






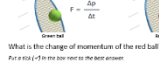
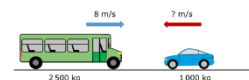
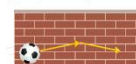

Progression toolkit: Changing momentum

Learning focus	In a collision (or any closed system), momentum is conserved and the size of the forces are equal to the rate of change of momentum.				
As students' conceptual understanding progresses they can:	<div> <div>CONCEPTUAL PROGRESSION</div> <div></div> </div>				
	Calculate momentum using $p = m \times v$. P	Describe what happens to the motion of objects colliding head on.	Determine changes in momentum, Δp .	Explain and use the relationship between force, change in momentum and time the force is acting.	Apply an understanding of $F = \Delta p / \Delta t$ to explain how forces and momentum can be controlled. B
Diagnostic questions	Gaining momentum Rugby tackle Boom!	Bouncing	Stop that!	Wet sand	Follow through
Response activities	Crash test		Wall game	Crumple zones	

Key:

P Prior understanding from earlier stages of learning

B Bridge to later stages of learning

Gaining momentum	Rugby tackle	Boom!	Bouncing	Stop that!																									
<p>BEST STUDENT WORKSHEET</p> <p>Gaining momentum</p> <p>An object is two times harder to stop if its momentum doubles. Doubling its mass doubles its momentum. Doubling its velocity doubles its momentum.</p> <p>This relationship can be written in shorthand as:</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> $\text{momentum} = \text{mass} \times \text{velocity}$ $p = m \times v$ </div> <p>momentum, p, in kilogram metres per second (kg m/s) mass, m, in kilogram (kg) velocity, v, in metres per second (m/s)</p>  <p>Velocity is speed in a particular direction. It is a vector. Momentum is a vector too. It means whether the momentum of an elephant is towards you or away from you!</p> <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>BEST STUDENT WORKSHEET</p> <p>Rugby tackle</p> <p>Two rugby players tackle another. Before the tackle the players were running towards each other. The size of momentum of each player was the same.</p>  <p>a. How will they move after the tackle?</p> <ol style="list-style-type: none"> The player with the ball will be pushed backwards. The player who makes the tackle is pushed backwards. Neither player is pushed backwards (they both stop). The smaller player will be pushed backwards. <p>b. What is the best reason for your last answer?</p> <ol style="list-style-type: none"> The bigger player pushes with a bigger force. The force on both players is the same size. The force is bigger on the player who is tackled. It takes time to stop the player with the ball. <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>BEST STUDENT WORKSHEET</p> <p>Boom!</p> <p>A cannonball is fired out of a cannon. It flies from rest at the back of the cannon. It leaves the cannon at a speed of 400 m/s.</p>  <p>The cannon has the mass of 2000 kilograms.</p> <p>What happens when the cannonball is fired?</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>I am sure it's right</th> <th>I think it's right</th> <th>I think it's wrong</th> <th>I am sure it's wrong</th> </tr> </thead> <tbody> <tr> <td>a. The cannon does not move.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>b. The cannon pushes back on the cannonball.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>c. The force on the cannonball is bigger than the force on the cannon.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>d. The cannon moves backwards at 2 m/s.</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>		I am sure it's right	I think it's right	I think it's wrong	I am sure it's wrong	a. The cannon does not move.					b. The cannon pushes back on the cannonball.					c. The force on the cannonball is bigger than the force on the cannon.					d. The cannon moves backwards at 2 m/s.					<p>BEST STUDENT WORKSHEET</p> <p>Bouncing</p> <p>A basketball bounces on the ground.</p>  <p>Mass = 0.6 kg Speed going down = 2 m/s Speed going up = 2 m/s</p> <p>When the ball bounces, how does its momentum change?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <ol style="list-style-type: none"> It doesn't change. It changes 1.2 kg m/s downwards. It changes 1.2 kg m/s upwards. It changes 2.4 kg m/s downwards. It changes 2.4 kg m/s upwards. <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>BEST STUDENT WORKSHEET</p> <p>Stop that!</p> <p>An object is harder to stop quickly if it has more momentum. A car has more momentum if it's moving faster. An elephant has more momentum if it has more mass.</p> <p>The elephant and the car are both moving at the same speed towards you.</p> <p>a. Which one is hardest to stop quickly?</p> <ol style="list-style-type: none"> Elephant Mass = 6000 kg Top speed = 11 m/s Car Mass = 2000 kg Top speed = 30 m/s <p>b. What is the best reason for your last answer?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <ol style="list-style-type: none"> Mass has a bigger effect on momentum than speed. Speed has a bigger effect on momentum than mass. Mass is speed towards you is bigger. Elephant is bigger. <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>
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<p>BEST STUDENT WORKSHEET</p> <p>Wet sand</p> <p>David rides off a road into some wet sand. The force of the sand pushing on his tyres makes him stop.</p>  <p>1. David cycles twice as fast and has two times the momentum. How long does it take for the sand to stop him now? Put a tick (✓) in the box next to the best answer.</p> <ol style="list-style-type: none"> The same time. Two times longer. Four times longer. <p>2. Later, David cycles the same speed but pushes on his tyres with half the force. He is cycling at the original speed. How long does it take for the sand to stop him now? Put a tick (✓) in the box next to the best answer.</p> <ol style="list-style-type: none"> Half as long. The same time. Two times longer. <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>BEST STUDENT WORKSHEET</p> <p>Follow through</p> <p>A force acting on an object can create a change in its momentum.</p> <ul style="list-style-type: none"> The bigger the force, the bigger the change. The longer the force is acting, the bigger the change. <p>change in momentum = force x time the force is acting</p> <p>force, F, in Newton (N) Change in momentum, Δp, in kilogram metres per second (kg m/s) Time the force is acting, Δt, in seconds (s)</p> <p>1. As follows through, the red ball is in contact with the red ball twice as long as the green ball. The force on each is the same.</p>  <p>What is the change in momentum of the red ball? Put a tick (✓) in the box next to the best answer.</p> <ol style="list-style-type: none"> Two times less than the change in momentum of the green ball. The same as the change in momentum of the green ball. Two times more than the change in momentum of the green ball. <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>BEST STUDENT WORKSHEET</p> <p>Crash test</p> <p>Crash tests are used to check safety features on vehicles. A car and a bus are crashed into each other. They both come to a stop at the place that they hit.</p>  <p>2500 kg 7 m/s 1000 kg 8 m/s</p> <ol style="list-style-type: none"> Calculate the momentum of the bus before the collision. Show its size and direction. State the momentum of the car before the collision. Show its size and direction. How does the total momentum after the collision compare to the total momentum before the collision? <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>BEST STUDENT WORKSHEET</p> <p>Wall game</p> <p>Lucy kicks a football off a wall. It bounces off at an angle, but its speed does not change.</p>  <p>Some students are discussing what happens to the momentum of the football when it bounces.</p> <div style="border: 1px solid gray; padding: 5px; margin: 10px auto; width: fit-content;"> <p>Lucy: its momentum doesn't change because its mass and speed stay the same.</p> <p>Misha: momentum is a vector.</p> <p>Nash: its direction changes, so the momentum must change as well.</p> <p>Paul: momentum towards the wall equals momentum away from the wall.</p> <p>Olivia: the ball's momentum change in the direction the wall pushes on it.</p> </div> <p>To answer:</p> <ol style="list-style-type: none"> Who is right about the momentum of the ball? Explain your answer. Who is wrong about the momentum of the ball? What would you say to help them understand? <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>BEST STUDENT WORKSHEET</p> <p>Crumple zones</p> <p>When it crashes, a car's body will crumple around the point of impact. Safety seats are carried out of all types of car. Cars are tested to make them as safe as possible for passengers.</p>  <p>What happens when a car crashes and comes to a stop? Pick one phrase in each line to explain what happens.</p> <ul style="list-style-type: none"> The car's body will crumple around the point of impact. As it crumples the car slows down. Crumpling makes it take less time / a little longer / about the same time to stop fully. Its momentum changes less quickly / more quickly / at the same rate. Which means that less force / more force / the same force is used to stop the car. The passengers feel less force / more force / the same force. <p>To answer:</p> <ol style="list-style-type: none"> Do you think cars are designed to crumple when they crash? Describe how much a car should crumple when it crashes and explain why? <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>																									
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