Impulse, Momentum, Collisions

Cut Short Lab Report Due Friday

Part I: Challenge & Givens

Procedure

Trials (3*) data and calculations

Percent error based on either calculated/theoretical energy or calculated theoretical velocities

Conclusions - From part two, utilize your data with your final conclusion

Part II:

Procedure for Trials 1 - 3

Procedure & Sketch for Trial 4

Questions, FBD, & calculations from handout

- Uniform circular motion analysis
- Conservation of energy analysis

Error Analysis

Final Conclusion

*Utilize your data!

Momentum

So what exactly is momentum?

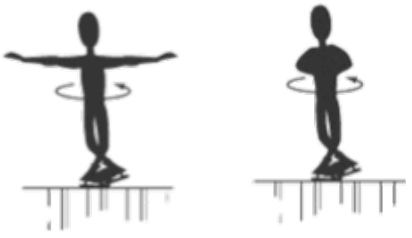
'Weighted velocity"

Tendency of an object to remain in motion after an applied force is removed

Linear - tendency to remain moving

$$p = m \cdot v$$

Angular - tendency to remain rotating



p = linear momentum
m = mass
v = velocity

SI Units: $kg \cdot \frac{m}{s}$

Vector quantity *(same direction as velocity)*

Impulse

How is a force utilized

Force multiplied by the time interval over which the force acts.

$$J = F \cdot \Delta t$$

J = Impulse

F = Force

Δt = time of contact

SI Unit: $N \cdot s$

Vector quantity *(same direction as force applied)*

* Joules vs. Impulse

W = 15 J

KE = 25 J

Unit

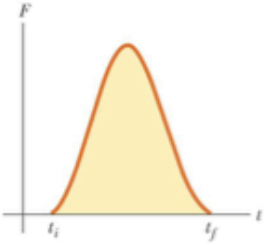
J = 17 N·s

Variable

Impulse

Impulse can also be determined by looking at the area beneath a force vs. time graph.

Impulse is a vector quantity with the same direction as the direction of the change in momentum.



Impulse has a magnitude equal to the area under the force-time graph.

Impulse-Momentum Theory

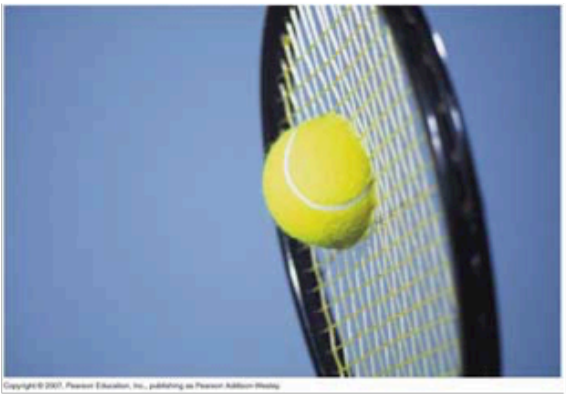
Impulse causes a change in momentum

$$J = \Delta p$$

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

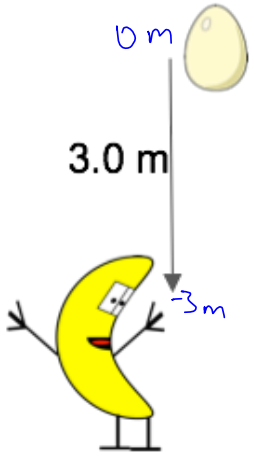
$$F \cdot \Delta t = mv_f - mv_o$$

The greater the impulse, the greater the change in momentum



Impulse-Momentum Theory Practice

Impulse changes momentum, but how the force is applied can make a huge difference!



Kinematics

$V = ?$
$V_0 = 0 \text{ m/s}$
$a = -9.8 \text{ m/s}^2$
$y = -3 \text{ m}$

$V^2 = V_0^2 + 2a(y - y_0)$
$V^2 = (0)^2 + 2(-9.8)(-3 - 0)$
$V^2 = 0 + 58.8$
$V = -7.67 \text{ m/s}$

Average mass of a large egg = 63 g = 0.063 kg

If the egg falls from rest, how fast will it be after 3.0 m?

What if you want to catch it? What will be its change in momentum?

$\Delta p = mv_f - mv_0$
$\Delta p = (0.063)(0) - (0.063)(-7.67)$
$\Delta p = 0.48 \text{ kg} \cdot \text{m/s}$

if we catch the egg in $\Delta t = 0.100$ s or $\Delta t = 0.500$ s

$F \cdot \Delta t = \Delta p$
$F \cdot (0.1) = 0.48$
$F = 4.8 \text{ N}$

$F \cdot \Delta t = \Delta p$
$F \cdot (0.500) = 0.48$
$F = 0.96 \text{ N}$

* more time, less force

Conservation of Momentum

The total momentum of a closed or isolated system remains constant.

For two or more objects interacting,

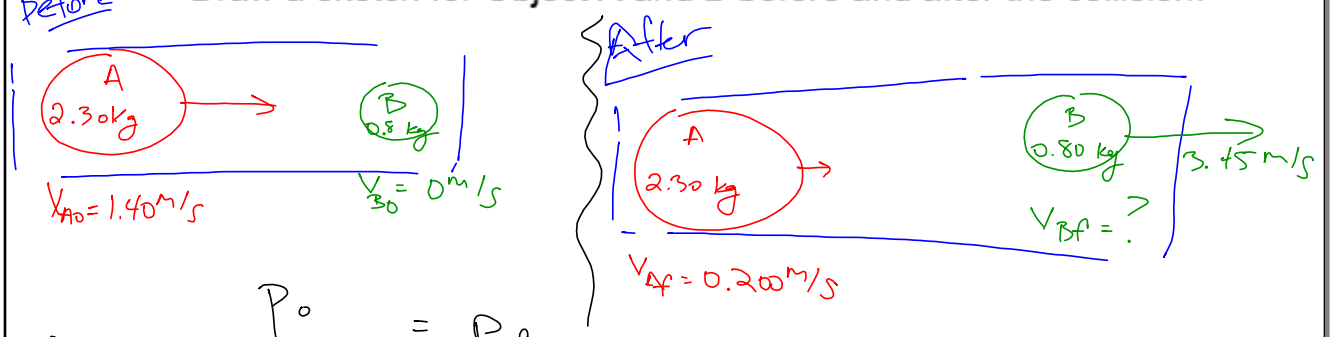
the total momentum of the objects before = the total momentum of the objects afterwards

Closed or isolated system - defined collection of object with no external forces.

Conservation of Momentum Example

You have a system with two objects, Object A (mass = 2.30 kg) and Object B (mass = 0.800 kg). Initially, Object A has an initial velocity of 1.40 m/s to the right. Object B is stationary. The two collide. After the collision, Object A is still moving to the right, but only with a velocity of 0.200 m/s. Object B also is moving to the right with an unknown velocity. What is the velocity of Object B after the collision?

*Draw a sketch for Object A and B before and after the collision.



$P_0 = P_f$

$m_A v_{A0} + m_B v_{B0} = m_A v_{Af} + m_B v_{Bf}$

$(2.30)(1.40) + (0.800)(0) = (2.30)(0.200) + (0.800) v_{Bf}$

$3.22 + 0 = 0.46 + 0.800\, v_{Bf}$

$v_{Bf} = 3.45\ m/s$