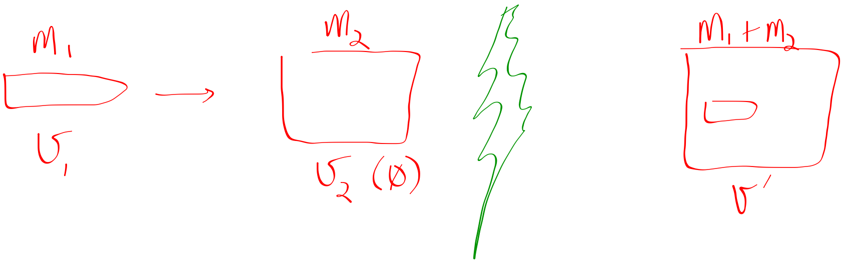
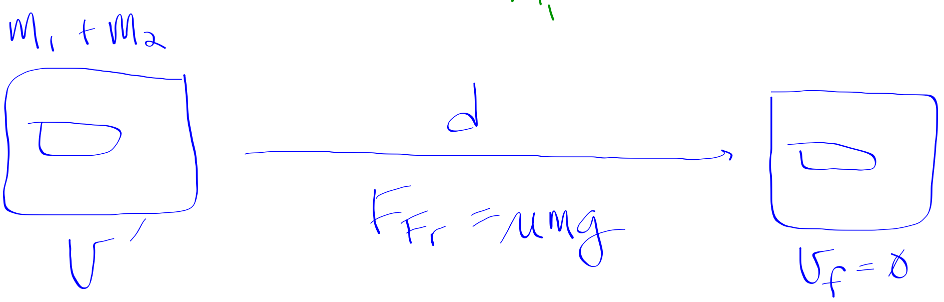
7. A 44-g bullet strikes and becomes embedded in a 1.54-kg block of wood placed on a horizontal surface just in front of the gun. If the coefficient of kinetic friction between the block and the surface is 0.28, and the impact drives the block a distance of 18.0 meters before it comes to rest, what was the muzzle speed of the bullet? (Hint: this requires both CLEE and conservation of momentum.)



$$m_1 v_1 + \cancel{m_2 v_2}^{\,0} = (m_1 + m_2) v'$$

$$v_1 = \frac{(m_1 + m_2)}{m_1} v'$$



$$\frac{1}{2} m v_0^2 + \cancel{mgh_0} + \cancel{\frac{1}{2} k x_0^2} + W_{NC} = \cancel{\frac{1}{2} m v^2} + \cancel{mgh} + \cancel{\frac{1}{2} k x^2}$$

$$\frac{1}{2} m v_0^2 + W_{NC} = 0$$

$\downarrow$

$$W_{Fr} = -\mu mg \cdot d$$

$$\frac{1}{2} m v_0^2 + -\mu mgd = 0$$

$$\frac{1}{2}(m_1 + m_2)(v')^2 + -\mu (m_1 + m_2) g \cdot d = 0$$

$$v' = \sqrt{\frac{2(+\mu \cancel{(m_1 + m_2)} g \cdot d)}{\cancel{m_1 + m_2}}}$$

Impulse:

$$\sum F = ma$$

$$\updownarrow$$

$$\sum F = \frac{\Delta p}{\Delta t}$$

Sum of the forces on a systems = $\dfrac{\text{change in momentum of the system}}{\text{amount of time}}$

Objectives:

- Students will understand what impulse is and how to calculate it
- Students will be able to use the relationship between impulse and change in momentum to analyze forces and motions of objects
- Students will be able to predict forces between objects based on changes in momentum

When: No outside forces exist to act on a system (or when the change in time of a system is small enough to "cheat") - momentum is conserved

If there are external forces, or if we adjust our system to consider each object separately, then impulse allows us to use changes in momentum to investigate the forces that are present:

$$\Delta p \cong \Sigma F$$

(of an object) (size of external force)

$$\Delta t \cdot \sum F = \frac{\Delta p}{\Delta t} \cdot \Delta t$$

$$\boxed{\underbrace{\sum F \cdot \Delta t}_{} = \Delta p}$$ impulse

This product of the net force and time is known as the **IMPULSE** imparted to the system whose momentum is changing.

Impulse is a vector quantity.

$\sum F$ must be the average force if F isn't constant.

Units: [N x s], or [kg x (m/s)]

BECAUSE

IMPULSE also equals the change in momentum.

Here's how we'll think about impulse (for the most part):

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

force of one object

"FORCE GIVER"

change in momentum of another object

"IMPULSE RECEIVER"

$$\Sigma F \Delta t = \Delta p$$

Net force on a system × Δt = change in momentum of that system

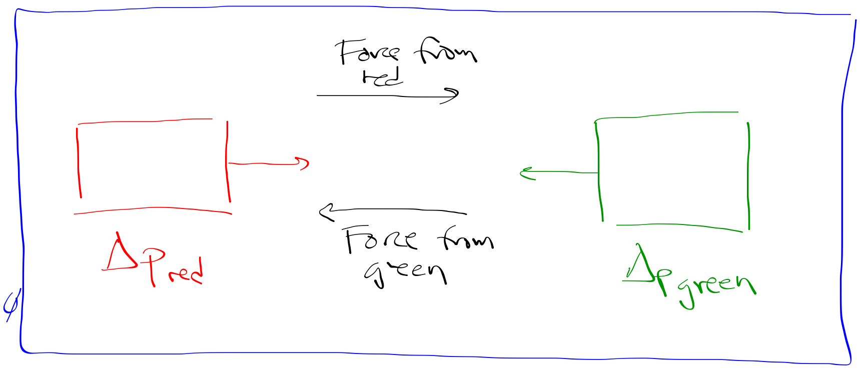
System: both carts!

$\Sigma F = 0$

$\Delta p = 0$

$\Delta p_{red} + \Delta p_{green} = 0$

$\Delta p_{red} = -\Delta p_{green}$

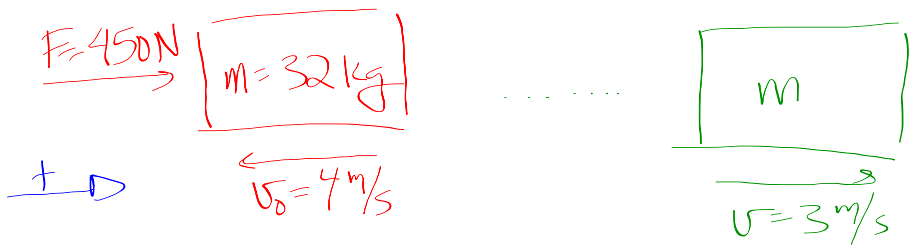


$$\Sigma F_{red} \Delta t = \boxed{\Delta p_{red}}$$

$$\Sigma F_{green} \Delta t = \boxed{\Delta p_{green}}$$

$$\Sigma F_{red} \Delta t = \Delta p_{red} = \Sigma F_{green} \Delta t = \Delta p_{green}$$

EXAMPLE: How long must a 450 N force be applied to change the velocity of a 32-kg mass from 4 m/s to 3 m/s in the opposite direction? Assume a horizontal frictionless surface.



$$\Sigma F \Delta t = \Delta p$$

$$\Delta t = \frac{\Delta p}{\Sigma F} = \frac{m(v - v_0)}{\Sigma F} = \frac{(32)(3 - {}^-4)}{450}$$

$$\boxed{\Delta t = 0.5\,s}$$

Lab:

- Don't spend multiple minutes getting motion sensors to work!
- Take bumpers when you're ready
- Practice achieving target velocities
- Go ahead & collect data

Pre-lab:

- Use rubber bumper tips on force sensors
- Use at least one non-magnetic cart
- Zero one force sensor