Momentum

Discussion: Why don't we bowl with ping pong balls?

- https://www.youtube.com/watch?v=Pj8timZ_Y5I

Momentum

- If inertia is mass at rest, then momentum is mass in motion. Measured in kg*m/s.

$$p = mv$$

p represents momentum (kg*m/s)
m represents mass (kilograms)
v represents velocity (m/s)

Is it possible for a ping pong ball to have as much momentum as a bowling ball?

Ping pong ball vs. Bowling ball calculations

- Let's say we roll a 5 kg (about 12 lbs, the smallest size) bowling ball at 1 m/s. How much momentum does it have?

- How fast would we have to roll a 3 gram ping pong ball for it to have the same momentum?

Conservation of momentum

- In a closed system with no outside forces, TOTAL momentum is conserved.
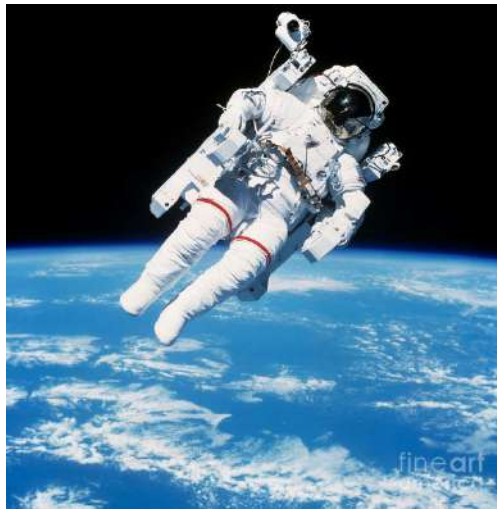
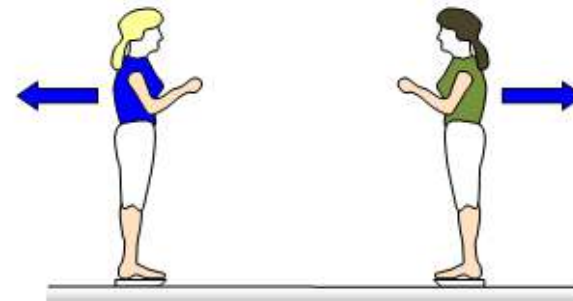$$\Sigma p = m_1 v_1 + m_2 v_2 + \ldots$$

Figure 1(a)

Figure 1(b)

Calculate the total momentum of...

- A system of two identical balls, both with a mass of 10 kg, m_1 and m_2
  - Both have a velocity of + 10 m/s
  - One ball is at rest, the other has a velocity of +10 m/s
  - One ball is at rest, the other has a velocity of -10 m/s
  - Both have a velocity of -10 m/s

Collisions: Lab

- There are two kinds of collisions: perfectly elastic and perfectly inelastic.
- Explore these two kinds of collisions using a computer simulation.

Collisions Lab

Collisions

	Perfectly Elastic	Perfectly Inelastic
What happens?	Objects bounce off each other	Objects stick together
Is p conserved?	yes	yes
Is KE conserved?	Yes	No (where does the energy go?)

Perfectly Elastic Collision

- Nick Rahbany (mass = 60 kg) runs at 10 m/s with a yoga ball towards an innocent, at-rest Connie Rahbany (mass=50 kg). Assuming the collision was 100% elastic and Nick's final velocity is 0.91 m/s, how fast and in which direction does Connie fly?

- https://www.youtube.com/watch?v=W9EqU1_DXUw

Another Perfectly Elastic Collision

Jake de Boer gets owned

- Jake de Boer (45 kg) is running at 2.6 m/s and gets mauled by a 60 kg guy running at 4.2 m/s. If the guy has a velocity of 2.8 m/s after the collision, what is Jake de Boer's velocity as he falls to the ground?
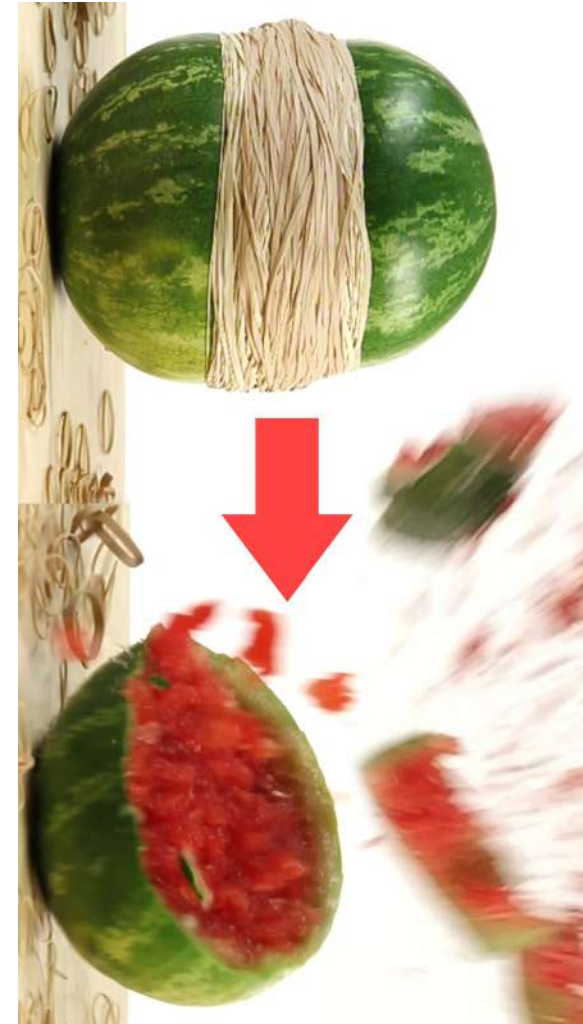
Perfectly inelastic collision

- A 0.067 kg bullet is shot at 534 m/s into the chest of Noah Swart (poor Noah). If Noah was at rest and has a mass of 70 kg, what is Noah's velocity after he gets shot?
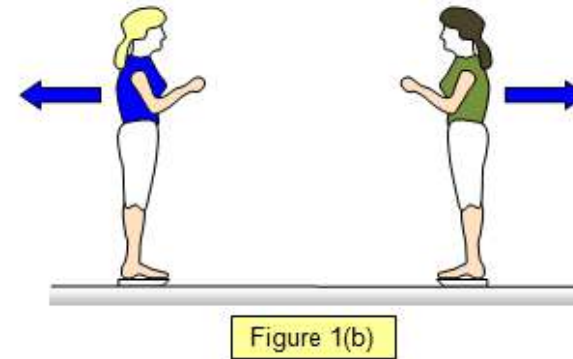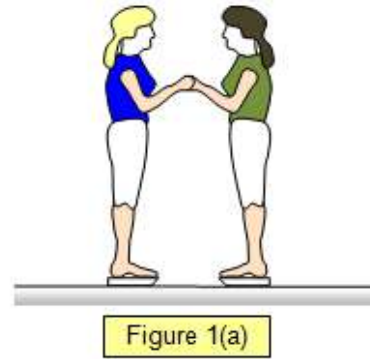
Explosions

- Kind of like collisions, but in reverse.
- Conservation of momentum still applies.

A 5 kg watermelon is exploded using rubber bands. It flies off into two
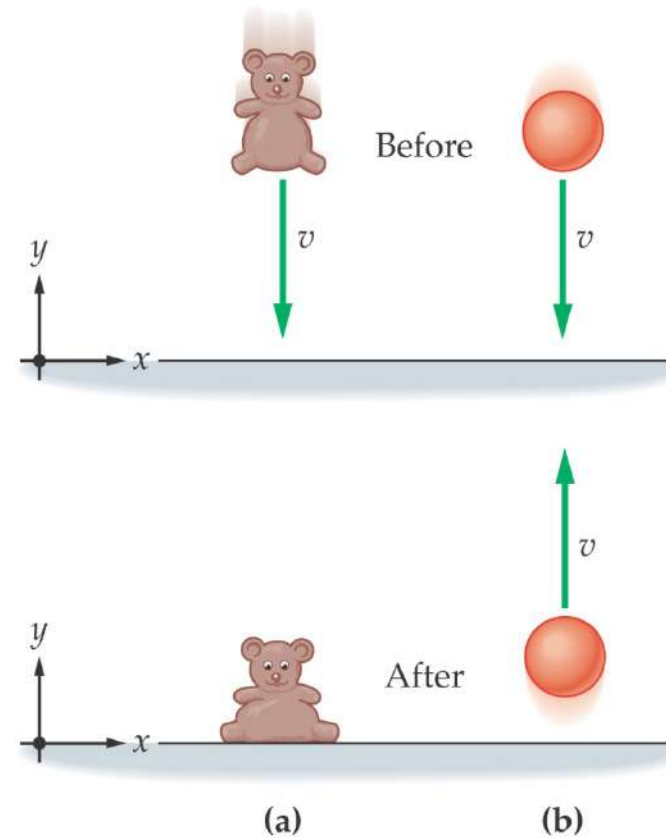
Figure 1(a)

Figure 1(b)

While free floating in space, jet packs broken, what can an astronaut do to get back to his ship?

Change in Momentum (Impulse)

○ An outside force is required to change momentum. Change in momentum is called impulse (j).

$$j = \Delta p$$

Before

v

v

y

x

After

v

y

x

(a)

(b)

Impulse and Force

- An outside force is required to change the total momentum of a system.

$$j = F \Delta t$$

Impulse and Force Problem

- A 25 kg child changes his speed from 2 m/s to 8 m/s in a time of 15 seconds. What was the force experienced by the child?

Why are airbags and seatbelts important?

- In your explanation, touch upon:
  - Newton's Law of Inertia
  - Momentum
  - Force and time (Impulse)

F t = change in momentum   F t = change in momentum

Riding the punch increases the time of collision and reduces the force of collision.

- https://www.youtube.com/watch?v=BVKJfXsfbVc

- Crash Test simulator: http://www.mrmont.com/games/crashtest.html
- Car crash at 124 mph (200 kmh): http://www.telegraph.co.uk/news/newstopics/howabout that/11834857/Car-crash-simulation-at-124mph.html
- Wear your seat belt: https://www.youtube.com/watch?v=d7iYZPp2zYY