Activity E1
Conservation of linear momentum: explaining collisions: teacher and trainer notes

This quick, practical activity is a chance to learn by either teacher demonstration or hands on investigation. It is intended to consolidate the concept of the conservation of linear momentum and provide the teacher or trainer with the opportunity to lead a whole class discussion without dictating the outcome.

It provides an opportunity for learners to formulate their ideas in pairs and to feed back to the rest of the group, rather than the teacher 'telling the learners what the teacher wishes to hear'.

This is a form of formative assessment whereby the teacher or trainer can monitor whether the learners have grasped the concepts and whether the topic needs reinforcement or extension.

Learning objectives

Learners should be able to:

- describe and explain collisions in terms of 'conservation of linear momentum'
- develop the ability to use science terminology to correctly describe observations
- develop the ability to predict, test and evaluate the effect of altering a variable.

Materials required

- a selection of ball bearings
- two strong cylinder magnets (provided in the resources pack)
- a runway, possibly two rulers side by side
- a mechanism to hold the rulers in place (adhesive putty or tape)
- mini-whiteboards for each learner

- an overhead projector and screen for demonstration (optional)
- the short video clip which can be downloaded from CD ROM *Resources*.

Strong magnets are available from a number of suppliers via the internet. Typing ‘super magnets’ into a search engine will give a number of options. High-strength NdFeB magnets were used in the pilots.

- example session plan from CD ROM *Resources*.

Time needed

About 30 minutes or more for higher level extension tasks.

Starting points

Learners should already have an understanding of the concepts of linear momentum and the conservation of linear momentum. You might use this activity in the session following the teaching of these concepts to check that learning has taken place and that the learners do not have misconceptions about the theory.

Alternatively, you might use the activity with learners who have no prior knowledge of linear momentum to stimulate open-ended thinking and to introduce science terminology and concepts.

If you want to check learners’ prior knowledge, you could ask a few ‘warm-up’ questions. Learners could write their responses on their mini-whiteboards. For example:

- Write down the equation for calculating the momentum of a moving body (expected response: momentum = mass × velocity).
- Write down the law for the conservation of linear momentum for a collision (expected response: total momentum before = total momentum after or $m_A v_A = m_B v_B$).

Examples might be:

- a cannon firing a cannonball
- a free railway wagon colliding with a stationary wagon
- a bullet embedding in a free-moving target.

Suggested approach

This practical activity is designed to engage learners in discussion about momentum and to help them to predict the possible effects of a collision. You may choose to perform a demonstration and then ask pairs or groups of learners to try it out themselves. The costs are low enough to allow a hands on activity for the whole group.

Start the session by asking learners for personal examples of where they have experienced collisions. These may be planned, as in playing sport (kicking a football or hitting a hockey ball with a hockey stick), or unplanned (cars in collisions). If you record these examples on a flip chart, learners can return to them later and offer explanations. Use these real-life examples to relate the topic to the concepts of linear momentum, the conservation of linear momentum from the previous session and to set the scene for the activity.

Learners need to use their existing knowledge of momentum to explain the following:

- what is happening?
- why is it happening?

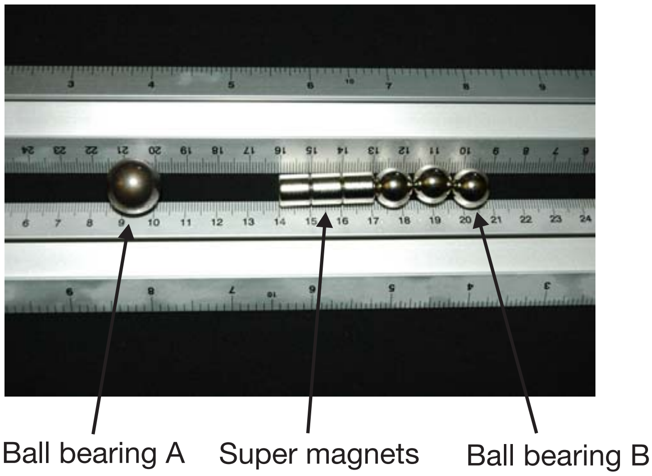
Groups should be prepared to feed back their conclusions to the whole class. Your role is to manage the feedback and discussion so that learners explain the events themselves, using the term and concept of momentum.

Preparation

Fix the two objects (rulers, pieces of wood, pencils, and so on) that make the runway on a bench. They need to hold the strong magnets in place. You might do this on an overhead projector, which allows the shadow of the collision to be projected onto the screen. This means that learners can witness the collisions if this is carried out as a demonstration. Figure E1.1 shows a plan view of the experiment.

Ball bearing A is placed about 40 mm from the super magnets. This is just sufficient to stop it from being attracted to the magnets. If this ball bearing is gently pushed towards the magnets it is attracted and rapidly gains momentum. Almost instantaneously after ball bearing A collides with the super magnet, ball bearing B, shoots away from the super magnets as a result of the transfer of momentum.

Fig. E1.1



Consolidating and checking learning

Learners should now work in pairs or small groups for a few minutes to analyse their findings, discuss their observations and record on their mini-whiteboards their initial interpretation of:

- what has happened
- why it has happened.

You should observe the whiteboard responses and use them to initiate a whole class discussion through which learners are encouraged to describe the events, in their own words, using their understanding of linear momentum. You will need to explore in particular the learners' understanding of the 'conservation of linear momentum', for example, by asking the learners to estimate the momentum on either side of the collision.

An effective strategy is to use open questioning to promote in-depth reasoning. You might, for example, use assertive questioning to:

- ask one or more groups to explain their initial reasoning in more depth
- ask other groups if they agree or disagree – and why
- ask others to interrogate the arguments and to improve on the explanations.

Ensure that this part of the activity concludes with a clear summary of the main points.

Higher level tasks

Next, ask learners to apply their understanding to new situations. In pairs, they could predict and write down on their mini-whiteboards what will happen if the size of ball bearing B is now reduced. See Figures E1.2 and E1.3 below.

Fig. E1.2

Fig. E1.3

The learner response is not about estimating the magnitude of **momentum**. You could expect learners to conclude that, if the mass of ball bearing B was halved the **velocity** of ball B will double, thus demonstrating their understanding of the law of conservation of momentum.

Caution: If ball bearing B is of very small mass and ball bearing A is large, then the small ball bearing may leave the system at a relatively high velocity! This can be quite spectacular. Ensure that learners wear appropriate eye protection and stay well out of range.

Learners could then investigate the effect of reducing the mass of ball bearing B.

You could give learners the masses of the ball bearings and ask them to estimate some of their velocities. It should be possible to estimate the velocity of the smallest ball bearing quite easily as it may travel several metres in one second!

Remember that your role is to guide the learners into a sound understanding of the concepts and to encourage them to reason creatively and critically. Encourage them to arrive at their conclusions through investigation and discussion and resist the temptation to simply tell them what is happening. You need to hear their understanding expressed in their own words to be sure learning has taken place. Learners might find it relevant to revisit the real-life examples of collisions on the flip chart to frame their explanations.

What learners might do next

Learners could investigate the velocity of ball bearing B by measuring its velocity using light gates and digital timers. They could also investigate what would happen if the collision time increased by putting different thicknesses of sponge in front of the super magnet. This would be the equivalent of crumple zones in cars.

Learners could apply this understanding and develop the topic further to investigate and evaluate the performance of different materials or different car designs in collisions. Finally learners might suggest changes to vehicle design to reduce the likelihood of death to pedestrians if hit by a car, supporting their conclusions with sound evidence and explanation.

Alternatively, learners may like to revisit and investigate the real-life examples of collisions on the flip chart.

This type of investigation lends itself well to summary on a poster or 'visual organiser'. Learners enjoy the visual and practical approach to summarising their learning as it allows them to express their ideas in different ways, for example through formulas or drawings, or with the use of diagrams, charts or comparison tables. These also give teachers and trainers a good insight into learner understanding.