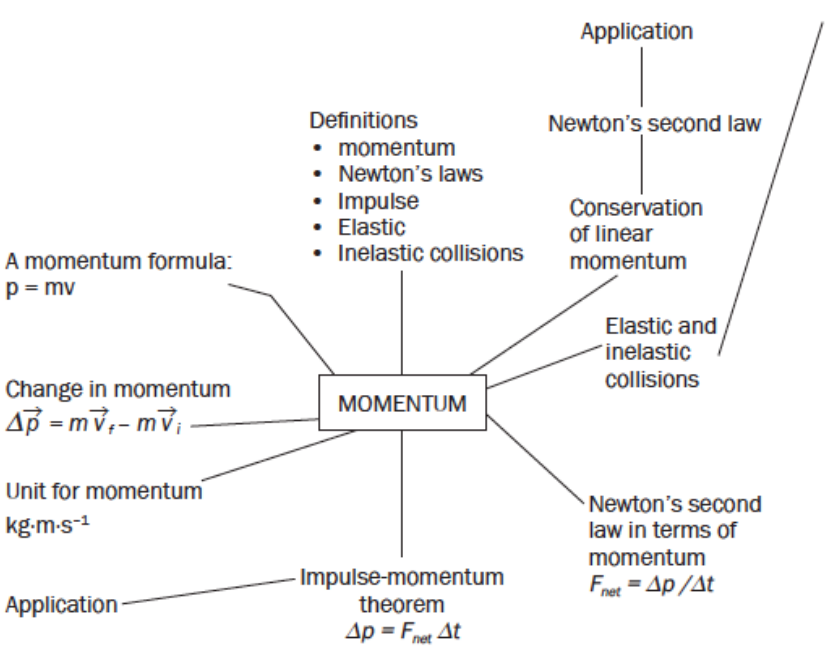
Monyetla: Physical Sciences Grade 12

MOMENTUM AND IMPULSE

Summary



Problem types:

1. Two objects collide and continue to move as separate objects after the collision:
   $\sum\vec{p}_i = \sum\vec{p}_f$
   $m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$
2. Two objects collide and unite:
   $\sum\vec{p}_i = \sum\vec{p}_f$
   $m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = (m_1 + m_2)\vec{v}_f$
3. Two moving objects that are initially joined, then separate:
   $\sum\vec{p}_i = \sum\vec{p}_f$
   $(m_1 + m_2)\vec{v}_1 = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$
4. Two stationary objects that are initially joined, separate (e.g. during an explosion):
   $\sum\vec{p}_i = \sum\vec{p}_f$
   $(m_1 + m_2)\vec{v}_1 = m_1 f_{1f} + m_2\vec{v}_{2f}$
   $0 = m_1 v_{1f} + m_2\vec{v}_{2f}$
   $m_1\vec{v}_{1f} = -m_2\vec{v}_{2f}$
5. An object falls vertically onto another object that is moving horizontally below it:
   $\sum p_i = \sum p_f$
   $m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2)v_f$
   $m_1 v_{1i} + m_2(0) = (m_1 + m_2)v_f$
   $m_1 v_{1i} = (m_1 + m_2)v_f$

Conservation of linear momentum

- **Should be an Isolated system**
- **Isolated system is when the resultant (or net) external forces acting on the system is zero.**

$$\sum_{pi} = \sum_{pf}$$

POSSIBILITY 1:

- Two separate objects move towards each other and collide, after the collision they bounce off each other and move away.
- Think of snooker balls colliding.

$$m_1 v_{1\,i} + m_2 v_{2\,i} = m_1 v_{1\,f} + m_2 v_{2\,f}$$

POSSIBILITY 2:

- Two separate objects move towards each other and collide, after the collision they combine and move as one system.
- Think of cars colliding and sticking together.
- There can only be one velocity for objects that are joined. For this scenario it will be v_f.

$$m_1 v_{1\,i} + m_2 v_{2\,i} = (m_1 + m_2) v_f$$

POSSIBILITY 3:

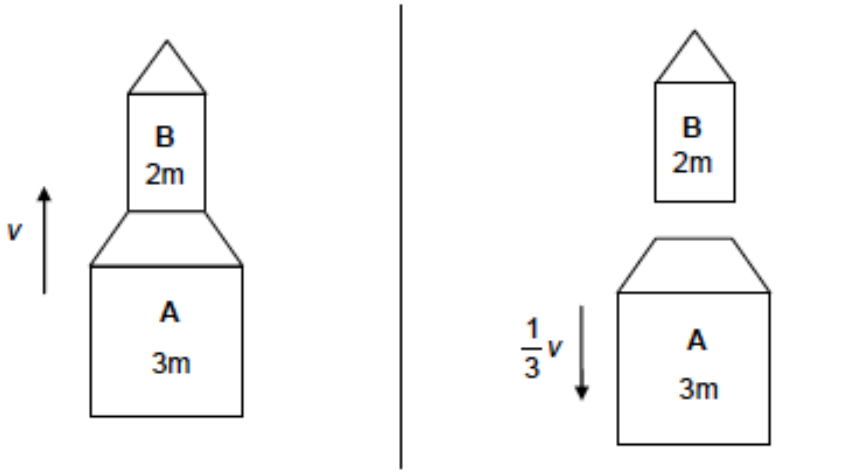
- Where there are 2 objects that start as one (connected) system, after an explosion they move apart and are now two separate objects.
- Think of a trailer connected to a car.
- There can only be one velocity for objects that are joined. For this scenario it will be v_i.

$$(m_1 + m_2) v_i = m_1 v_{1\,f} + m_2 v_{2\,f}$$

May/ June 2021

QUESTION 4 (Start on a new page.)

A simple rocket system consists of two parts, **A** of mass 3m, and **B** of mass 2m, as shown in the diagram below. **B** is stacked on top of **A**.



BEFORE EXPLOSION **AFTER EXPLOSION**

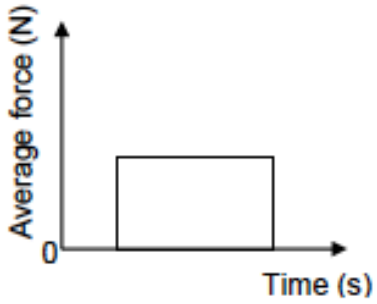
4.1 State the *principle of conservation of momentum* in words. (2)

The rocket is travelling vertically upwards at a constant speed v when an internal explosion causes **A** to move DOWNWARDS at a speed $\frac{1}{3}v$.

Ignore ALL external forces on the rocket.

4.2 Calculate the velocity of **B** in terms of v immediately after the internal explosion. (5)

The graph below shows the average force exerted by **A** on **B** during the internal explosion as a function of time.



4.3 Name the physical quantity represented by the area under the graph. (1)

4.4 Redraw the graph in your ANSWER BOOK. On the same set of axes, sketch the graph of the average force that **B** exerts on **A** as a function of time. (2)

[10]

May/ June 2022

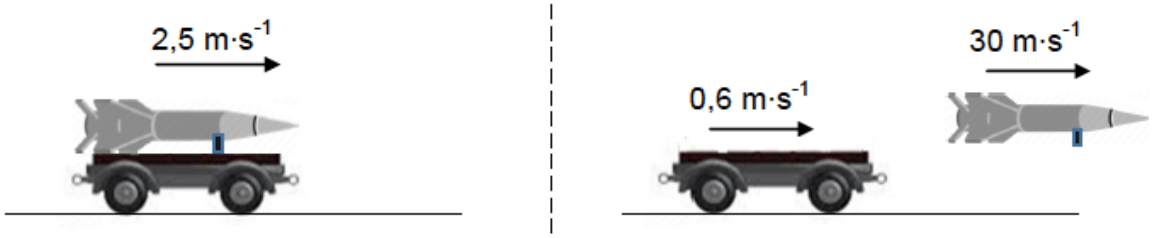
QUESTION 4 (Start on a new page.)

4.1 What is meant by an *isolated system* in physics? (2)

During an experiment, a rocket of unknown mass is mounted on a toy cart of mass 20 kg. The cart-rocket combination moves at a constant speed of 2,5 $m \cdot s^{-1}$ along a horizontal floor.

At a certain instant, the rocket is fired horizontally in the direction of motion at a speed of 30 $m \cdot s^{-1}$. As a result, the cart slows down to a speed of 0,6 $m \cdot s^{-1}$, as shown in the diagram below.

Ignore frictional effects.



Before rocket is fired

After rocket is fired

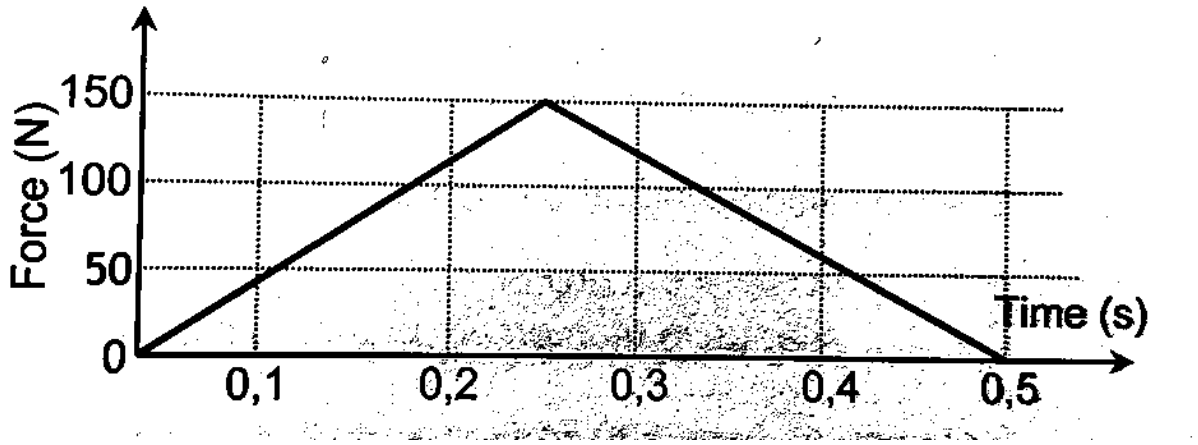
4.2 Use relevant physics principles to explain why the firing of the rocket will slow down the cart. (2)

4.3 Calculate the mass of the rocket at the instant the rocket was fired from the toy cart. (5)

[9]

QUESTION 8

During a hockey game, a player hits a stationary ball, having a mass of 150 g. The graph shows how the force on the ball varies over time.



8.1 What is represented by the area under the graph?

8.2 Calculate the velocity at which the ball leaves the hockey stick.

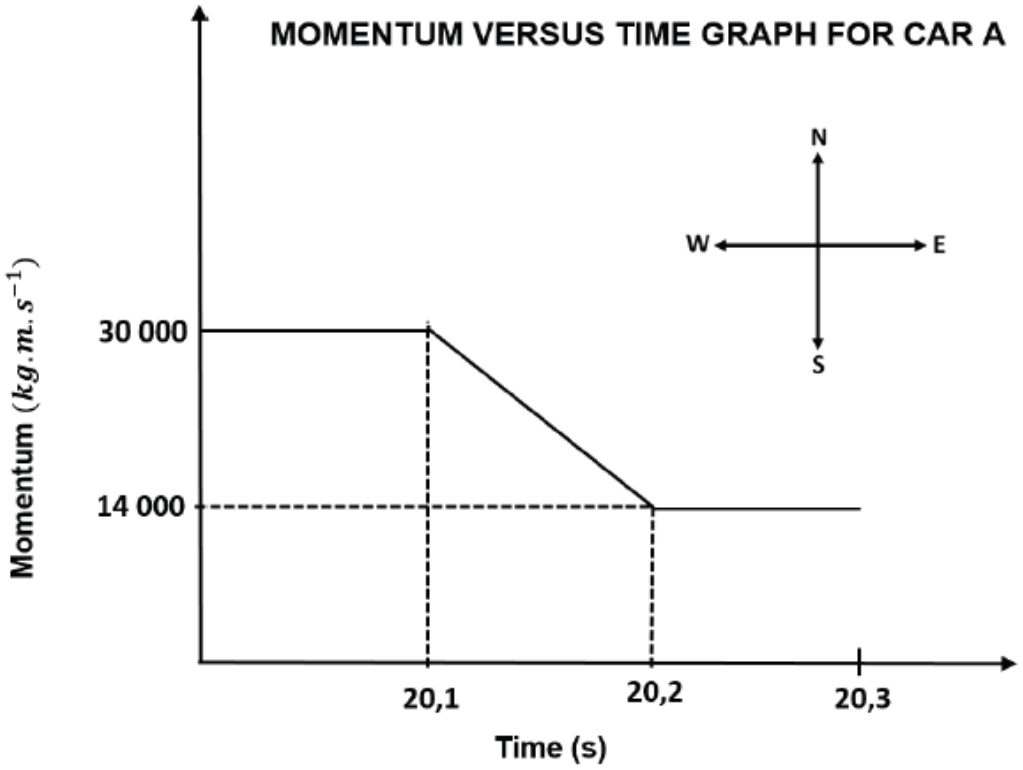
Question 9

The graph below shows how the momentum of car **A** changes with time *just before* and *just after* a head-on collision with car **B.**

Car **A** has a mass of 1 500 kg, while the mass of car **B** is 900 kg.

Car **B** was travelling at a constant velocity of 15 $m.s^{-1}$ west before the collision.

Take east as positive and consider the system as isolated.



9.1 What do you understand by the term *isolated system* as used in physics? (1)

Use the information in the graph to answer the following questions.

9.2 Calculate the:

9.2.1 Magnitude of the velocity of car **A** just before the collision. (3)

9.2.2 Velocity of car **B** just after the collision. (5)

9.2.3 Magnitude of the net average force acting on car **A** during the collision. (4)

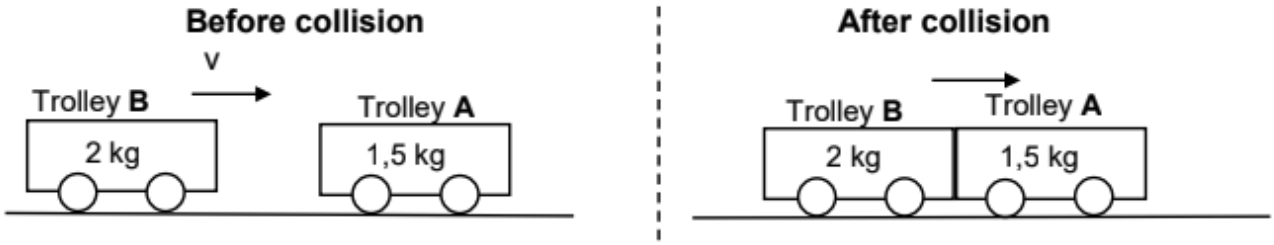
[13]

May/ June 2025

QUESTION 4 (Start on a new page.)

Trolley **A** of mass 1,5 kg is at rest on a frictionless horizontal surface. A second trolley **B**, of mass 2 kg, travelling horizontally at a constant speed v, collides with trolley **A**. The trolleys stick together and move at a constant velocity to the right, covering a distance of 0,8 m in 2 s. See the diagram below.

Ignore ALL frictional and rotational effects.



4.1 State the *principle of conservation of linear momentum* in words. (2)

4.2 Calculate speed v with which trolley **B** moves before the collision. (5)

4.3 Is the collision ELASTIC or INELASTIC? (1)

4.4 During another collision, trolley **B** exerts a greater force on trolley **A** and the change in momentum of trolley **A** is the same as before. How is the time for the collision affected?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

Write down a relevant equation that supports the answer. (2)
[10]