A Guide to Momentum and Impulse

Teaching Approach

In this series we investigate momentum and impulse. We calculate the momentum of a moving object and explain the relationship between net force and change in momentum for a variety of motions.

In physics, the change in a quantity is defined as the final value minus the initial value however learners often struggle to interpret what this means. It might be necessary to discuss an “increase” or “decrease” in momentum, and relate these discussions to actual events which the learners can observe. Also discuss a positive or negative value for a change in momentum, and relate these values to actual events.

We look at the concept of elastic and inelastic collisions. Elastic and inelastic collisions are defined, with appropriate examples. Calculations for elastic and inelastic collisions are explained. Educators can look at actual situations and define the concept of isolated systems where no external forces occur

Challenge the learner’s concept of impulse and momentum further with practical examples of collisions.

The videos can either be used independently for the learners to revise with after learning the content at school, or as part of the lessons. If it is possible, the use of multimedia to explain and reinforce concepts helps the learners understand and grasp new concepts.
The task video has been prepared in such a way as it could be used as either an exercise tool, or it can be used as a complete test for the learners, or as a way for the learners to test their knowledge independently.

Video Summaries

Some videos have a 'PAUSE' moment, at which point the teacher or learner can choose to pause the video and try to answer the question posed or calculate the answer to the problem under discussion. Once the video starts again, the answer to the question or the right answer to the calculation is given.

Mindset suggests a number of ways to use the video lessons. These include:

- Watch or show a lesson as an introduction to a lesson
- Watch or show a lesson after a lesson, as a summary or as a way of adding in some interesting real-life applications or practical aspects
- Design a worksheet or set of questions about one video lesson• Then ask learners to watch a video related to the lesson and to complete the worksheet or questions, either in groups or individually
- Worksheets and questions based on video lessons can be used as short assessments or exercises
- Ask learners to watch a particular video lesson for homework (in the school library or on the website, depending on how the material is available) as preparation for the next days lesson; if desired, learners can be given specific questions to answer in preparation for the next day's lesson

1. What is Momentum?

In this lesson we define momentum as mass times velocity and calculate the momentum of a moving object using p = mv. We describe the vector nature of momentum; in other words, that it has both magnitude and direction.

2. Newton's Second Law in Terms of Momentum

In this lesson we state Newton's Second Law in terms of momentum by finding two equations for acceleration. We then discuss the relationship between net force and change in momentum for a variety of motions.

3. Conservation of Momentum during Collisions

In this lesson we explain what is meant by a system and discuss internal and external forces. We then look at the law of conservation of momentum and distinguish between elastic and inelastic collisions.

4. Momentum and Impulse

In the last lesson we define impulse as the product of the net force and the contact time. We use the impulse-momentum theorem to calculate the force or change in momentum for a variety of situations.

Resource Material

1. What is Momentum?	http://www•physicsclassroom•com/class/momentum/u4l1a•cfm	A lesson on the impulse momentum change theorem.
	http://hyperphysics•phy-astr•gsu•edu/hbase/mom•html	This page defines momentum.
	http://www•phy-astr•gsu•edu/dhamala/Physics2211/Chapter9•pdf	Impulse and momentum
2. Newton's Second Law in Terms of Momentum	http://www•physicsclassroom•com/class/momentum/u4l2b•cfm	A lesson on the impulse momentum change theorem.
	http://www•phy-astr•gsu•edu/dhamala/Physics2211/Chapter9•pdf	Impulse and momentum
3. Conservation of Momentum during Collisions	http://www•physicsclassroom•com/class/momentum/u4l2b•cfm	A lesson on the impulse momentum change theorem.
	http://www•phy-astr•gsu•edu/dhamala/Physics2211/Chapter9•pdf	Impulse and momentum
4. Impulse	http://www•physicsclassroom•com/class/momentum/u4l1a•cfm	A lesson on the impulse momentum change theorem.
	http://www•mathsrevision•net/advanced-level-maths-revision/mechanics/impulse-and-momentum	Impulse and momentum.
	http://www•ph_y-astr•gsu•edu/dhamala/Physics2211/Chapter9•pdf	This page introduces the idea of impulse and momentum and looks at new problem solving strategies based on conservation laws.

Task

Question 1

A rugby forward of mass 120 kg storms forward towards the touch-line with a speed of 6 $m \cdot s^{-1}$

1.1 Calculate the magnitude of his momentum.

1.2 At what speed would a rugby fly-half of mass 72 kg have to run to have the same momentum as the storming forward in 1.1?

Question 2

Trolley A of mass 3 kg travels due east at a velocity of 7 $m \cdot s^{-1}$. Another trolley B of mass 4 kg follows along the same path at 12 $m \cdot s^{-1}$ and collides with it. After the collision, trolley A continues to travel east but with a velocity of 11 $m \cdot s^{-1}$. Calculate the velocity of trolley B after the collision.

Question 3

A dart of mass 100 g strikes a dartboard with a horizontal velocity of 6 $m \cdot s^{-1}$. The dart pushes its way into the dart board a little and takes 0,04 s to stop moving. Calculate the magnitude of the average force that the dartboard exerts on the dart to stop it.

Question 4

A canon fires a missile with a mass of 12 kg horizontally at 500 $m \cdot s^{-1}$ due west. The mass of the cannon is1500 kg. Calculate

4.1 The magnitude and direction of the momentum of the missile when it leaves the cannon

4.2 The velocity of the recoil of the cannon.

Question 5

According to the Guinness Book of World Records, the fastest recorded baseball pitch was delivered by Nolan Ryan in 1974. The pitch was measured at 45 $m \cdot s^{-1}$. Determine the impulse required to give a 145 g baseball such a momentum.

Question 6

Mpho was applying her makeup when she drove into a busy parking lot last Friday morning. Unaware that another car was stopped in her lane, Mpho rear-ended it. Mpho's 1300 kg car was moving at 11 $m \cdot s^{-1}$ and stopped in 0,14 seconds. Calculate the magnitude of the force experienced by Mpho's car.

Task Answers

Question 1

1.1 $p = mv$
$= 120 \times 6$
$= 720\ kg \cdot m \cdot s^{-1}$

1.2 $p = mv$
$720 = 72 \times v$
$v = 10\ m \cdot s^{-1}$

Question 2

$m_a v_{ia} + m_b v_{i\ b} = m_a v_{fa} + m_b v_{fb}$
$3 \times 7 + 4 \times 12 = 3 \times 11 + 4 \times v_{fb}$
$21 + 48 = 33 + 4\ v_{fb}$
$v_{fb} = 9\ m \cdot s^{-1}$ east

Question 3

mass = 100/1000 = 0,1 kg

$$F_{res} = \frac{m(v_f - v_i)}{\Delta t}$$
$$= \frac{0,1\ (0 - 6)}{0,04}$$
$$F_{res} = -15\ N$$

$F_{res} = 15$ N in the opposite direction

Question 4

1.1 $p = mv$
$= 12 \times 500$
$= 6000\ kg \cdot m \cdot s^{-1}$ forward direction

1.2 $(m_1+m_2)v_i = m_1v_1 + m_2v_2$ $\quad v_i = 0\ m \cdot s^{-1}$
$0 = 12 \times 500 + 1500 \times v_2$
$-6000 = 1500\ v_2$
$v_2 = -4\ m \cdot s^{-1}$
$v_2 = 4\ m \cdot s^{-1}$ backwards

Question 5

m = 145/1000 = 0,145 kg
Impulse = Δp
$= m(v_f - v_i)$
$= 0,145(45 - 0)$
$= 6,53\ N \cdot s$

Question 6

$$F_{res} = \frac{m(v_f - v_i)}{\Delta t}$$
$$= \frac{1300\ (0 - 11)}{0,14}$$
$F_{res} = -102\ 142,86$ N
$F_{res} = 102\ 142,86$ N in the opposite direction

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