Lesson 10.9 Conservation of momentum

Recommended teaching time for this lesson: 1 x 60 minute periods

Period 1

• 35 minutes of explicit teaching

• 25 minutes of suggested classroom activities

• 30 minutes homework

Period 2

• 20 minutes of explicit teaching

• 10 minutes of suggested classroom activities

• 30 minutes homework

Getting started

Key ideas

* The law of conservation of momentum states that, for two objects colliding in an isolated system, the total momentum before and after the collision is equal.
* Momentum is conserved in explosions and collisions.

Curriculum links

Science understanding

* Describe the principle of conservation of momentum.
* Solve problems involving momentum, impulse, the conservation of momentum and collisions in one dimension using

Science as a human endeavour

* Consider how knowledge of forces and motion has led to improvements in car safety through the development of technologies such as seatbelts, crumple zones and airbags.

Advice for teaching this lesson

Things to know before you start teaching

Conservation of momentum is the first part of collisions and will let students solve simpler versions of collisions. Emphasis should be given to students that conservation of momentum will always apply to any collision; however kinetic energy will not conserve. This will be explored in a later module. Collision questions can often require significant amounts of working out so helping students with their setting out is essential.

The starter activity suggests using a Newton’s cradle. A video has been provided but you may have this equipment in your lab.

Common misconceptions

* Students sometimes will get their negatives and positives mixed around when doing collision questions. This can lead to solutions that look valid but aren’t.

Differentiation strategies

The worked examples in the text use a very shortened form of working out that some students may find confusing. Ensuring that students set out all variables neatly, will aid them in keeping track of information and goals.

Ask students to consider some commonsense approaches when solving problems as a way to check their work. Many questions in this topic can easily be predicted to a rough idea of a correct solution with practice.

Starter activity: Newton’s cradle

Approximate time: 5 minutes

**Activity placement:** Place directly after Lesson overview

**Activity summary:** The perfect demonstration of conservation of momentum, using the Newton’s cradle to show that momentum is conserved in a simple elegant way.

Notes for the teacher

You may have a Newton’s cradle in your lab equipment, check with your lab technician beforehand. Otherwise, this is another example of a physics toy that is worthwhile acquiring for yourself.

Students may ask why the velocity of a single ball increases when two balls are dropped. The short answer is that it is conservation of energy, but a more detailed explanation can be found here: <https://www.phys.vt.edu/outreach/projects-and-demos/demonstrations-wiki/mechanics/newtons-cradle.html>.

Demonstrate one ball and two balls for students before letting them answer questions.

Video for answers to the questions is here: <https://www.youtube.com/shorts/nNQ96_KJ-8Y>.

Instructions for students

Your teacher will demonstrate a Newton’s cradle with one ball being dropped and then two balls being dropped. Alternatively, watch the video below. After either the demonstration or video, answer the following questions.

Newton’s cradle: <https://www.youtube.com/shorts/iJHVL2sS6P0>

* 1. Predict what will happen if three balls are dropped from one side. If your teacher has a seven-ball cradle what would happen if four balls are dropped?
  2. Predict what will happen if one ball is dropped from each side at the same time.

Answers

1. Student predictions will vary. The correct prediction is three balls will continue to move on both sides.
2. Student predictions will vary. The correct prediction is that the ball on each end will continue to bounce. The answer video for demonstration is: <https://www.youtube.com/shorts/nNQ96_KJ-8Y>

Classroom activity: Throwing away

Approximate time: 10 minutes

**Activity placement:** Place directly above “What are collisions?”

**Activity summary:** A hypothetical to test understanding of explosions in conservation of momentum.

Notes for the teacher

If a student has a skateboard this can easily be demonstrated in the classroom.

Instructions for students

Read the scenario below and answer the following question.  
You are riding on a skateboard when you are swooped by magpies. In a panic you throw your schoolbag backwards.

1. Describe what would happen to your speed in this scenario.

Helpful hints

* This scenario is similar to an explosion in that you have a mass separating.

Support activity

Notes for the teacher

This adds some scaffolding to the questions.

Instructions for students

Read the scenario below and answer the following question.  
You are riding on a skateboard when you are swooped by magpies. In a panic you throw your schoolbag backwards.

1. How would the momentum of your backpack change in this scenario?
2. Describe what would happen to your speed in this scenario.

Challenge activity

Notes for the teacher

This challenges students to use the equation to back up their answer.

Instructions for students

Read the scenario below and answer the following question.  
You are riding on a skateboard when you are swooped by magpies. In a panic you throw your schoolbag backwards.

1. Describe what would happen to your speed in this scenario.
2. Justify your response using the relevant equation.

Answers

1. You would speed up as you throw your backpack backwards.

Support activity

1. It would go from being forwards to being negative.
2. You would speed up.

Challenge activity

1. You would speed up.
2. Your initial momentum, *p*, could be calculated by . Since ‘*m*’ would reduce as you throw away part of your mass, and gain a negative momentum as it moves backwards, this means your velocity must increase to overcome the drop in ‘*m*’ and the drop in the system’s momentum by the backpack.

Classroom activity: Tennis serves

Approximate time: 10 minutes

**Activity placement:** Place directly above “Inelastic collisions”

**Activity summary:** A question to introduce students to systems where both objects are moving.

Notes for the teacher

Emphasise to students that scenarios where both objects are moving are no different from scenarios where only one object is moving.

Remind students to be careful with directions and negatives.

You may like to run this as a class activity with you solving on the board while students decide on next steps.

Instructions for students

Solve the following question.

1. A professional tennis serve reaches the opponent at about 25 m s–1 and returns after being hit by the racket at a velocity of 31 m s–1. The mass of an average tennis ball is 58 grams, while rackets have a mass of 300 grams. A tennis player can swing their racket at approximately 20 m s–1. Calculate the velocity of the racket after collision.

Helpful hints

* Set out your working like Worked example 10.9B. The only difference is you have two moving objects instead of one.

Answers

1. Let ‘1’ be the tennis ball, and ‘2’ be the racket.

Classroom activity: It’s just rocket science

Approximate time: 10 minutes

**Activity placement:** Place directly above “Skill drill – Gathering secondary data for a research investigation”

**Activity summary:** Asking students to consider how conservation of momentum is a key element of rocket science.

Notes for the teacher

There is an equation for loss of mass momentum. This could be a research task for advanced students.

You can advise students to consider this scenario as an example of continuous explosions.

Instructions for students

Read the statement below and answer the following question. *A rocket begins stationary, so therefore has a momentum of zero. As it begins to burn fuel and eject it the rocket starts to launch off the platform. This involves a final velocity change and a final mass change.*

1. Propose what would happen to the speed of the rocket if the mass reduced as the fuel is consumed.

Helpful hints

* You’ve studied explosions in this lesson already.

Answers

1. If the initial momentum is 0 kg m s–1 then the final momentum must also be 0 kg m s–1. This can be modelled with (the fuel is negative as it is in the opposite direction). This rearranges to . As the mass of the rocket will be decreasing, this means the velocity will also be increasing continually as well.