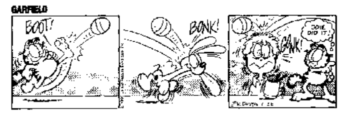
Chapter 7 - Momentum and Impulse

Intro to Impulse & Momentum



Conservation of momentum holds true in ALL collisions

Momentum = moving mass

momentum	p	kg m/s
impulse	J	kg m/s
		N s

p = mv

Impulse = change in momentum

J = Δp = Δmv

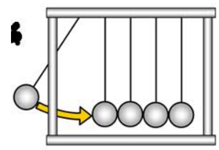
Units = kg m/s

If an object is **at rest**, it has **no momentum** - no matter how large its mass. Momentum is not the same as inertia.

momentum = (**mass**)(0) = 0

Conservation of Momentum

Momentum ALWAYS stays the same unless acted upon by an OUTSIDE, NET IMPULSE



Change in momentum requires change in velocity which requires a NET Force

The longer that net force is applied the bigger the change so....

J = Ft (note F is NET force)

Notice units... Ns = kg m/s

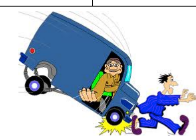
$J = Ft$, $J = \Delta mv$

$Ft = \Delta mv$

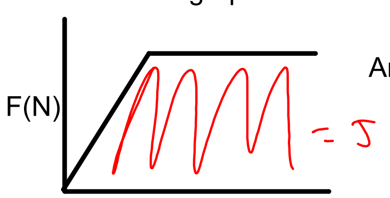
$F = \frac{m\Delta v}{t}$

$F = ma$

Impact Force	Impulse
How "hard"	How much "change"
Fnet	J



F vs t graph



Area = Ft
= J

Ways to CHANGE IMPACT with SAME IMPULSE

Big time/small force -- $_F t$

Examples:

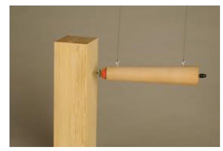
1. Car accident with air bag
2. Falling on wood floor
3. Jumping on trampoline

Small time/ Big Force: F t

Examples:

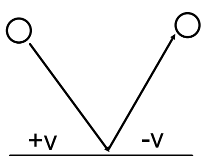
1. Karate chop
2. Car accident with not padded dash
3. Falling on concrete

What about bouncing? What would happen to impulse? What would happen to impact force?



Bouncing-

1. Small Time
2. BIG change in v = big J
3. BIGGEST F



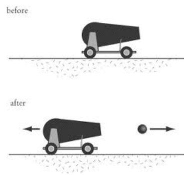
Sticky = $\Delta v = v$

bouncing = $\Delta v = 2v$

3 basic types of interactions for conservation of momentum

Remember....$p_o = p_f$ ALWAYS unless outside net impulse

1. Explosions - $p_{total} = 0$ the whole time



$p_o = 0$

$p_f = m_1v_{1f} + m_2v_{2f}$

so...

$m_1v_{1f} = - m_2v_{2f}$

Check questions---

Which has more momentum when you fire a gun...the bullet or the gun?

2. Sticky collisions - objects "Stick together" after collision

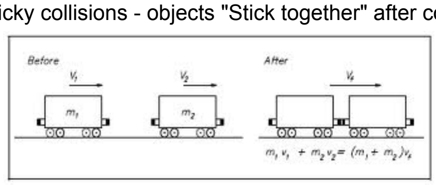


Figure 1 Momentum

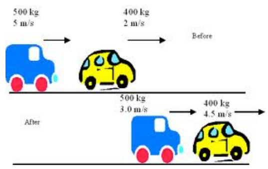
$p_o = m_1v_{1o} + m_2v_{2o}$ $\quad$ $p_f = (m_1 + m_2)v_f$

so... $m_1v_{1o} + m_2v_{2o} = (m_1 + m_2)v_f$

note this can be backwards...or a "reverse" sticky

Check question --- What happens to the momentum of a moving boat if a person jumps on it from a bridge above? What happens to it's speed?

3. Bouncy collision



$p_o = m_1v_{1o} + m_2v_{2o}$

$p_f = m_1v_{1f} + m_2v_{2f}$

so... $m_1v_{1o} + m_2v_{2o} = m_1v_{1f} + m_2v_{2f}$

Check question - Can two object moving opposite directions bounce so that they are moving the same direction after the collision?

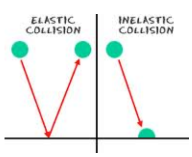
Elastic collisions

KE is conserved

$KE_o = KE_f$

AND

$p_o = p_f$



Inelastic collisions

KE is NOT conserved

$p_o = p_f$

BUT

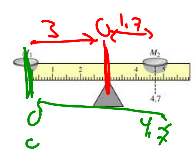
$KE_o \neq KE_f$

Center of Mass

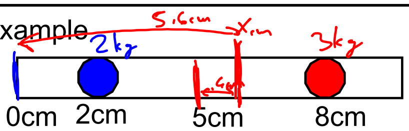
Where mass of an object is considered to be located and still conserve its momentum

$x_{cm} = \Sigma mx / \Sigma m$

x = dist from a set location



Example



What is x_{cm} relative to 0?

$m_1 = 2kg$ $x_1 = 2cm$

$m_1 = 3kg$ $x_2 = 8cm$

$$x_{cm} = \frac{(2)(2)+(3)(8)}{2+3} = 5.6cm$$

What is x_{cm} relative to 5 cm?

$m_1 = 2kg, x_1 = -3cm$

$m_2 = 3kg, x_2 = 3cm$

$$x_{cm} = \frac{(2)(-3)+(3)(3)}{2+3}$$

$$= 3/5 = .6cm$$