SUBJECT and GRADE	Physical Sciences Grade 12	
TERM 1	*Week 2*	
TOPIC	Momentum and Impulse.	
AIMS OF LESSONS	At the end of the lesson you should be able to: • Define Impulse • Use the impulse-momentum theorem ($F_{net}\Delta t = m\Delta v$) in calculations for a variety of situations (one dimension). • Impulse and safety considerations. • State the principle of conservation of linear momentum. • Explain what is meant by an isolated system, internal and external forces.	
RESOURCES	**Paper based resources** • ***Your text books*** • ***Notebook and drawing equipment***	**Digital resources:** **https://intl.siyavula.com/read/science/grade-12/momentum-and-impulse**
INTRODUCTION	NOTE: *You need to revise/refresh week 1's lesson on momentum* In grade 11 you have learned from Newton's second law: ➢ when a net force acts on a body it will result in an acceleration which alters the motion of the body. ➢ Thus a large net force will cause a larger acceleration than a small net force. The total change in motion of the object can be the same, if the large and small forces act for different time intervals. Keep this in mind and think about the following: How can airbags be useful during a collision?	

CONCEPTS AND SKILLS	DEFINITION: Impulse **Impulse is the product of the net force and the time interval for which the force acts:** Impulse = FΔt Impulse = mΔv However, from Newton's Second Law, we know that: $$\vec{F}_{net} = \frac{\Delta\vec{p}}{\Delta t}$$ $$\therefore \vec{F}_{net} \cdot \Delta t = \Delta\vec{p}$$ $$= \text{Impulse}$$ ➢ Impulse, FΔt, is measured in N·s. ➢ Δp is measured in kg·m·s−1 Therefore, we can define the impulse momentum theorem: Impulse = Δp The change in momentum is directly dependent on the magnitude of the resultant force and the duration for which the force is applied. ➢ Impulse is a vector, ➢ ∴ direction specific. **EXAMPLE:** Why can airbags be useful during a collision? State your answer by using the impulse-momentum theorem. **Answer:** From the impulse-momentum theorem, **FnetΔt = mv**: The airbag prolongs the time, **t**, of impact during the accident, thereby causing a smaller force, **Fnet,** to be exerted on the passenger according to **Fnet ∝1/t.**

EXAMPLE:

A golf ball with a mass of 0,1 kg is driven from the tee. The golf ball experiences a force of 1000 N while in contact with the golf club and moves away from the golf club at 30 $m.s^{-1}$. For how long was the golf club in contact with the ball?

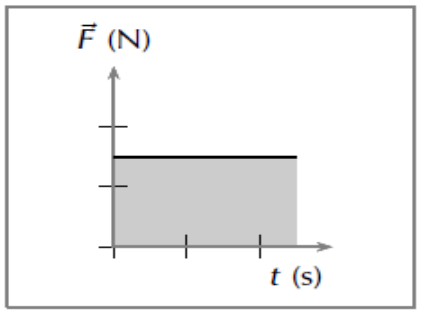
Answer:

$F_{net}\Delta t = m\Delta v$

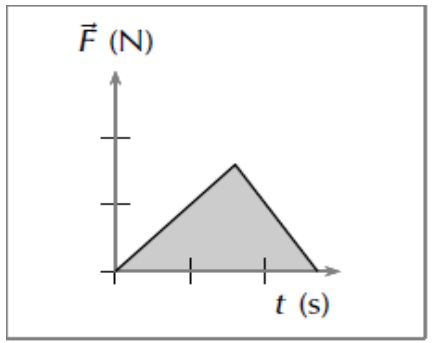
$1000t = (0,1)(30 - 0)$

$t = 3 \times 10{-}3$ s

The graphs below show how the force acting on a body changes with time.

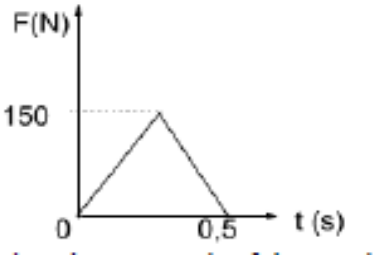


The area under the graph, shaded in,represents the impulse of the body.



EXAMPLE:

The following graph shows the force exerted on a hockey ball over time. The hockey ball is initially stationary and has a mass of 150 g.



Calculate the magnitude of the impulse (change in momentum) of the hockey ball.

***Fnet*Δ*t* = area under graph**

impulse = ½ *bh*

impulse = ½ (0,5)(150)

impulse = 37,5 N · s

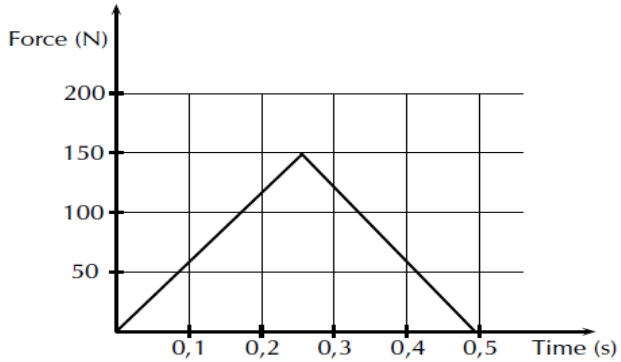
<u>Impulse and safety consideration</u>

A very important application of impulse is improving safety and reducing injuries.

- In many cases, an object needs to be brought to rest from a certain initial velocity.
- This means there is a certain specified change in momentum.
- If the time during which the momentum changes can be increased
- then the force that must be applied will be less and so it will cause less damage.

This is the *principle* behind *arrestor beds for trucks*,*airbags*, and *bending your knees when you jump off a chair and land on the ground.*

	CONSERVATION OF MOMENTUM **Conservation of linear momentum states:** *The total linear momentum of an isolated system remains constant* ***OR*** *'In an isolated system the total momentum before a collision (or explosion) is equal to the total momentum after the collision (or explosion)'.* – $$\Sigma p_{\text{before}} = \Sigma p_{\text{after}}$$ $$p_{\text{A(before)}} + p_{\text{B(before)}} = p_{\text{A(after)}} + p_{\text{B(after)}}$$ $$m_A v_{iA} + m_B v_{iB} + \ldots = m_A v_{fA} + m_B v_{fB} + \ldots$$ **System:** A set number of objects and their interactions with each other. **External forces**: Forces **outside** of the **system**./ forces caused by external agent outside of the system.**example**: **F_{grav}** ;**F_{spring}** **Internal forces**: forces exchanged by the particles in the system. **Example**: **Fapp** ; **Ffrict** ;**Fair** ;**Ftens** ; **Fnorm** **Isolated system:** A system on which the **net external force is zero**. ***NOTE***: Forces external to the system may change the total momentum when their sum is not 0, but internal forces, regardless of the nature of the forces, will not contribute to the change in the total momentum. To analyze a mechanical system, it is important to recognize which forces are internal and which are external.
ACTIVITIES/ ASSESSMENT	**ACTIVITY** 1.A 150 N resultant force acts on a 300 kg trailer. Calculate how long it takes this force to change the trailer's velocity from 2 $m.s^{-1}$ to 6 $m.s^{-1}$ in the same direction. Assume that the forces act to the right which is the direction of motion of the trailer.

	2. A bullet of mass 20 g strikes a target at 300 $m.s^{-1}$ and exits at 200 $m.s^{-1}$. The tip of the bullet takes 0,0001 s to pass through the target. Determine: a) the change of momentum of the bullet. b) the impulse of the bullet. c) the magnitude of the force experienced by the bullet. 3.During a game of hockey, a player strikes a stationary ball of mass 150 g. The graph below shows how the force of the ball varies with the time.  a) What does the area under this graph represent? b) Calculate the speed at which the ball leaves the hockey stick. c) The same player hits a practice ball of the same mass, but which is made from a softer material. The hit is such that the ball moves off with the same speed as before. How will the area, the height and the base of the triangle that forms the graph, compare with that of the original ball?
CONSOLIDATION	***Remember to keep these steps in mind for calculations*** Step 1: Identify what information is given and what is asked for Step 2: Convert to S.I. units Step 3: Choose a frame of reference (+/-) Step 4: Apply mathematical skills and calculate ➢ Do not write laws and definitions in own words ➢ Do not forget to write down the unit by the final answer and direction where necessary
VALUES	Safety during collisions based on scientific principles. The use of safety belts can save lives during collisions.