KEY Momentum

Recap

Momentum
- ★ p=mv
- ★ Conservation of momentum
  - ○ P_{tot}=constant
  - ○ $P_{tot}=P'_{tot}$
  - ○ $p_1 + p_2 = p'_1 + p'_2$ (F_{net}=0)

Impulse
- ★ Change in momentum
- ★ $\Delta p = F_{net} \bullet \Delta t$
- ★ Force acts on an object
- ★ If you are looking at the impulse between 2 objects, they are experiencing the same impulse

Types of collision
- ★ Totally Elastic
  - ○ Conserves kinetic energy and momentum
- ★ Partially inelastic
  - ○ Particles don’t stick together
  - ○ Momentum is conserved
  - ○ Kinetic energy is not conserved
  - ○ Example
    - ■ Air hockey
- ★ Totally Inelastic
  - ○ Particles stick together
  - ○ Momentum is conserved
  - ○ Kinetic energy is not conserved
  - ○ Example:
    - ■ A ball caught in a glove

Practice

A runaway train car that has a mass of 15,000 kg travels at a speed of 5.4 m/s down a track. Compute the time required for a force of 1500 N to bring the car to rest. Link to the Video on solving

$m = 15{,}000\,kg$
$v_i = 5.4\,m/s$
$F = 1500\,N$
$t = ?$
$v_f = 0\,m/s$

$p = mv$

$\Delta P = F_{net} \cdot t$

$\frac{P_f - P_i}{F} = \frac{Ft}{F}$

$\frac{mv_f - mv_i}{F} = t$

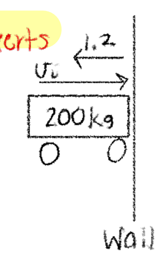
$t = \frac{m(v_f - v_i)}{F}$

$t = \frac{15000 \cdot (0 - 5.4)}{-1500}$

$t = 54\,s$

Suppose a child drives a bumper car head-on into the side rail, which exerts a force of 4000 N on the car for 0.200 s. (a) What impulse is imparted by this force? (b) Find the final velocity of the bumper car if its initial velocity was 2.80 m/s and the car plus driver has a mass of 200 kg. You may neglect the friction between the car and the floor. Link to the Video on solving

$F = {}^{-}4000\,N$ $t = .200\,s$ ☆Force is negative because the car exerts the force☆



ⓐ $\Delta P = F_{net} \cdot \Delta t = {}^{-}4000\,N \cdot .200\,s = {}^{-}800\,N \cdot s$

ⓑ $\Delta P = 800\,N \cdot s$ $v_f = ?$ $v_0 = 2.8\,m/s$ $m = 200\,kg$

$\Delta P = F_{net} \cdot t$

$P_f - P_i = F_{net} \cdot t$

$m(v_f - v_i) = F_{net} \cdot t$

$v_f = \frac{F_{net} \cdot t}{m} + v_i = \frac{{}^{-}4000 \cdot .20}{200} + 2.8\,m/s = 1.2\,m/s$

A 0.450-kg hammer is moving horizontally at 7.00 m/s when it strikes a nail and comes to rest after driving the nail 1.00 cm into a board. (a) Calculate the duration of the impact. (b) What was the average force exerted on the nail? Link to the Video on solving

$m = .450\ \text{Kg}$ $v_i = 7.00\ \text{m/s}$ $x = 1.00\ \text{cm} \longrightarrow .01\ \text{m}$ $v_f = 0\ \text{m/s}$

(a) $x = \frac{1}{2}(v_f + v_i)t$

$.01 = \frac{1}{2}(0 + 7)t$

$.01 = 3.5t$

$2.86 \times 10^{-3}\ \text{s} \approx t$

(b) $\Delta P = F \cdot t$

$F = \frac{\Delta P}{t} = \frac{m(v_f - v_i)}{t} = \frac{.45 \cdot (0-7)}{2.86 \times 10^{-3}}$

$F = -1.10 \times 10^{3}\ \text{N}$

When serving a tennis ball, a player hits the ball when its velocity is zero (at the highest point of a vertical toss). The racquet exerts a force of 540 N on the ball for 5.00 ms, giving it a final velocity of 45.0 m/s. Using these data, find the mass of the ball. Link to the Video on solving

$v_o = 0\ \text{m/s}$ $F = 540\ \text{N}$ $v_f = 45.0\ \text{m/s}$ $t = 5.00 \times 10^{-3}\ \text{s}$ $m = ?$

$\Delta P = F \cdot t$

$m(v_f - v_o) = F \cdot t$

$m = \frac{F \cdot t}{(v_f - v_o)} = \frac{540 \cdot 5 \times 10^{-3}}{(45 - 0)} = .06$

Consider the following question: A car moving at 10 m/s crashes into a tree and stops in 0.26 s. Calculate the force the seatbelt exerts on a passenger in the car to bring him to a halt. The mass of the passenger is 70 kg. Would the answer to this question be different if the car with the 70-kg passenger had collided with a car that has a mass equal to and is traveling in the opposite direction and at the same speed? Link to the Video on solving

$v_0 = 10\,m/s$ $v_f = 0\,m/s$ $t = .26s$ $F = ?$ $m = 70kg$

$\Delta P = F \cdot t$

$m(v_f - v_i) = F \cdot t$ $F = \frac{m(v_f - v_i)}{t} = \frac{70(-10)}{.26} = -2692N$

$P_i = P_f$

$P_1 + P_2 = P_f$

$m_1 v_1 + m_2 v_2 = P_f$

$(70 \cdot 10) + (70 \cdot -10) = P_f$

$700 + -700 = P_f$

$0 = P_f$

A 1.80-kg falcon catches a 0.650-kg dove from behind in midair. What is their velocity after impact if the falcon's velocity is initially 28.0 m/s and the dove's velocity is 7.00 m/s in the same direction? Is this an elastic collision or an inelastic collision? Link to the Video on solving

falcons: $m_f = 1.80kg$ $v_{if} = 28.0\,m/s$

dove: $m_d = .650kg$ $v_{id} = 7.00\,m/s$

$m_T = 1.80 + .650 = 2.45kg$

$v_{fT} = ?$

$P_{before} = P_{After}$

$P_f + P_d = P_T$

$m_f v_{if} + m_d v_{id} = m_T v_f$

$v_f = \frac{m_f \cdot v_{if} + m_d v_{id}}{m_T} = \frac{(1.8 \cdot 28) + (.65 \cdot 7)}{2.45} = 22.4\,m/s$