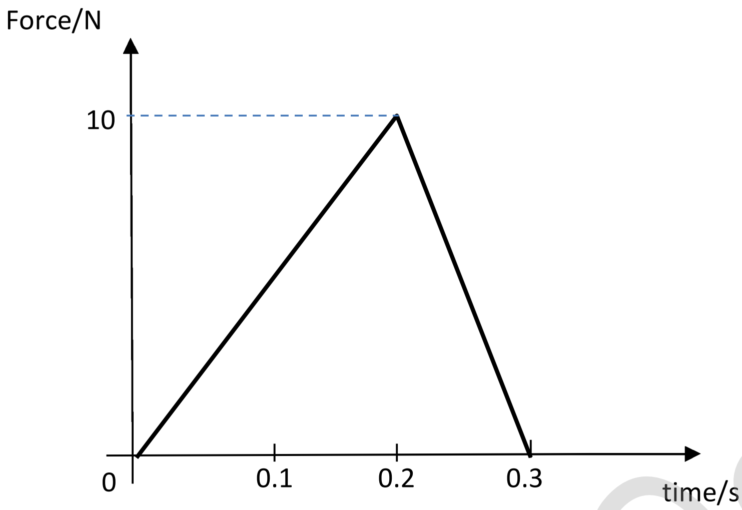
DYNAMICS

Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by The Physics Cafe

1 A varying force acts upon an object. The graph below shows how the force acting on the object varies with time.



The magnitude of the maximum change in momentum of the object is

A 3.0 Ns **B** 2.0 Ns **C** 1.5 Ns **D** 1.0 Ns

2 A stationary Thoron nucleus of mass 220*u* emits an alpha particle of mass 4*u* with kinetic energy E_α.

Which of the following gives the correct value of

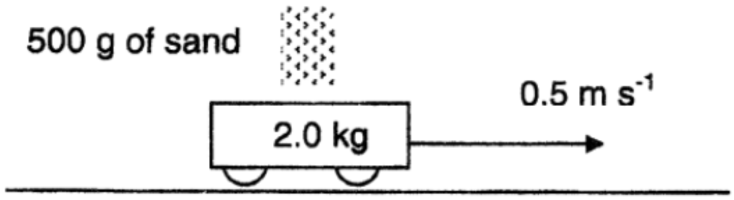
the ratio $\dfrac{\textit{speed of alpha particle}}{\textit{speed of the recoiling daughter nucleus}}$

and *kinetic energy* of the daughter nucleus immediately after the emission?

	$\dfrac{\textbf{\textit{speed of alpha particle}}}{\textbf{\textit{speed of the recoiling daughter nucleus}}}$	***kinetic energy of the recoiling daughter nucleus***
A	55	$\frac{1}{55} E_\alpha$
B	54	$(\frac{1}{54})^2 E_\alpha$
C	54	$\frac{1}{54} E_\alpha$
D	$\frac{1}{54}$	$54 E_\alpha$

(ACJC, 2014)

3 The diagram shows a trolley moving on a frictionless horizontal table at a speed of 0.5 m s^{-1}. 500 g of sand is then released onto the trolley.



What is the change in the momentum of the trolley?

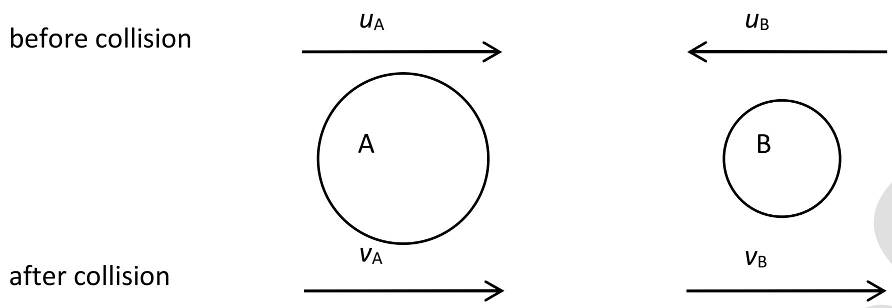
A zero **B** 0.15 N s **C** 0.20 N s **D** 1.80 N s

4 A stationary polonium nucleus (A = 210, Z = 84) emits an α particle with kinetic energy E_α.

Which of the following is the kinetic energy of the recoiling nucleus?

A $\frac{2}{105}E_\alpha$ **B** $\frac{2}{103}E_\alpha$ **C** $\frac{2}{5}E_\alpha$ **D** $\frac{42}{103}E_\alpha$

5 Two spheres A and B approach each other along the same straight line with speed u_A and speed u_B. The spheres collide and move off with speeds v_A and v_B, both in the same direction as the initial direction of sphere A, as shown below.



Which equation applies to an elastic collision?

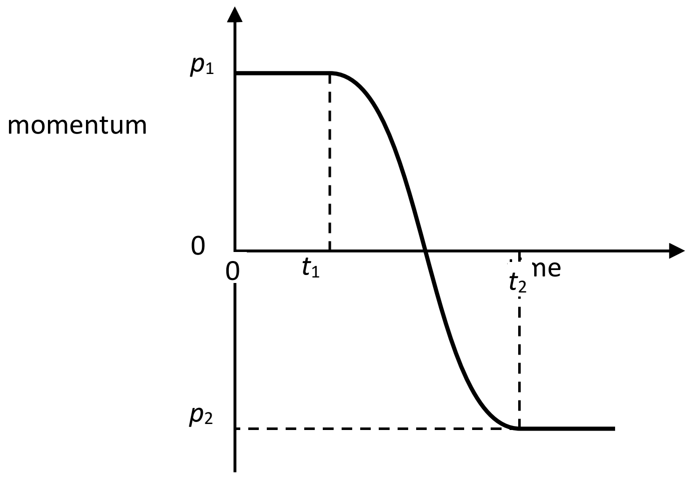
A $u_A + u_B = v_B - v_A$

B $u_A - u_B = v_B - v_A$

C $u_A - u_B = v_B + v_A$

D $u_A + u_B = v_B + v_A$

6 The graph shows the variation with time of the momentum of a ball as it is kicked in a straight line.



Initially, the momentum is p_1 at time t_1. At time t_2 the momentum is p_2.

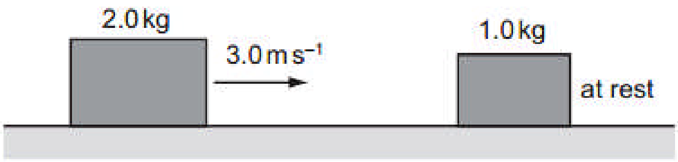
What is the magnitude of the average force acting on the ball between times t_1 and t_2?

A $\frac{p_1 - p_2}{t_2}$ **B** $\frac{p_1 - p_2}{t_2 - t_1}$ **C** $\frac{p_1 + p_2}{t_2}$ **D** $\frac{p_1 + p_2}{t_2 - t_1}$

7 A stationary radioactive nucleus decays into two nuclei, one of which is an alpha particle which has a mass of 4 units and the other, the daughter nucleus of mass 40 units. If the daughter nucleus has an initial kinetic energy of 200 eV, what is the kinetic energy of the alpha particle?

A 20 eV **B** 500 eV **C** 2000 eV **D** 20 000 eV

8 A 2.0 kg mass travelling at 3.0 m s^{-1} on a frictionless surface collides head-on with a stationary 1.0 kg mass. The masses stick together on impact.



How much energy is lost on impact?

A zero **B** 2.0 J **C** 2.4 J **D** 3.0 J

9 Two masses moving to the right as shown below make a head-on elastic collision.

Determine their velocities after the collision.

	4.0 kg mass	**3.0 kg mass**
A	1.6 m s^{-1} to the left	4.6 m s^{-1} to the right
B	1.6 m s^{-1} to the right	4.6 m s^{-1} to the left
C	2.4 m s^{-1} to the left	5.4 m s^{-1} to the right
D	2.4 m s^{-1} to the right	5.4 m s^{-1} to the right

10 Which of the following is not one of Newton's laws of motion?

A The rate of change of momentum of a body is directly proportional to the external force acting on the body and takes place in the direction of the force.

B The total momentum of a system of interacting bodies remains constant, provided no external force acts.

C If body A exerts a force on body B, then body B exerts an equal and oppositely-directed force on body A.

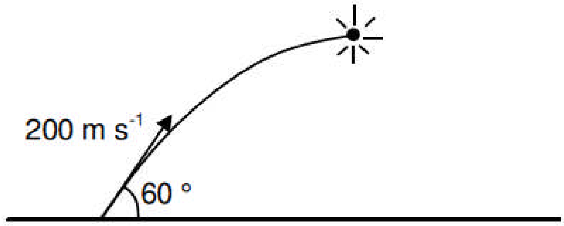
D A body continues in a state of rest or of uniform motion in a straight line unless acted upon by some external force.

11 A stationary uranium nucleus, $^{238}_{92}\text{U}$, undergoes radioactive decay with emission of a helium nucleus, $^{4}_{2}\text{He}$, of kinetic energy *E*.

What is the kinetic energy of the daughter nucleus?

A $\frac{4}{234}E$ **B** $\frac{4}{238}E$ **C** E **D** $\frac{238}{4}E$

12 A firework of mass 30 g is launched with an initial velocity of 200 m s^{-1} at an angle of 60° to the horizontal. At the highest point in flight, the firework explodes into 2 smaller pieces X and Y of mass 10 g and 20 g respectively.



Immediately after the explosion, X is momentarily at rest.

What is the speed of Y immediately after the explosion?

A 100 m s^{-1} **B** 150 m s^{-1} **C** 260 m s^{-1} **D** 300 m s^{-1}

13 A body initially at rest explodes into two fragments of mass *M* and 3 *M*, having a total kinetic energy of *E*. The kinetic energy of the fragment of mass *M* after the explosion is

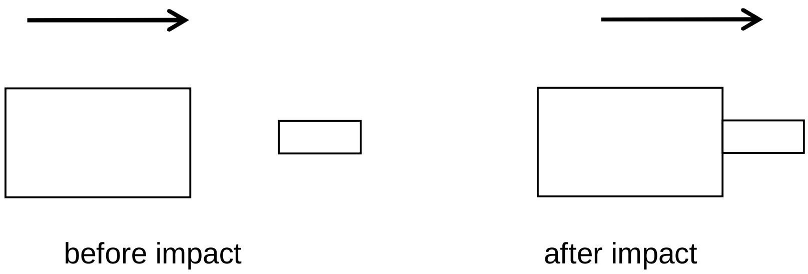
A $\frac{E}{4}$

B $\frac{E}{3}$

C $\frac{2E}{3}$

D $\frac{3E}{4}$

14 A body **X** collides with a body **Y**. The two bodies stick together on impact and then move together.



Which statement is correct?

A Some of **X**'s momentum becomes kinetic energy of **Y**

B Some of **X**'s momentum is lost as heat

C The momentum of the system is reduced by the forces during impact

D **X** transfers some of its momentum to **Y**

15 A ball of mass 300 g is being kicked and it leaves a table horizontally with a speed of 10 m s^{-1}. The falling ball then enters a stationary cart of mass 1.2 kg at an angle of 30° below the horizontal. After the ball lands into the cart, the cart immediately moves off with the ball horizontally at a particular speed. Air resistance is considered to be negligible.

What is the final speed and momentum of the ball and cart?

	Final speed/ m s^{-1}	Final momentum / kg m s^{-1}
A	1.7	2.6
B	2.0	3.0
C	5.8	7.0
D	5.8	8.7

DYNAMICS WORKED SOLUTIONS

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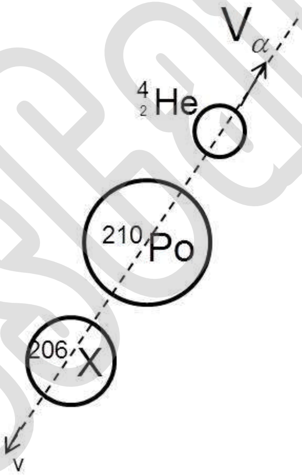
1 Ans: **C**
Area under F-t graph gives change in momentum

2 Ans: **C**
Use Conservation of momentum to get ratio of speed, hence KE

3 Ans: **C**
Applying conservation of momentum to trolley.
$m_{trolley}v_{trolley} = (m_{trolley}+m_{sand})v_{trolley\&sand}$
$v_{trolley\&sand} = (2.0)(0.5)/(2.5) = 0.4 \text{ m s}^{-1}$
$\Delta P_{trolley} = |(2.0)(0.4 - 0.5)| = 0.2 \text{ N s}$

4 Ans: **B**



Let *x* be the recoiling nucleus.

By conservation of momentum:
total initial momentum = total final momentum
$M.0 = m_x v + m_\alpha V_\alpha$
$v = -\dfrac{m_\alpha V_\alpha}{m_x}$

KE of X = $\frac{1}{2} m_x v^2 = \frac{1}{2} m_x \left(-\dfrac{m_\alpha V_\alpha}{m_x}\right)^2$

$= \frac{1}{2} m_\alpha V_\alpha^2 \left(\dfrac{m_\alpha m_x}{m_x^{\,2}}\right) = E_\alpha \left(\dfrac{4}{210-4}\right) = E_\alpha \left(\dfrac{2}{103}\right)$

5 Ans: **A**

6 Ans: **B**

7 Ans: **C**

8 Ans: **D**
Applying Principle of Conservation of Momentum:
(2 x 3) + (1 x 0) = (2 + 1) v
V = 2.0 m s^{-1}
KE lost = ½ (2)(3)^2 – ½ (2+1)(2)^2 = 3.0 J

9 Ans: **D**

From conservation of linear momentum:
Total linear momentum before collision = Total linear momentum after collision
4.0(5.0) + 3.0 (2.0) = 26 = 4.0 v_1 + 3.0 v_2
For elastic collision, relative speed of approach = relative speed of separation:
5.0 – 2.0 = 3 = $v_2 - v_1$
Solving simultaneously,
v_1 = 2.4 m s^{-1}, v_2 = 5.4 m s^{-1}
Since both velocities are positive, hence the two masses move to the right after the collision.

10 Ans: **B**

The total momentum of a system of interacting bodies remains constant, provided no external force acts.

11 Ans: **A**

Conservation of momentum: $0 = 234\,v + 4\,v_{He}$

$v = (4 / 234)\,v_{He}$

KE: helium, $E = \frac{1}{2} m v_{He}^2 = \frac{1}{2}(4u)\,v_{He}^2$

Daughter nucleus, $E = \frac{1}{2} m v^2 = \frac{1}{2}(234u)\left((4/234)\,v_{He}\right)^2$

$= 4 / 234\,E$

12 Ans: **B**

By conservation of momentum,

$$mu\cos 60^\circ = 0 + m_2 v$$

$$(30)(200)\left(\frac{1}{2}\right) = (20)\,v$$

$$v = 150\ \text{m s}^{-1}$$

13 Ans: **D**

14 Ans: **D**

15 Ans: **B**

By COLM (horizontally),

$10\,(0.3) + 0\,(1.2) = v\,(1.2 + 0.3)$

$v = 2\ \text{m s}^{-1}$

Final momentum = $(1.5)(2) = 3\ \text{kg m s}^{-1}$