**3.** June/2021/Paper_7407_01/No.05

**0 5 . 1** **Figure 10** shows a ship leaving a harbour at a constant velocity.
The ship moves at the same velocity as a person walking on the harbour wall alongside the ship.

**Figure 10**




The momentum of the ship is approximately $1 \times 10^7$ N s.

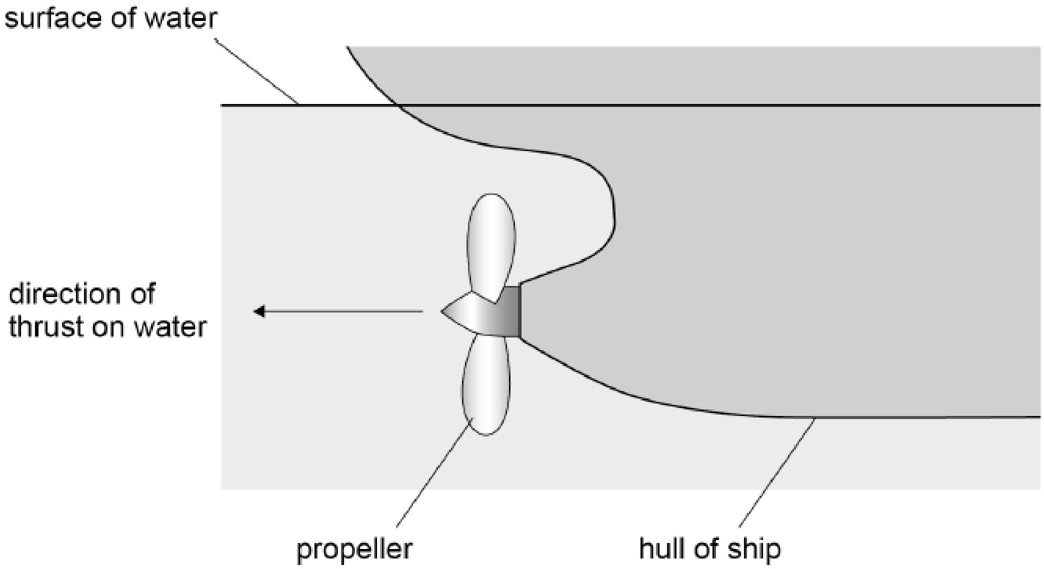
Estimate the mass of the ship.

**[2 marks]**

mass of ship = ____________________ kg

**0 5 . 2** **Figure 11** shows the direction of the thrust exerted by the ship's propeller as the propeller rotates. The ship's engine makes the propeller rotate. When more water is accelerated, more work is done by the engine.

**Figure 11**



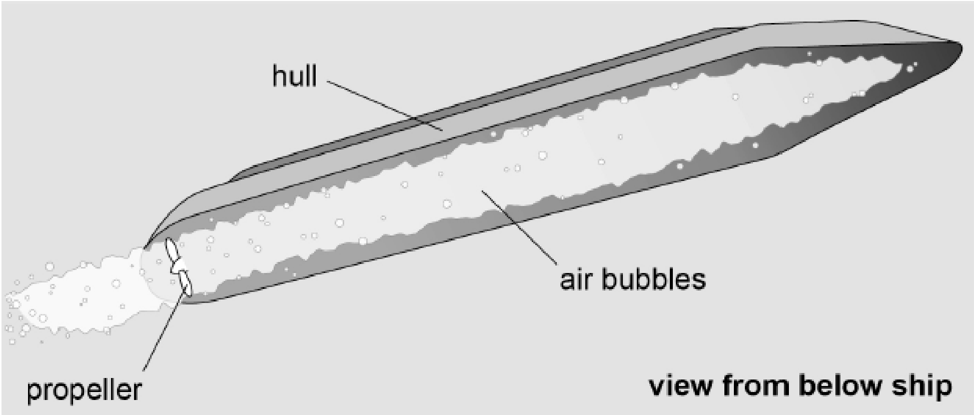

Explain, using Newton's laws of motion, how the thrust of the propeller on the water enables the ship to maintain a constant momentum.

**[4 marks]**

**0 5 . 3** **Figure 12** shows the bottom of the hull with a drag reduction system in operation. Air bubbles are introduced into the water below the hull. This reduces the work done per second against the drag on the hull at any given speed.

However, when the air bubbles reach the propeller they decrease the mass of water being accelerated by the propeller every second. This decreases the thrust produced by the propeller at a given speed of rotation.

**Figure 12**




The system enables the ship to save fuel while maintaining the same momentum.

Explain why the system delivers this fuel saving.
In your answer, consider the effects of the introduction of the system on

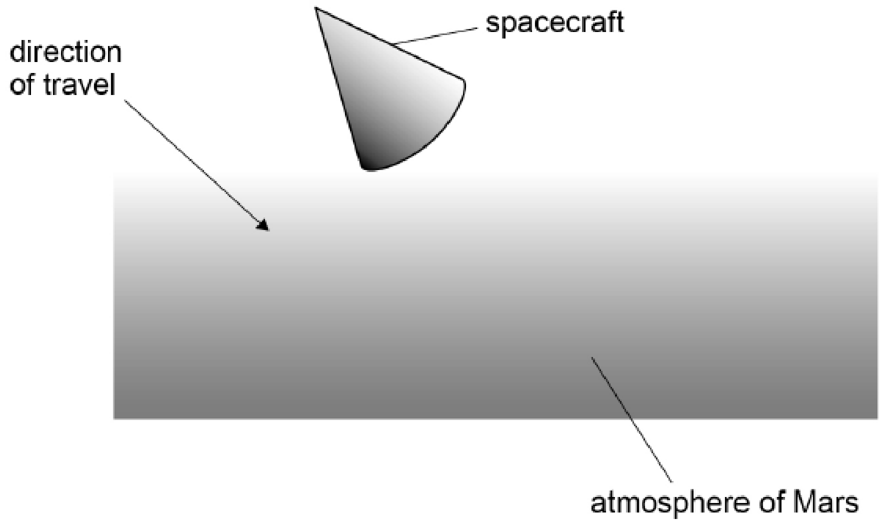
- the thrust
- the drag on the hull.

**[3 marks]**

**4.** June/2020/Paper_7407_01/No.02

**0 2** A spacecraft entering the atmosphere of Mars must decelerate to land undamaged on the surface.

**Figure 1**




**0 2 . 1** **Figure 1** shows the spacecraft of total mass $610\ \text{kg}$ entering the atmosphere at a speed of $5.5\ \text{km s}^{-1}$.

Calculate the kinetic energy of the spacecraft as it enters the atmosphere.
Give your answer to an appropriate number of significant figures.

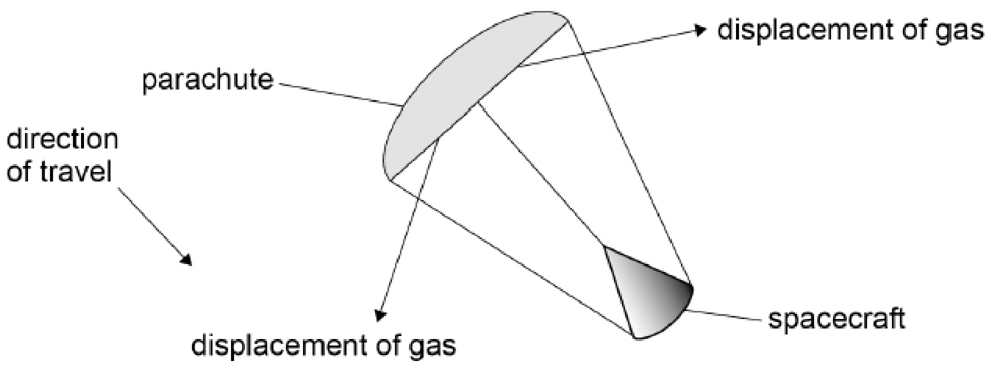
**[3 marks]**

kinetic energy = ______________________ J

**0 2 . 2** A parachute opens during the spacecraft's descent through the atmosphere.

**Figure 2** shows the parachute–spacecraft system, with the open parachute displacing the atmospheric gas. This causes the system to decelerate.

**Figure 2**




Explain, with reference to Newton's laws of motion, why displacing the atmospheric gas causes a force on the system **and** why this force causes the system to decelerate.

**[4 marks]**

**0 2 . 3** As the parachute–spacecraft system decelerates, it falls through a vertical distance of $49\ \text{m}$ and loses $2.2 \times 10^5\ \text{J}$ of kinetic energy.
During this time, $3.3 \times 10^5\ \text{J}$ of energy is transferred from the system to the atmosphere.
The total mass of the system is $610\ \text{kg}$.

Calculate the acceleration due to gravity as it falls through this distance.

**[3 marks]**

acceleration due to gravity = ____________________ $\text{m s}^{-2}$

**0 2 . 4** Dust from the surface of Mars can enter the atmosphere. This increases the density of the atmosphere significantly.

Deduce how an increase in dust content will affect the deceleration of the system.

**[3 marks]**

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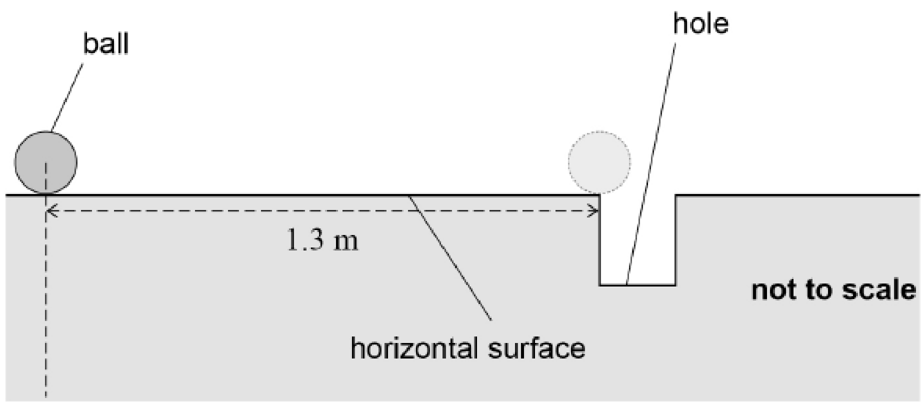
**5.** June/2020/Paper_7407_01/No.03

**0 3 . 1** **Figure 3** shows a golf ball at rest on a horizontal surface 1.3 m from a hole.

**Figure 3**




A golfer hits the ball so that it moves horizontally with an initial velocity of 1.8 $m\,s^{-1}$.
The ball experiences a constant deceleration of 1.2 $m\,s^{-2}$ as it travels to the hole.

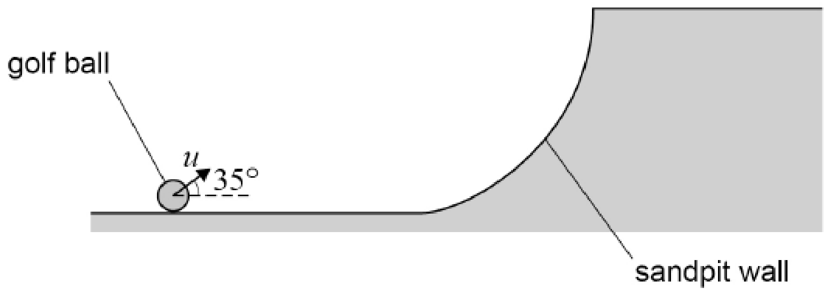
Calculate the velocity of the ball when it reaches the edge of the hole.

**[2 marks]**

velocity = ______________________ $m\,s^{-1}$

**0 3 . 2** Later, the golf ball lands in a sandpit. The golfer hits the ball, giving it an initial velocity $u$ at $35°$ to the horizontal, as shown in **Figure 4**. The horizontal component of $u$ is $8.8\ \text{m s}^{-1}$.

**Figure 4**



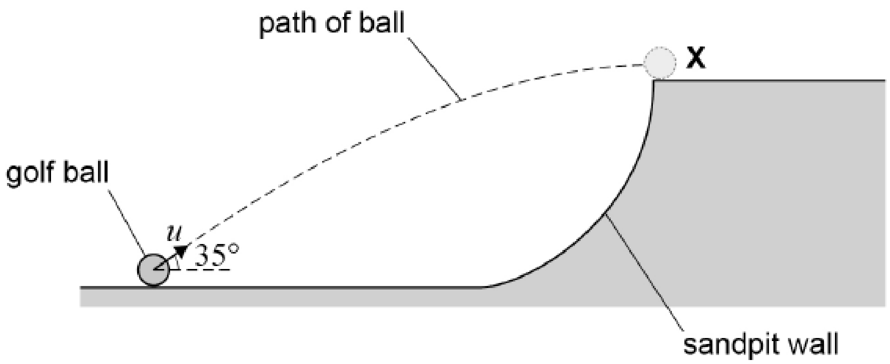

**not to scale**

Show that the vertical component of $u$ is approximately $6\ \text{m s}^{-1}$.

**[1 mark]**

**0 3 . 3** The ball is travelling horizontally as it reaches **X**, as shown in **Figure 5**.

**Figure 5**




**not to scale**

Assume that weight is the only force acting on the ball when it is in the air.

Calculate the time for the ball to travel to **X**.

**[2 marks]**

time = ____________________ s

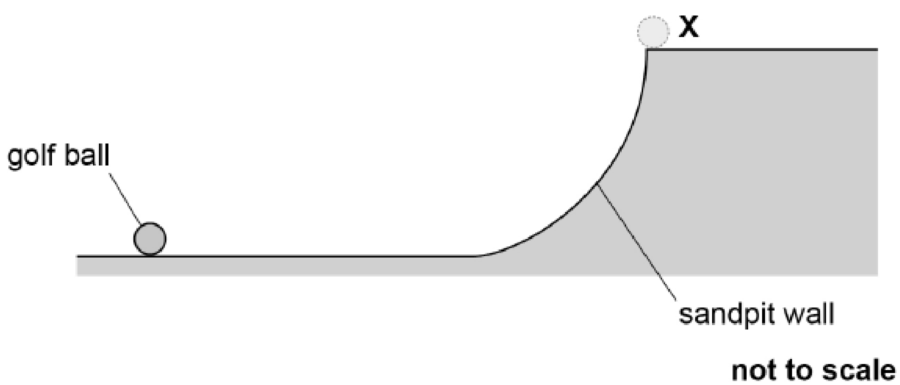
**0 3 . 4** Calculate the vertical distance of **X** above the initial position of the ball.

**[2 marks]**

vertical distance = ____________________ m

The golfer returns the ball to its original position in the sandpit. He wants the ball to land at **X** but this time with a **smaller** horizontal velocity than in **Figure 5**.

**Figure 6**




**0 3 . 5** Sketch on **Figure 6** a possible trajectory for the ball.

**[1 mark]**

**0 3 . 6** Explain your reason for selecting this trajectory.

**[2 marks]**