

Momentum

- Momentum is what Newton called the “**quantity of motion**” of an object.
- Also called “**Mass in motion**”

$$p = mv$$

p = momentum
 m = mass
 v = velocity

The units for momentum are: $\frac{kg \cdot m}{s}$

Momentum

- Momentum is affected by mass and velocity
- A speeding bullet may have the same momentum as a slow moving car
- The more momentum an object has, the more force will be needed to change its motion

Example: It is hard to stop a large, fast train

What is the momentum of a 2200 kg car driving at 26 m/s?

$$m = 2200 \text{ kg} \quad v = 26 \text{ m/s}$$

$$p = mv$$

$$p = (2200 \text{ kg})(26 \text{ m/s}) = 57200 \frac{kg \cdot m}{s}$$

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Impulse

- Impulse is the change in momentum
- Impulse relates the time and force needed to change an objects momentum

More contact time → Less force needed

Less contact time → Less force needed

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Impulse – Momentum Theorem

$$I = F \cdot t = \Delta p = m(v_f - v_i)$$

I = impulse
 F = force
 t = time
 Δp = change momentum
 m = mass
 v_f = final velocity
 v_i = initial velocity

The units for momentum are: $N \cdot s$

Impulse Examples

- What should a boxer do when he gets hit?

$$F \cdot t = \Delta p$$

When a boxer “rolls with the punch” he increases the contact time of the punch.

This makes the force much smaller.



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More Impulse Examples

- Dropping an egg on a pillow will increase the time of the momentum change. This lowers the force.
- A car uses an airbag to increase the time the head changes its momentum during an accident.
- A car driving into a wall will change its momentum very fast, resulting in a huge force.
- A car hitting the brakes and slowing down gradually will result in very low forces.

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Conservation of Momentum

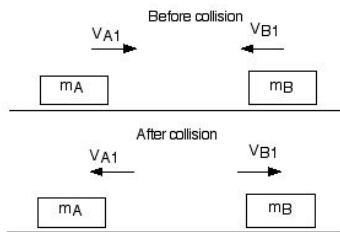
- Total momentum in a system does not change.
- Momentum is transferred between objects during a collision

If two cars collide, the final motion can be predicted based on their momentum

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Elastic Collision

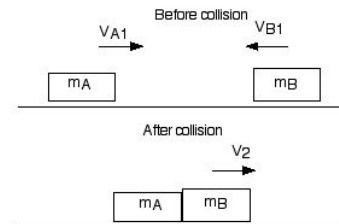
- **This occurs when cars bounce off each other.**
- The distance the cars bounce depends on the original momentum



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Inelastic Collision

- **This occurs when cars stick together.**
- The cars will combine and move in the direction of the car with greater momentum



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