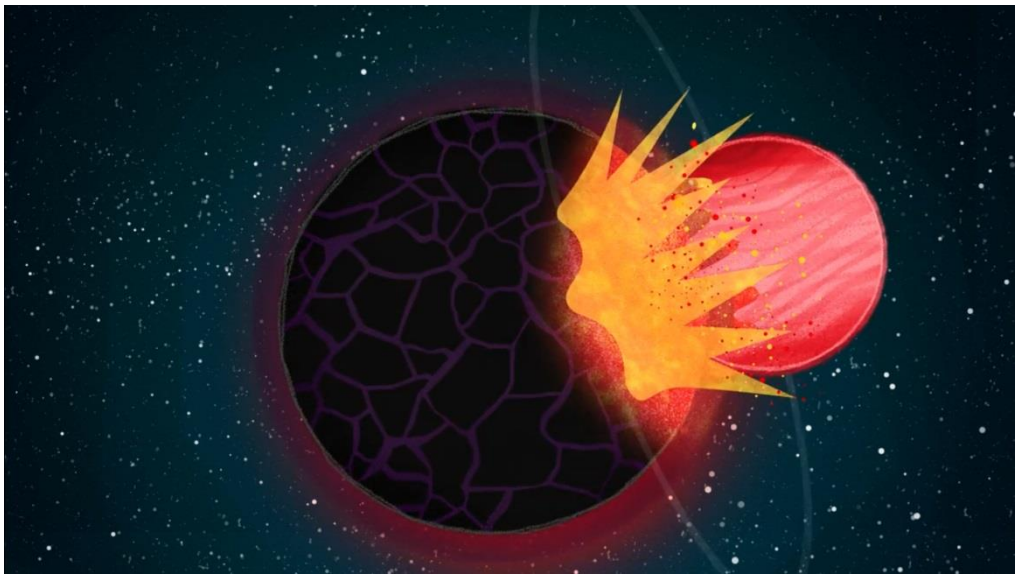
Conservation of Momentum

Key Stage 4

Topics covered: Conservation of momentum, velocity, forces, collisions, units

Watch the video "Collisions and Explosions in the Universe"
https://vimeo.com/259656456



Teacher's Notes

This resource covers the concept of conservation of momentum and includes an activity calculating momentum and masses in a closed system and a practical activity to demonstrate a real world situation in an open system. Both activities support development of skills handling units and using standard form as well as rounding calculations at appropriate stages.

Practical Notes

Students roll one marble towards a stationary marble to cause a collision. Using a flat surface such as a table and basic equipment:

- 2 x marbles
- Stopwatch
- Metre ruler
- Scales

Then students use data collected to calculate momentum and are asked to interpret their results. Extend the activity by using marbles of different weights and changing the positions of the marbles to vary the distance measurements. If you have light gates they would be perfect for this experiment and give far more accurate velocity readings, limiting human error.

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Student Activity

Conservation of Momentum

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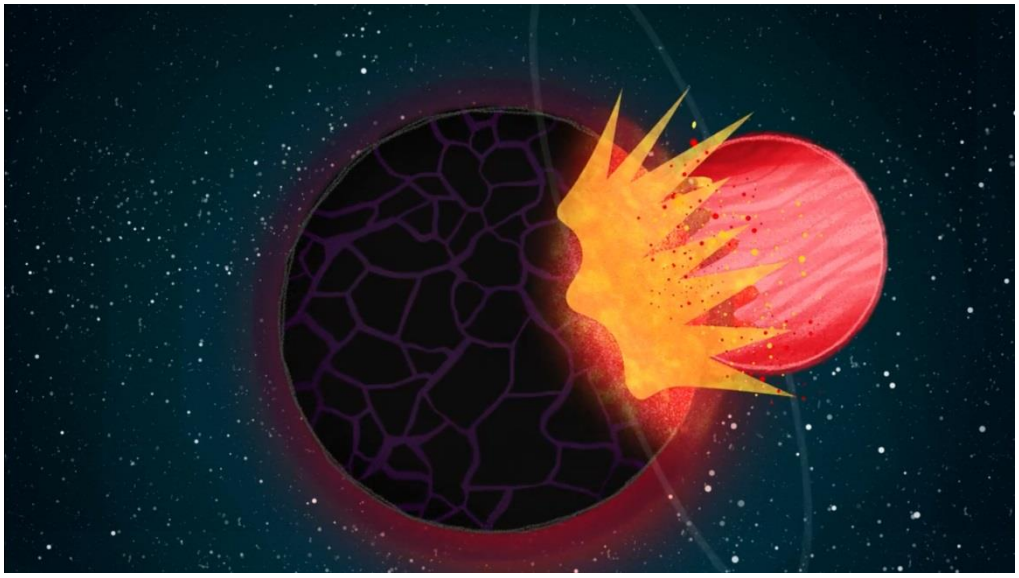

A person who is still and not moving has no momentum; a person running has larger momentum than a person walking. Momentum is the product of the mass and velocity of an object:

$$p = mv \qquad (1)$$

Momentum is conserved in collisions and explosions, also known as events. Conservation of momentum states that in a closed system, the total momentum before an event occurs is equal to the total amount of momentum after the event:

$$m_1 v_1 = m_2 v_2 \qquad (2)$$

When two bodies collide, one may lose momentum causing the other to gain this lost momentum. This ensures momentum is conserved.

1)

a) Scientists believe the Moon was formed from a collision between Early Earth and a Mars-sized ancient planet named Theia. Assuming the collision occurred in a closed system and using the values in the table below, calculate the momentum for each body using equation (1). (**Hint:** Be careful with units!)

Object	**Mass (kg)**	**Velocity (kms^{-1})**	**Momentum ($kgms^{-1}$)**
Earth	5.972×10^{24}	30	
Theia	6.390×10^{23}	4	
Moon	7.348×10^{22}	1	

b) Using the values you calculated in part a) and with the help of equation (2), find the momentum of Early Earth.

c) Assume Early Earth had the same velocity as Earth does now; calculate the mass of Early Earth. Comment on this assumption.

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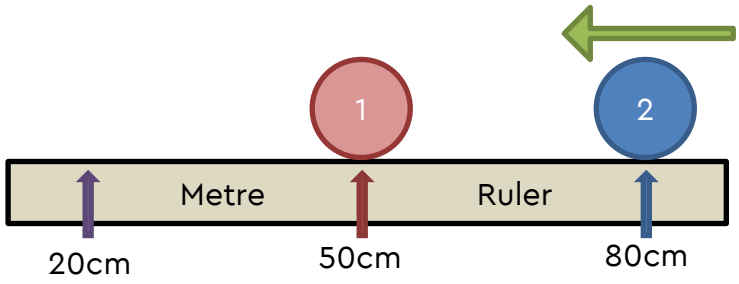
Student Practical

Activity – In pairs

Equipment
2 x marbles
Stopwatch
Metre ruler
Scales

1) Weigh the marbles and record their masses
2) Place the ruler down flat horizontally on a level surface (table or floor)
3) Place marble 1 at about 50cm, touching the ruler, and marble 2 at around 80cm
4) Make note of the marbles initial positions



5) One person push marble 2 (gently) towards marble 1 whilst the second person starts the stopwatch
6) Lap the time when the collision occurs and again when marble 1 reaches the 20cm mark (it may roll past this!)
7) Record the distance and time each marble has travelled

Marble	Mass (g)	Distance (cm)	Time (s)
Marble 1			
Marble 2			

2) Using the data from the experiment and equation (1), calculate the momentum of each marble before and after the event.

Remember $v = \frac{d}{t}$

3) Does your experiment obey conservation of momentum? Explain your answer

Bonus: Try the experiment again using different positions and compare your results

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Answers

Conservation of Momentum

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1) a) Earth momentum = 1.792 x 10^{29} $kgms^{-1}$
Theia momentum = 2.556 x 10^{29} $kgms^{-1}$
Moon momentum = 7.348 x 10^{25} $kgms^{-1}$

b) Remember we have four momentums in total, two from before the collision and two from afterwards.
Early Earth momentum = 1.766 x 10^{29} $kgms^{-1}$

c) Mass of Early Earth = 5.888 x 10^{24} kg
Early Earth's velocity would likely be different than Earth's current velocity

Activity Answers

2) Marble 2 may roll backwards after colliding with marble 1, meaning both marbles have momentum after the collision. The momentum of marble 2 after the collision needs to be accounted for in any conservation of momentum calculations
3) No, answers may be similar but not equal (momentums should be equal for conservation of momentum)
    - System is not closed
    - Momentum lost as velocity not constant due to friction and air resistance