




# Chapter 6



## Momentum



# Linear Momentum


- Momentum =  $p$
  - Momentum = mass x velocity
  - $p = mv$
  - Units are kilogram-meters per second ( $\text{kg}\cdot\text{m/s}$ )
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- The faster you move, the more momentum you have and the more difficult it is to come to a stop.
  - The more massive a ball is, the more force it will exert on another object because of the momentum.
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- Bowling ball versus soccer ball demo
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# Impulse

- A change in momentum takes force and time – Impulse-momentum theorem
  - $\text{Force}(\text{time}) = \text{change in momentum}$
  - $Ft = mv_f - mv_i$
  - $Ft$  is called impulse
  - Units of impulse are  $\text{Ns}$
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- A 1000 g football is thrown with a velocity of 10 m/s to the right. A stationary receiver catches the ball and brings it to rest in .02 seconds. What is the force exerted on the ball by the receiver?



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- Stopping time and distances depend on the impulse-momentum theorem.
  - Highway safety engineers use the impulse-momentum theorem to determine stopping distances and safe following distances for cars and trucks.
  - The impulse-momentum theorem is used to design safety equipment that reduces the forces exerted on a human body during collisions
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# Egg Air Bag Lab



- On a trampoline, jumpers are protected from injury because the rubber reduces the force of the collision by allowing it to take place over a longer period of time.




# Egg Impulse

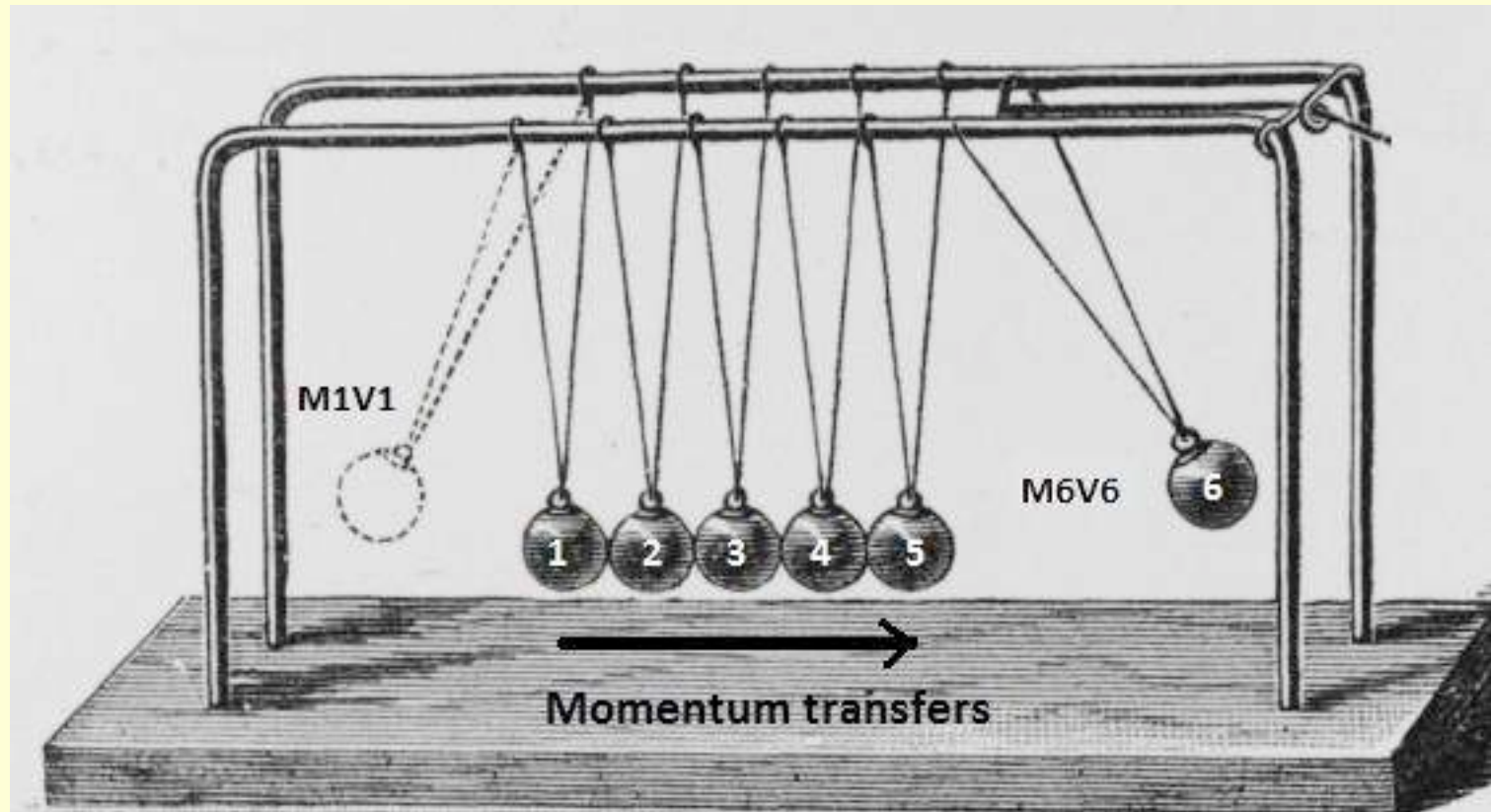




# Conservation of Momentum

- When two or more objects collide, the total momentum of the two objects together remains the same.
  - $M_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$
  - The total momentum before = the total momentum after
  - If initially both objects are at rest, then the initial momentum = 0
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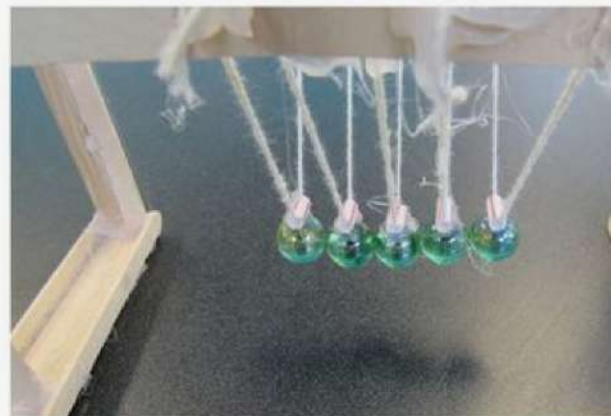
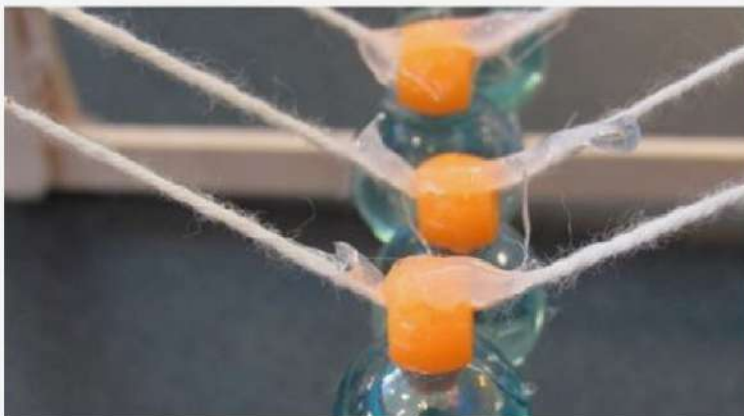
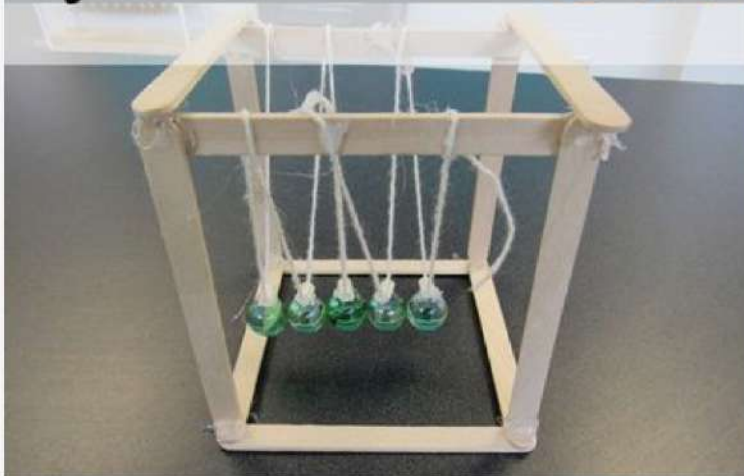
# Newton's Cradle



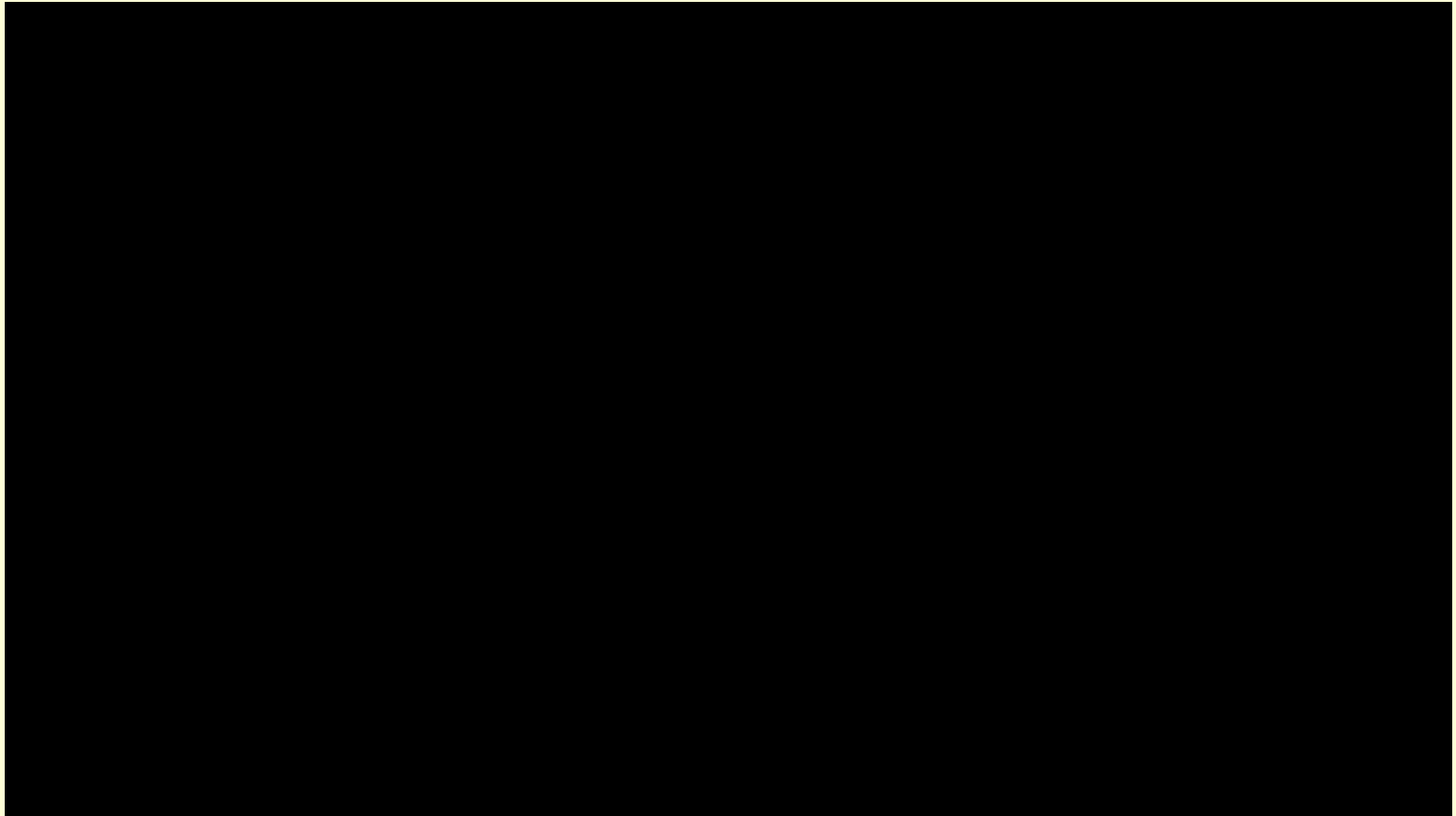


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# newton's CRADLES



# Clackers





- A 50,000 g throws a 10 kg tank with a speed of 10 m/s. Assuming the astronaut starts from rest, find the astronaut's final speed.




# Swinging Weight Demo





# Collisions

- 2 major types of collisions:
  - Perfectly inelastic collisions – when 2 objects collide and move together as one mass. (Some car accidents)
  - Elastic collisions – 2 objects collide and return to their original shapes with no change in total kinetic energy. After the collisions, the objects move off separately. (Marbles and Pool/Billiards)
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- A 1000 kg car traveling at 10 m/s collides with a 4000 kg truck that is initially at rest. The car and truck stick together and move together after the collision. What is the final velocity of the two vehicle mass?






# Perfectly Inelastic Collisions

- $M_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$
  - Kinetic energy is not constant in inelastic collisions.
  - Some of the energy is converted to sound and heat (like in a car wreck).
  - “Perfectly” inelastic collisions – no energy is lost due to sound and heat.
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# Elastic Collisions

- Momentum and kinetic energy remain constant in an elastic collision.
  - $m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$
  - $v$  is positive if the object moves to the right and negative if moves to the left.
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- A  $.04 \text{ kg}$  marble sliding to the right at  $5 \text{ m/s}$  makes an elastic collision with a  $.05 \text{ kg}$  marble moving to the left at  $2 \text{ m/s}$ . After the collision, the first marble moves to the left at  $1 \text{ m/s}$ . Find the velocity of the second marble after the collision.

