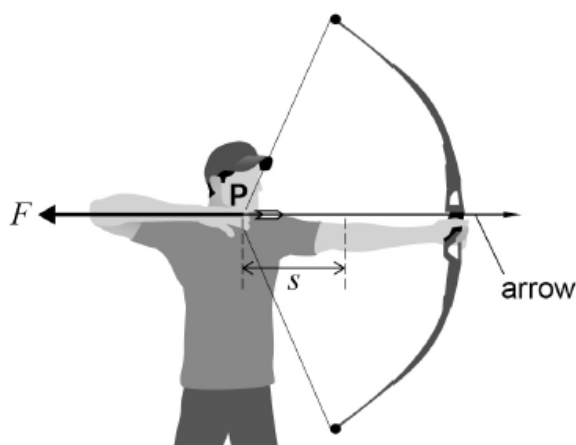


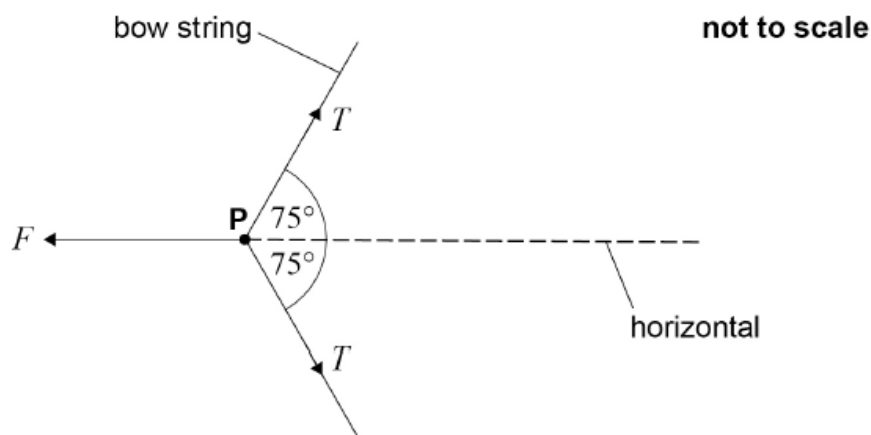
Force, energy and momentum – AS Physics

1. No.4

0 4

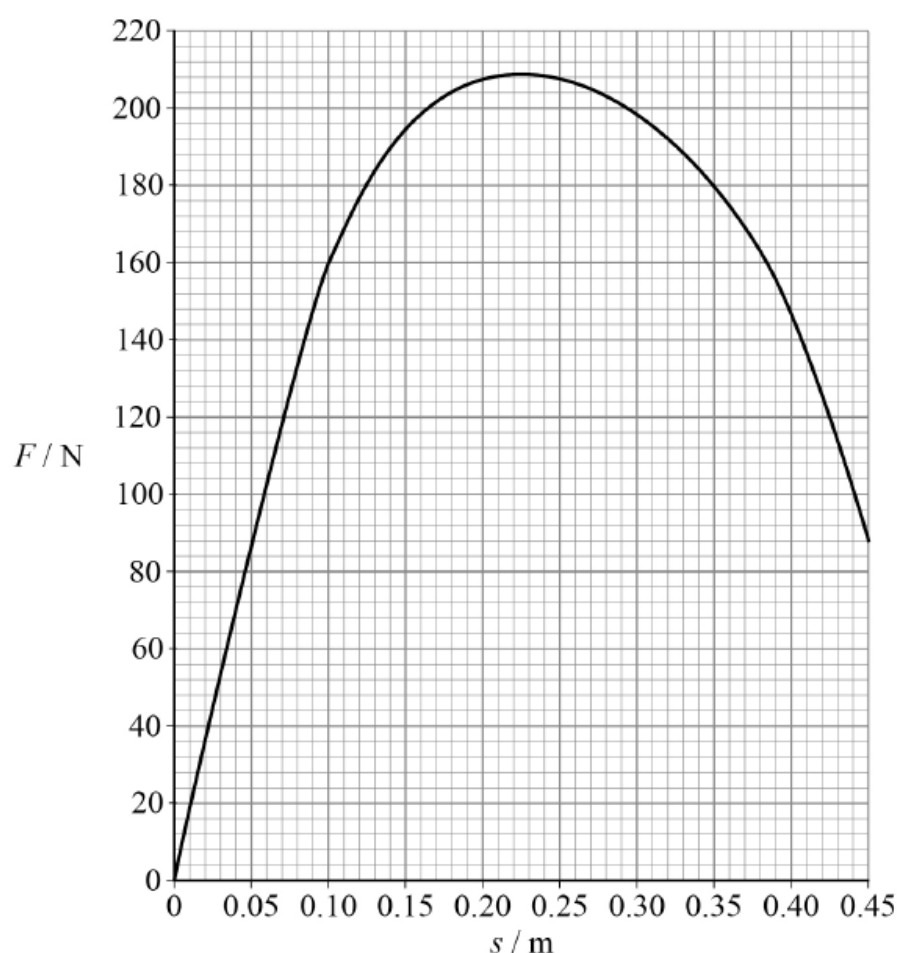
Figure 4 shows an archer using a bow in a competition.**Figure 4**The archer exerts a force F to pull point **P** on the string back through a distance s .

0 4 . 1

Figure 5 is a simplified diagram of the bow string showing the forces acting on **P**. The tension in the string is T and the string makes an angle of 75° to the horizontal.**Figure 5**In **Figure 5**, F is 160 N and **P** is in equilibrium.Calculate T .**[2 marks]** $T =$ _____ N

The bow is designed so that F varies with s as shown in **Figure 6**.

Figure 6



0 4 . 2

An arrow of mass 21 g is placed in the bow.

The archer pulls **P** back by a distance s of 0.22 m and then releases the arrow in a horizontal direction.

Assume that there are no resistive forces acting on the arrow as it is released.

Determine the initial horizontal acceleration of the arrow.

[2 marks]

initial horizontal acceleration = _____ m s^{-2}

The arrow is replaced with a different arrow of mass m .

The archer pulls **P** back by a distance s_r so that the energy stored in the bow is 64 J and F is 160 N.

0 4 . 3

Deduce s_r .

[2 marks]

$s_r =$ _____ m

0 4 . 4

The bow has an efficiency of 0.82

The arrow leaves the bow in a horizontal direction with a velocity of 190 km h^{-1} .

Calculate m .

[3 marks]

$m =$ _____ kg

2. No.5

0 5

Figure 7 shows a robotic helicopter that is used on Mars. The helicopter is powered by a battery. Before each flight, the battery is charged by a solar panel.

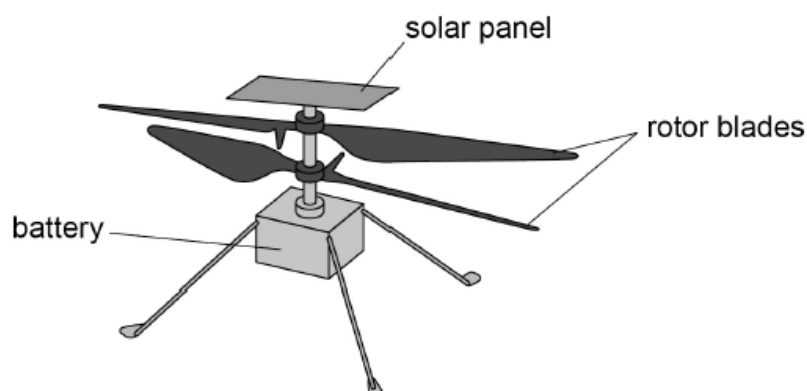
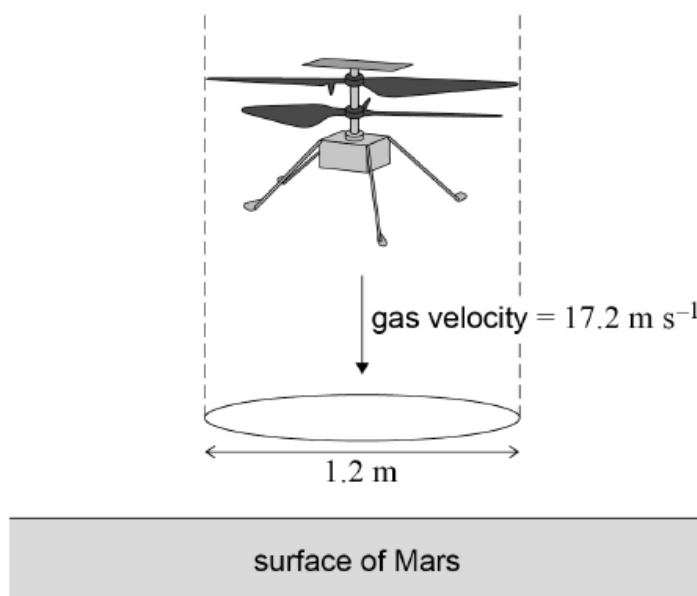
Figure 7

Figure 8 shows the helicopter hovering at a constant height above the surface of Mars. The rotor blades move a column of atmospheric gas vertically downwards at a velocity of 17.2 m s^{-1} . The diameter of this column is 1.2 m .

Figure 8

0 5 . 1 The gas moved by the rotor blades has a density of 0.020 kg m^{-3} .

Show that the helicopter moves approximately 0.4 kg of gas every second.

[3 marks]

The movement of the gas creates an upward force on the helicopter. This upward force enables the helicopter to hover at a constant height.

The gravitational field strength on Mars is 3.72 N kg^{-1} .

0 5 . 2 Calculate the mass of the helicopter.

[3 marks]

mass = _____ kg

0 5 . 3

The battery stores 0.035 kW h of energy before a flight.
The flight lasts for 39 s.
The battery has a power output of 340 W during the flight.

Determine the percentage of the initial energy stored in the battery that is transferred during the flight.

[2 marks]

percentage = _____ %

0 5 . 4

The helicopter has a maximum flight time of a few minutes due to the limited amount of energy stored in the battery. The battery accounts for about 15% of the helicopter's mass.

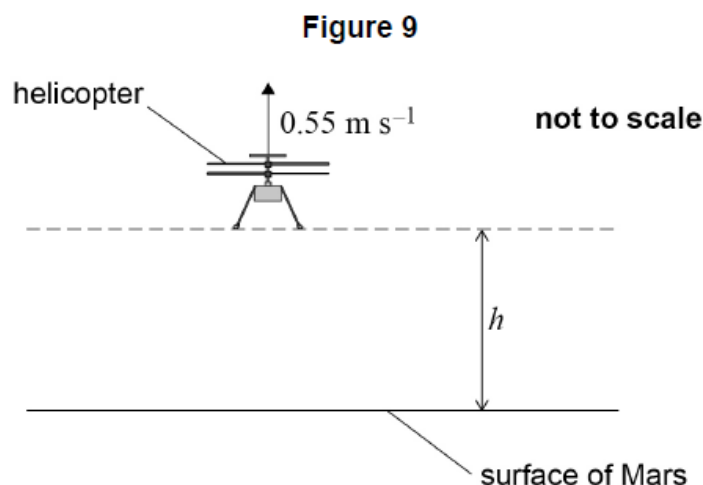
A student suggests that adding another identical battery that doubles the energy available to the helicopter would double its flight time.

Deduce without calculation whether the student's suggestion is correct.

[3 marks]

Figure 9 shows a simplified side view of the helicopter moving vertically upwards with a speed of 0.55 m s^{-1} .

At the instant shown, the helicopter is at a height h and the blades stop rotating.



The gravitational field strength on Mars is 3.72 N kg^{-1} .

The weight of the helicopter is the only force acting on it when the blades stop rotating. Drag forces on the helicopter are negligible as it rises to a maximum height and then falls back to the surface.

0 5 . 5

Calculate the time taken for the helicopter to reach its maximum height from the instant the blades stop rotating.

[2 marks]

time = _____ s

0 5 . 6

When the helicopter makes contact with the surface it has a velocity of 2.2 m s^{-1} .

Calculate h .

[2 marks]

$h =$ _____ m

0 5 . 7

A student suggests that the acceleration of the helicopter is constant from the instant the blades stop rotating until the helicopter makes contact with the surface.

Discuss this suggestion with reference to an appropriate Newton's law of motion.

[2 marks]

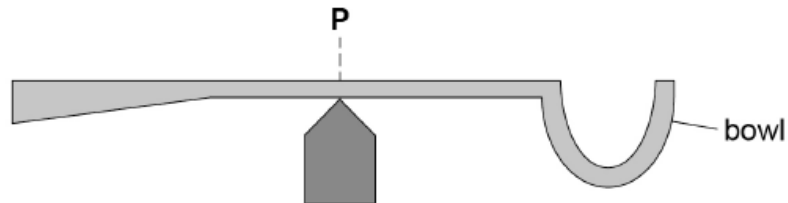
3. June/2023/Paper_7407/2/No.3

0 3

Figure 9 shows a spoon used to measure the mass of food.

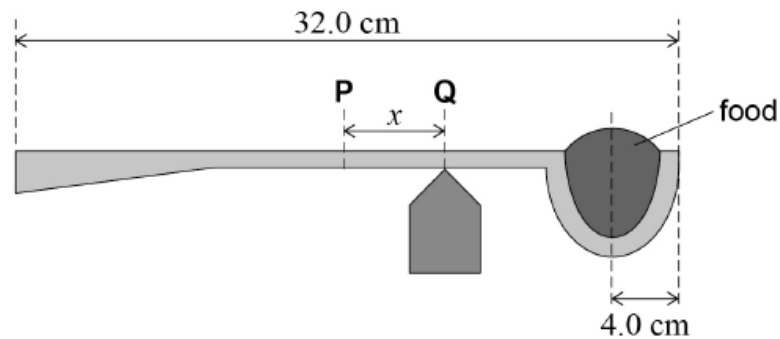
The empty spoon balances when a pivot is placed under a point **P** halfway along the spoon.

Figure 9



The spoon tilts when food of mass M is placed in the bowl. The spoon is rebalanced by moving the pivot a distance x to the right of **P**. The new position of the pivot is under point **Q** in **Figure 10**.

Figure 10



The total length of the spoon is 32.0 cm. The weight of the food acts through a line at a distance of 4.0 cm from the right-hand edge of the spoon.

0 3 . 1

Explain why the spoon in **Figure 10** is balanced when the pivot is at **Q**.

[2 marks]

0 3 . 2 The empty spoon has mass m .

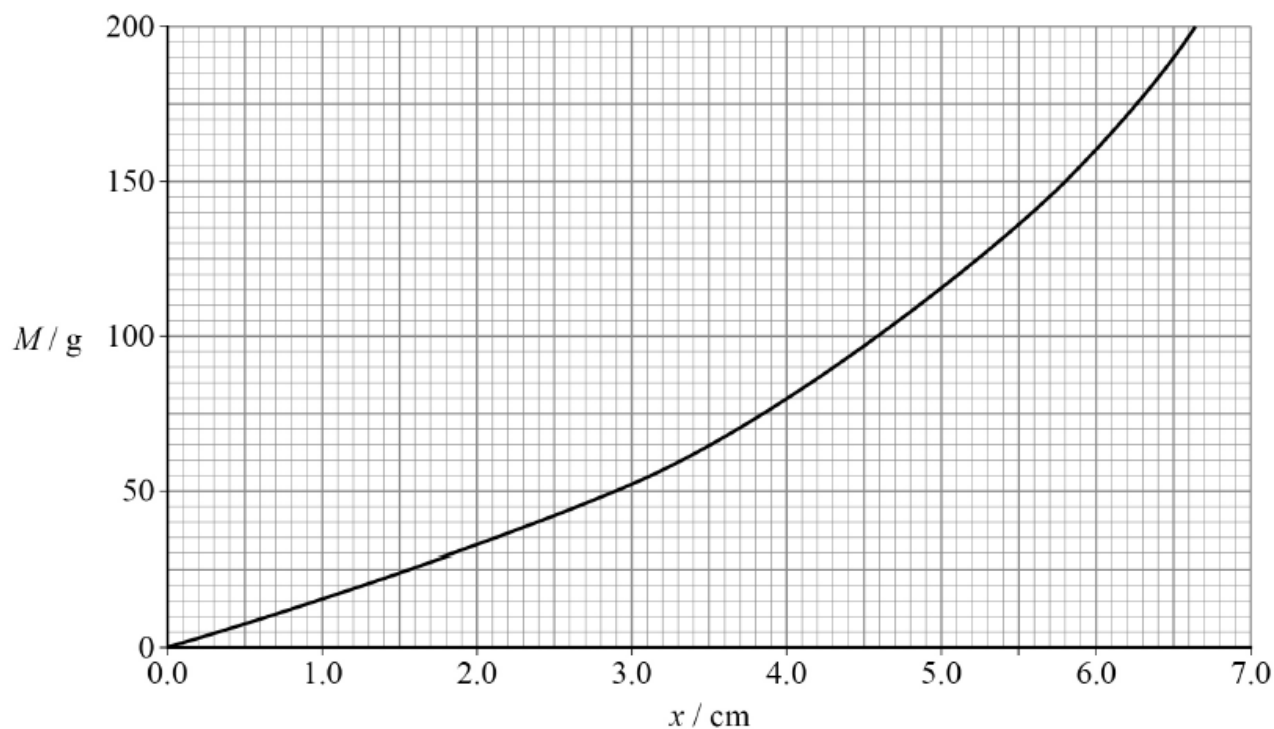
Show that, for the arrangement in **Figure 10**,

$$\frac{m}{M} = \frac{(12.0 - x)}{x}$$

[2 marks]

0 3 . 3 **Figure 11** shows how x varies with M .

Figure 11



Determine, using **Figure 11**, the weight of the empty spoon.

[3 marks]

weight = _____ N

0	3	.	4
---	---	---	---

A scale, in grams, is marked on the spoon between **P** and the bowl. **Figure 11** is used to calibrate this scale in intervals of 25 g.

M can be measured by balancing the spoon. The value is read from the point of the scale directly above the pivot.

State and explain how the uncertainty in the value read from the scale changes as M increases.

[3 marks]

4. June/2023/Paper_7407/2/No.8

An object of mass 0.20 kg moves with an initial velocity u . It collides with a stationary object of mass 0.30 kg .

The objects stick together when they collide.
No external forces act on the objects.

What is the final velocity of the two objects after the collision?

[1 mark]

A $0.40u$

☐

B $0.67u$

☐

C $1.5u$

☐

D $2.5u$

☐

5. June/2023/Paper_7407/2/No.9

P and **Q** represent displacements.



What is the resultant displacement when **P** and **Q** are added?

[1 mark]

- A**  ☐
- B**  ☐
- C**  ☐
- D**  ☐

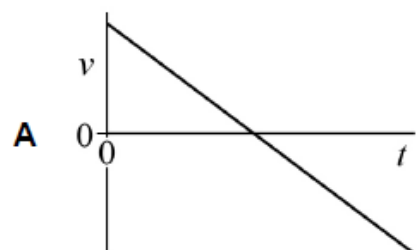
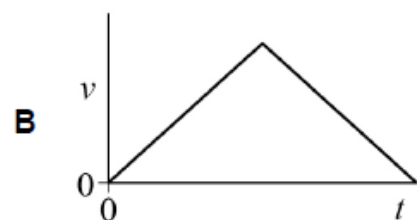
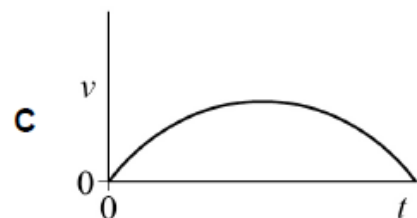
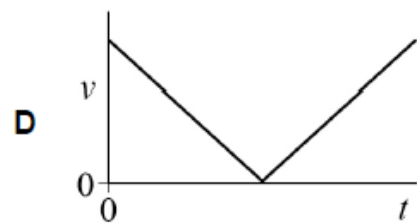
6. June/2023/Paper_7407/2/No.10

A girl kicks a football vertically upwards at time $t = 0$

Air resistance is negligible.

What is the variation of the vertical component of velocity v of the football with t until it reaches the ground?

[1 mark]

☐☐☐☐

7. June/2023/Paper_7407/2/No.26

A ball is dropped from a height h . The ball hits the ground with a velocity v .

The ball is now dropped from a height of $2h$.

Air resistance is negligible.

What is the velocity at which the ball hits the ground?

[1 mark]

A v

☐

B $\sqrt{2}v$

☐

C $v\sqrt{2}$

☐

D $2v$

☐

8. June/2023/Paper_7407/2/No.33

A pellet of mass 25 g travelling horizontally at 40 m s^{-1} enters a fixed wooden block. The pellet stops after travelling a horizontal distance of 2.5 cm in the block.

What is the average resistive force acting on the pellet?

[1 mark]

A 20 N

☐

B 800 N

☐

C 1600 N

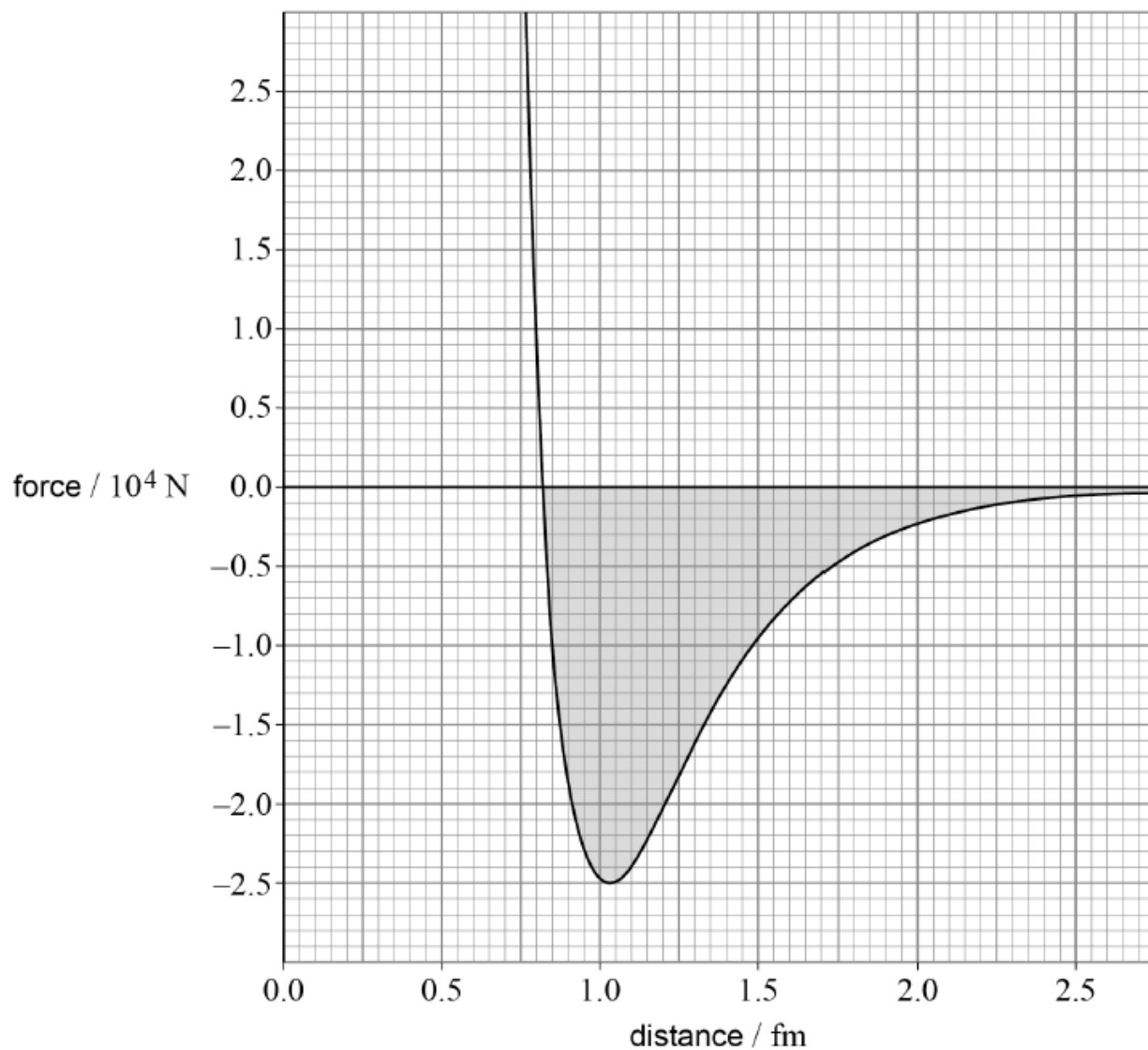
☐

D 8000 N

☐

9. June/2023/Paper_7407/2/No.34

The graph shows the variation of force with distance between a proton and a neutron.



The shaded area represents

[1 mark]

A acceleration.

☐

B impulse.

☐

C rate of change of kinetic energy.

☐

D work done.

☐