1)

Which one of the following has the same unit as the rate of change of momentum?

A work

B energy

C acceleration

D weight

2)

The nucleus of a radioactive isotope X is at rest and decays by emitting an α particle so that a new nuclide Y is formed.
Which one of the following statements about the decay is correct?

A The momentum of Y is equal and opposite to the momentum of the α particle.

B The momentum of Y is equal to the momentum of X.

C The kinetic energy of Y is equal to the kinetic energy of the α particle.

D The total kinetic energy is the same before and after the decay.

3)

Trolley T_1, of mass 2.0 kg, collides on a horizontal surface with trolley T_2, which is also of mass 2.0 kg. The collision is elastic. Before the collision T_1 was moving at $4.0\ m\ s^{-1}$ and T_2 was at rest.

Which one of the following statements is correct?

Immediately after the collision

A T_1 is at rest and T_2 moves at $4.0\ m\ s^{-1}$.

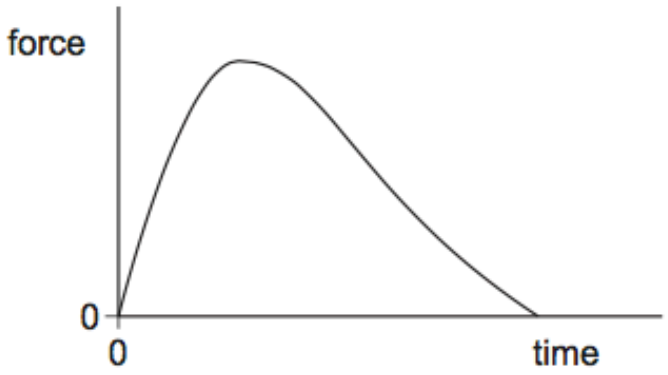
B T_1 will rebound from T_2 at $4.0\ m\ s^{-1}$.

C T_1 and T_2 will both move at $2.8\ m\ s^{-1}$.

D T_1 and T_2 will both move at $1.4\ m\ s^{-1}$.

4)

The graph shows how the force acting on a rocket varies with time.



Which one of the following is represented by the area under the graph?

A distance travelled

B gain in kinetic energy

C change in velocity

D change in momentum

5)

A golf club strikes a stationary golf ball of mass $4.8 \times 10^{-2}\,\text{kg}$ and the ball leaves the club with a speed of $95\,\text{m s}^{-1}$. If the average force exerted on the ball is $7800\,\text{N}$, how long are the ball and club in contact?

A $5.8 \times 10^{-4}\,\text{s}$

B $1.2 \times 10^{-2}\,\text{s}$

C $0.51\,\text{s}$

D $0.58\,\text{s}$

6)

Water of density $1000\,\text{kg m}^{-3}$ flows out of a garden hose of cross-sectional area $7.2 \times 10^{-4}\,\text{m}^2$ at a rate of $2.0 \times 10^{-4}\,\text{m}^3$ per second. How much momentum is carried by the water leaving the hose per second?

A $5.6 \times 10^{-5}\,\text{N s}$

B $5.6 \times 10^{-2}\,\text{N s}$

C $0.20\,\text{N s}$

D $0.72\,\text{N s}$

7)

Which one of the following is a possible unit of impulse?

A $\mathrm{N\,s^{-1}}$

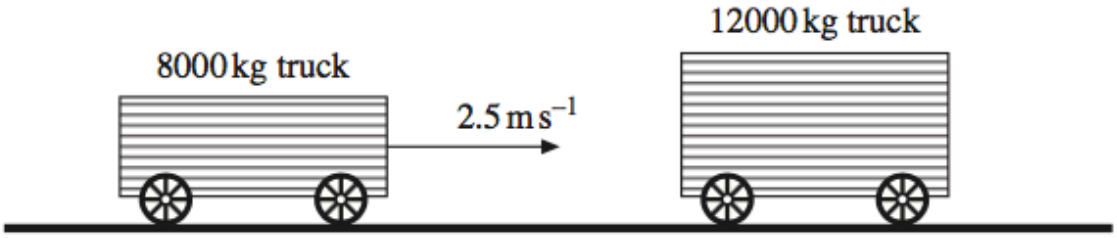
B $\mathrm{kg\,m\,s^{-1}}$

C $\mathrm{kg\,m\,s^{-2}}$

D $\mathrm{s\,N^{-1}}$

8)

A railway truck of mass 8000 kg travels along a level track at a velocity of $2.5\,\mathrm{m\,s^{-1}}$ and collides with a stationary truck of mass 12000 kg. The two trucks move together at the same velocity after the collision.



What is the change in momentum of the 8000 kg truck due to the impact?

A 8000 N s

B 12000 N s

C 20000 N s

D 25000 N s

9)

A gas molecule of mass m moving at velocity u collides at right angles with the side of a container and rebounds elastically. Which one of the following statements concerning the motion of the molecule is **incorrect**?

A The magnitude of the change in momentum of the molecule is zero.

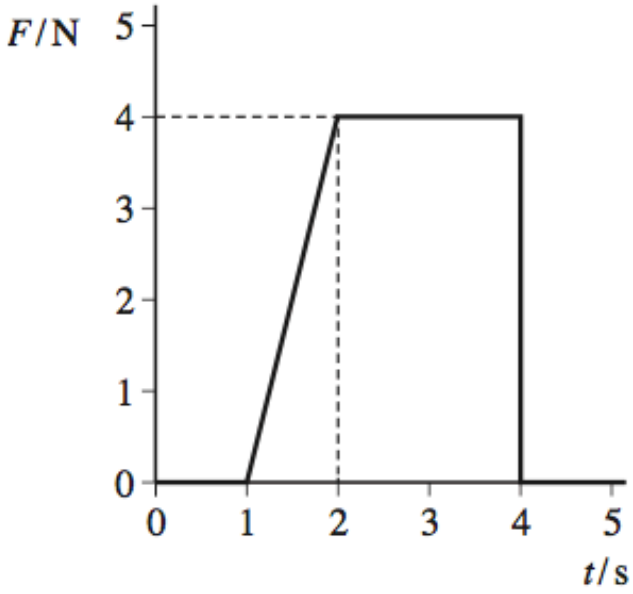
B The magnitude of the change in momentum of the molecule is $2mu$.

C The force exerted by the molecule on the side of the container is equal to the force exerted by the container on the molecule.

D The change in kinetic energy of the molecule is zero.

10)

The graph shows how the resultant force, F, acting on a body varies with time, t.



What is the change in momentum of the body over the 5 s period?

A 2 N s

B 8 N s

C 10 N s

D 12 N s

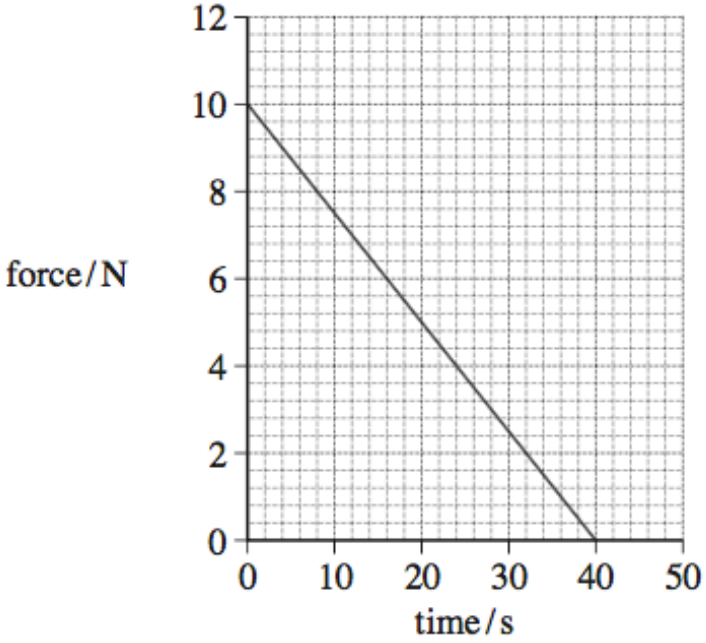
11)

Which line, **A** to **D**, in the table shows correctly whether the moment of a force, and momentum, are scalar or vector quantities?

	moment of force	**momentum**
A	scalar	scalar
B	scalar	vector
C	vector	scalar
D	vector	vector

12)

The graph shows how the force acting on a body changes with time.



The body has a mass of 0.25 kg and is initially at rest. What is the speed of the body after 40 s assuming no other forces are acting?

A $200\,\text{m s}^{-1}$

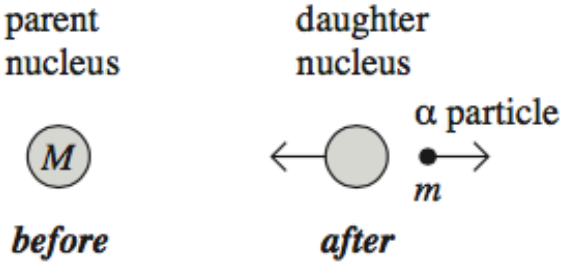
B $400\,\text{m s}^{-1}$

C $800\,\text{m s}^{-1}$

D $1600\,\text{m s}^{-1}$

13)

A stationary unstable nucleus of mass M emits an α particle of mass m with kinetic energy E.



What is the speed of recoil of the daughter nucleus?

A $\dfrac{\sqrt{2mE}}{(M-m)}$

B $\dfrac{\sqrt{2mE}}{M}$

C $\dfrac{(M-m)}{\sqrt{2mE}}$

D $\dfrac{2mE}{(M-m)^2}$

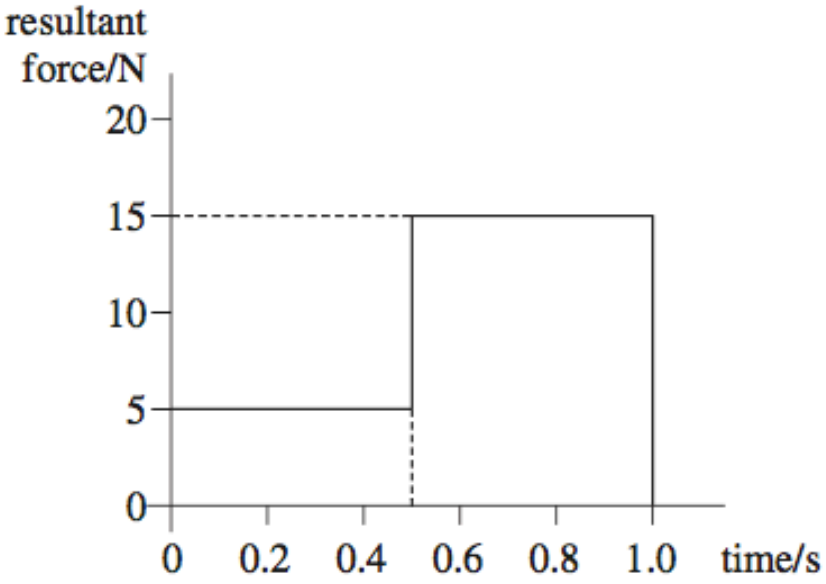
14)

Two ice skaters, initially at rest and in contact, push apart from each other.
Which line, **A** to **D**, in the table states correctly the change in the total momentum and the total kinetic energy of the two skaters?

	total momentum	**total kinetic energy**
A	unchanged	increases
B	unchanged	unchanged
C	increases	increases
D	increases	unchanged

15)

The graph shows how the resultant force applied to an object of mass 2.0 kg, initially at rest, varies with time.



What is the speed of the object after 1.0 s?

A $2.5\,m\,s^{-1}$
B $5.0\,m\,s^{-1}$
C $7.5\,m\,s^{-1}$
D $10\,m\,s^{-1}$

16)

Which of the following is a possible unit for rate of change of momentum?

A $\mathrm{N\,s}$
B $\mathrm{N\,s^{-1}}$
C $\mathrm{kg\,m\,s^{-1}}$
D $\mathrm{kg\,m\,s^{-2}}$

17)

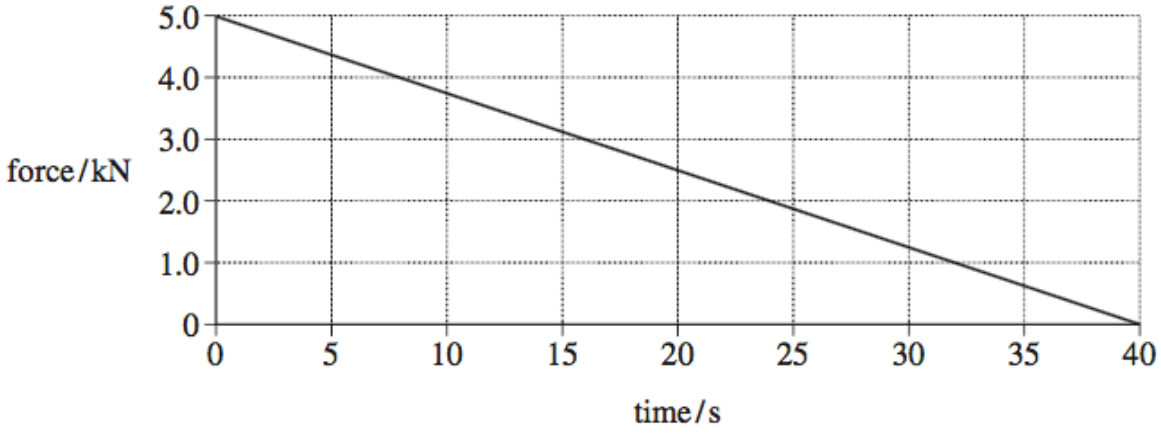
Which one of the following statements is correct?

The force acting on an object is equivalent to

A its change of momentum.
B the impulse it receives per second.
C the energy it gains per second.
D its acceleration per metre.

18)

The graph shows how the force on a glider of mass 2000 kg changes with time as it is launched from a level track using a catapult.



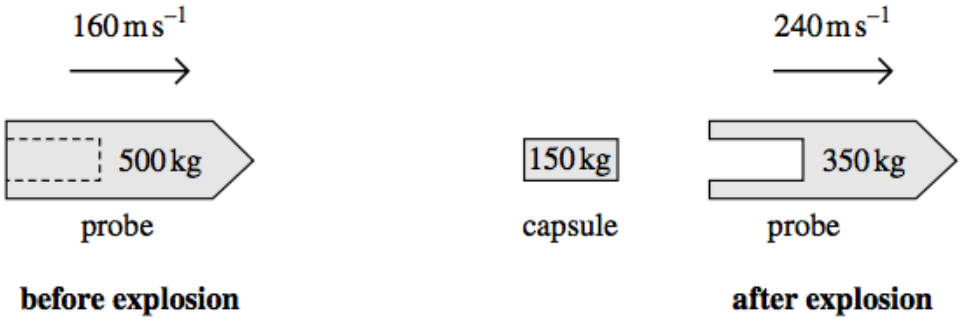
Assuming the glider starts at rest what is its velocity after 40 s?

A $2.5\,\mathrm{m\,s^{-1}}$
B $10\,\mathrm{m\,s^{-1}}$
C $50\,\mathrm{m\,s^{-1}}$
D $100\,\mathrm{m\,s^{-1}}$

19)

Deep space probes often carry modules which may be ejected from them by an explosion. A space probe of total mass 500 kg is travelling in a straight line through free space at 160 m s^{-1} when it ejects a capsule of mass 150 kg explosively, releasing energy. Immediately after the explosion the probe, now of mass 350 kg, continues to travel in the original straight line but travels at 240 m s^{-1}, as shown in **Figure 2**.

Figure 2



(a) Discuss how the principles of conservation of momentum and conservation of energy apply in this instance.

The quality of your written communication will be assessed in this question.

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(6 marks)

(b) (i) Calculate the magnitude of the velocity of the capsule immediately after the explosion and state its direction of movement.

magnitude of velocity = ... $m\,s^{-1}$

direction of movement .....

(3 marks)

(b) (ii) Determine the total amount of energy given to the probe and capsule by the explosion.

answer = ... J

(4 marks)

20)

(a) State, in words, how the force acting on a body is related to the change in momentum of the body.

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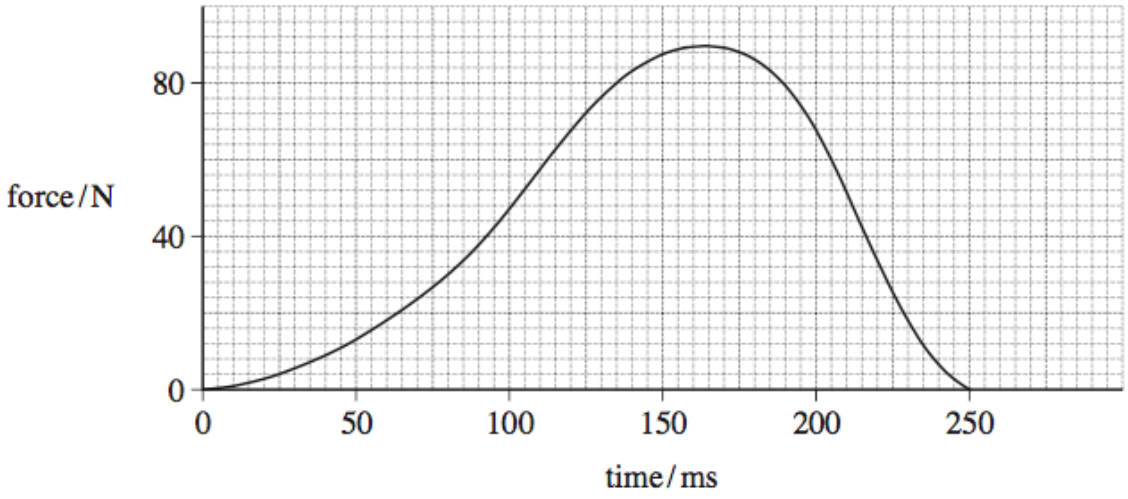
(1 mark)

(b) A football of mass 0.42 kg is moving horizontally at 10 m s^{-1} towards a footballer's boot, which then kicks it. **Figure 1** shows how the force between the boot and the ball varies with time while they are in contact.

Figure 1



(b) (i) What is the significance of the area enclosed by the line on a force–time graph and the time axis when a force acts on a body for a short time?

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(1 mark)

(b) (ii) Estimate the impulse that acts on the ball, stating an appropriate unit.

answer = ...

(4 marks)

(b) (iii) Calculate the speed of the ball after it has been kicked, assuming that it returns along the same horizontal line it followed when approaching the boot. Express your answer to an appropriate number of significant figures.

answer = ...m s^{-1}

(4 marks)

(c) Discuss the consequences if the ball had approached the boot at a higher speed but still received the same impulse.

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(3 marks)

21)

(a) State, in words, the relationship between the force acting on a body and the momentum of the body.

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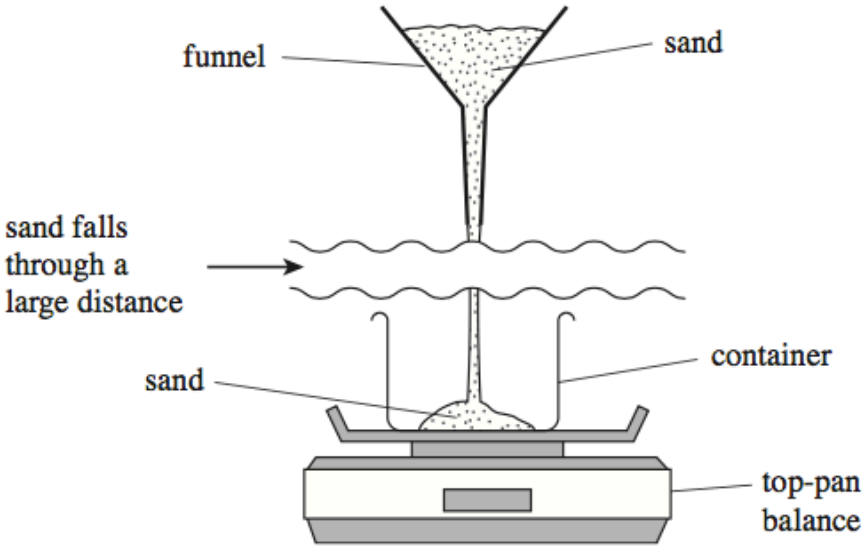
(1 mark)

(b) A container rests on a top-pan balance, which measures mass in kg. A funnel above the container holds some sand. The sand falls at a constant rate of $0.300\,\text{kg}\,\text{s}^{-1}$ into the container, having fallen through an average vertical height of 1.60 m.
This arrangement is shown in **Figure 1**.

Figure 1



(b) (i) Show that the velocity of the sand as it lands in the container is $5.6\,\text{m}\,\text{s}^{-1}$.

(1 mark)

(b) (ii) Calculate the magnitude of the momentum of the sand that lands in the container in each second.

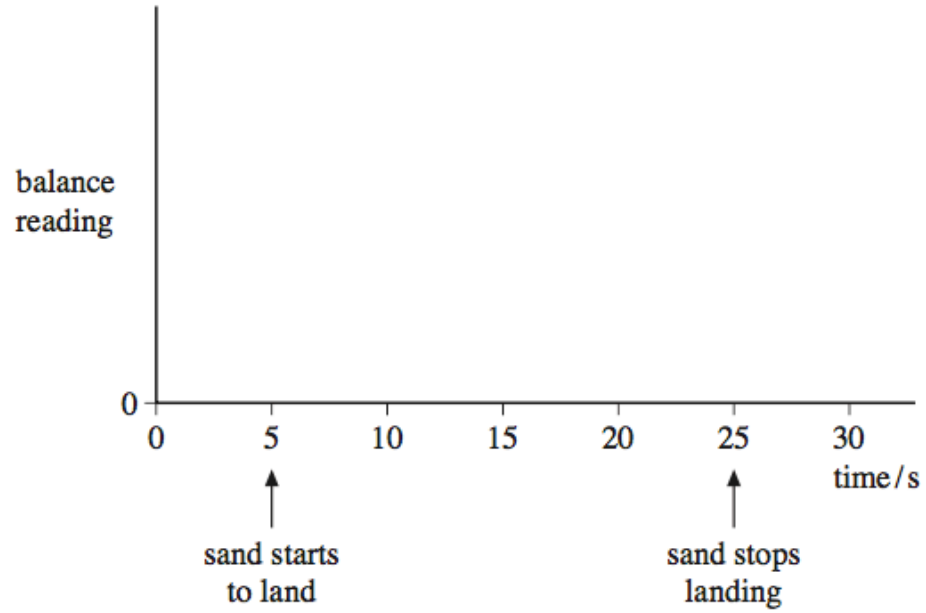
answer = ... N s

(1 mark)

(b) (iii) The mass of the container is 0.650 kg. Show that the reading of the balance, 10.0 s after the sand starts landing continuously in the container, will be 3.82 kg. You may assume that the sand comes to rest without rebounding when it lands in the container.

(3 marks)

(c) It takes 20.0 s for all of the sand to fall into the container.
On the axes below, sketch a graph to show how the reading of the balance will change over a 30.0 s period, where t = 5.0 s is the time at which the sand starts to land in the container. No further calculations are required and values need not be shown on the vertical axis of the graph.



(3 marks)