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.)

$m_1 v_1' + m_2 v_2' = mv$

$\boxed{0.044 v_1' = 1.584 v}$ same

$\boxed{v_0 = 9.94 \text{ m/s}?}$

$$\frac{1}{2}mv_0^2 + \cancel{mgh_0}^{0} + \cancel{\frac{1}{2}kx_0^2}^{0} + W_{NC} = \cancel{\frac{1}{2}mv^2}^{0} + \cancel{mgh}^{0} + \cancel{\frac{1}{2}kx^2}^{0}$$

$$\frac{1}{2}mv_0^2 + W_{NC} = 0 \qquad W_{NC} = W_{Fr}$$

$$W_{Fr} = F_{Fr} \cdot d$$

$$W_{Fr} = \mu F_N \cdot d$$

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

$$\frac{1}{2}\cancel{m}v_0^2 + {}^{-}\mu \cancel{m} g \cdot d = 0$$

$$v_0 = \sqrt{2\mu g \cdot d}$$

$$= 9.94 \text{ m/s}$$

$$0.044 v_1' = 1.584(9.94)$$

$$v_1' = 357.8 \text{ m/s}$$

RECALL

$$\Sigma F = ma$$

$$\Updownarrow$$

$$\Sigma F = \frac{\Delta P}{\Delta t}$$

When: $\Sigma F = \frac{\Delta p}{\Delta t}$

$\Sigma F = 0$ (No outside forces exist to act on a system)

OR

$\Delta t \Rightarrow 0$ (We can cheat -- because the time that passes is so small, the forces are unable to do any work because there is no displacement)

$\Sigma F = 0 = \Delta p$ **MOMENTUM IS CONSERVED**

$\Sigma F \neq 0$ If not: then the concept of impulse is useful

$$\Sigma F = \Delta P / \Delta t \quad ; \quad \Sigma F = ma, \quad \Sigma F \neq 0$$

$$\underbrace{\Sigma F \Delta t} = \Delta P$$

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.

average net force

ΣF must be the average force if F isn't constant.

Units: [N x s], or $\underbrace{\text{[kg x (m/s)]}}_{\text{BECAUSE}}$

IMPULSE also equals the change in momentum.

$$\Sigma F \Delta t = \text{IMPULSE} = \Delta P$$

IMPULSE APPLIED BY OBJECT #1

CHANGE IN MOMENTUM OF OBJECT #2

The impulse of Object #1 creates a change in the momentum of Object #2 (for a collision between two objects).

When trying to determine the impulse delivered, looking at an object's change in momentum is usually more useful because velocities are easier to measure than either forces or short times.

obj. 1 → obj. 2

$\xrightarrow{F_{1\to 2}}$

$\xleftarrow{F_{2\to 1}}$

$$\left.\begin{array}{l} \boxed{Imp_1 = F_1 \cdot \Delta t} \\ Imp_2 = F_2 \cdot \Delta t \end{array}\right\} \text{same magnitude...}$$

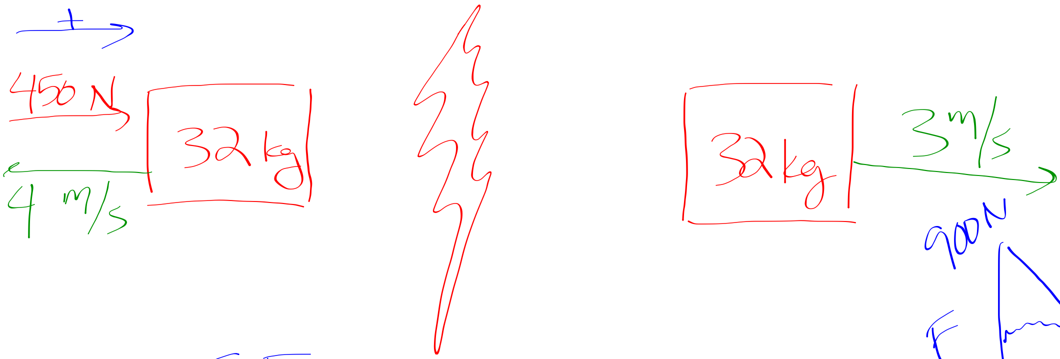
$$\boxed{p_1' \xrightarrow{\neq} p_1} \quad \Sigma p$$

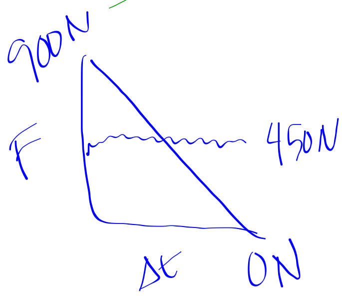
$$\|$$

$$\boxed{p_2' \xrightarrow{\neq} p_2} \quad \Sigma p$$

$$\Delta p_1 = \boxed{\Delta p_2}$$

EXAMPLE 1: 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.





$$\Sigma F \cdot \Delta t = \Delta p = p - p'$$

$$450 \cdot \Delta t = (3)(32) - (-4)(32)$$

$$\Delta t = \frac{224}{450} = \boxed{0.498\ s}$$

The 450 N force exerts an inpulse of

$450(.498) = 224.1$ N·s IN THE + DIRECTION

The momentum of the 32-kg mass changes by

$(3)(32)-(-4)(32) = 224.1$ kg m/s IN THE + DIRECTION

Collisions

For elastic collisions:

Momentum is conserved $(\Delta p = 0)$ ✓

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$$

Kinetic energy is conserved $(\Delta KE = 0)$ ✓

$$\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = \frac{1}{2} m_1 (v_1')^2 + \frac{1}{2} m_2 (v_2')^2$$

For inelastic collisions (any collision not perfectly elastic):

Momentum is conserved

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$$ ✓

Energy is still conserved, but KE is not; some of the original KE that exists before the collision leaves the system as sound, light, thermal, work, etc....

$$\Delta KE \neq 0$$