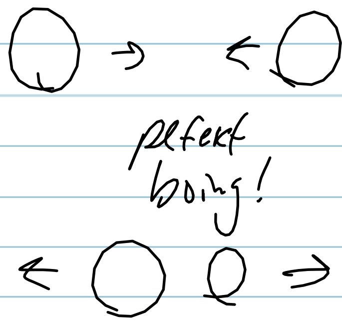
# Conservation of Momentum

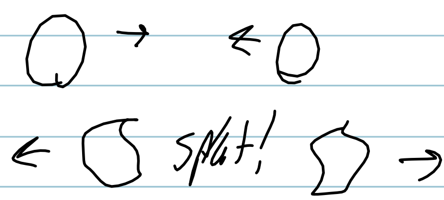
Collisions

elastic collisions (perfect)



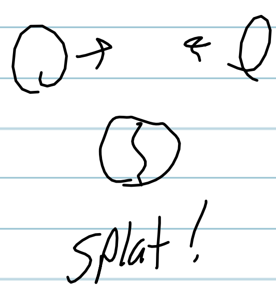

$$K_i = K_f$$

inelastic collisions



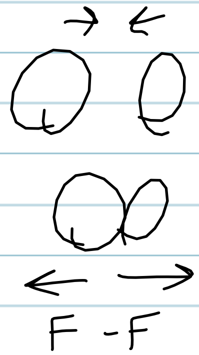

$$K_i > K_f$$

totally inelastic collision



# How do we handle inelastic collisions?

$$\Delta p = Ft$$




$$\Delta p = -\Delta p$$

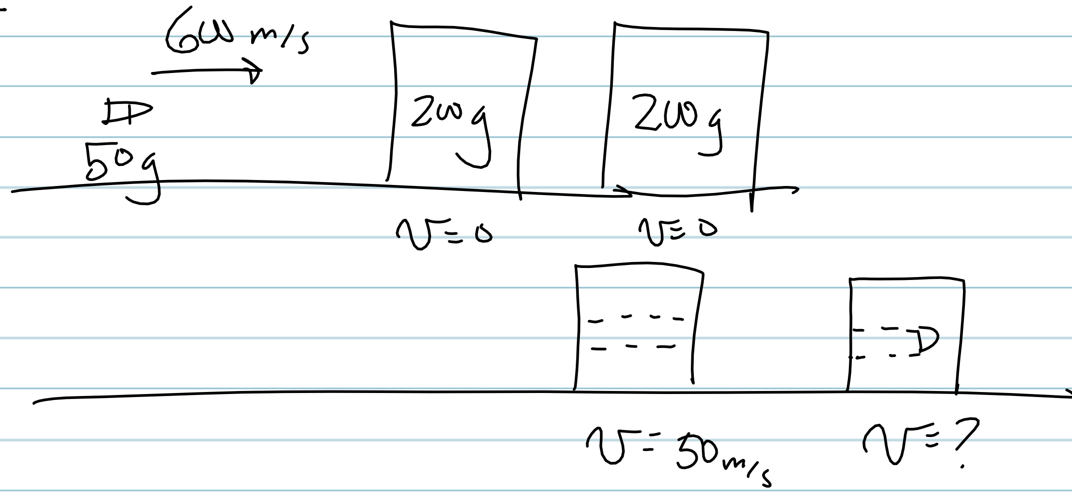
loss = gain

momentum is never lost

only if internal forces are acting

$$p_i = p_f \quad (\Sigma F_{ext} = 0)$$

Ex 2




$$p_i = (50g)(600\,m/s) = 30{,}000\,g\,m/s$$

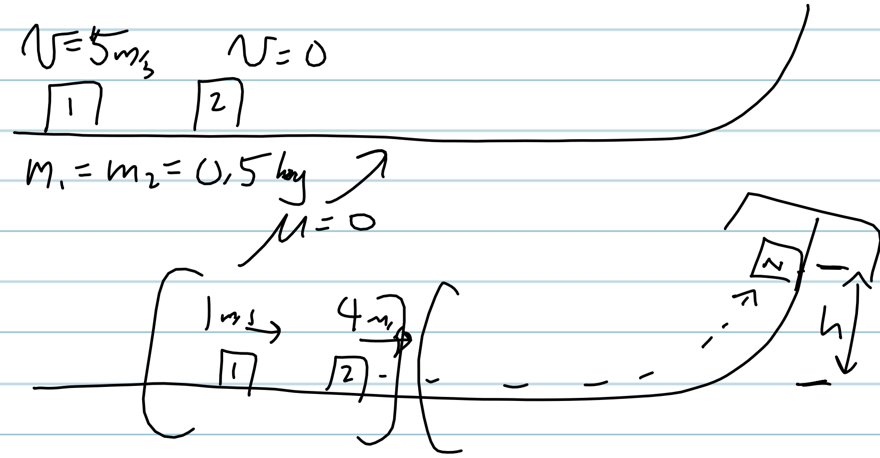
$$p_f = (200g)(50\,m/s) + (250g)(v) = 10{,}000\,g\,m/s + (250g)v$$

$$30{,}000\,g\,m/s = 10{,}000\,g\,m/s + (250g)v$$

$$20{,}000\,g\,m/s = (250g)v$$

$$80\,m/s = v$$

## Ex 3




$$p_i = (0.5\,kg)(5\,m/s) = 2.5\,kg\,m/s$$

$$p_f = (0.5\,kg)(1\,m/s) + (0.5\,kg)v = 0.5\,kg\,m/s + (0.5\,kg)v$$

$$2.5\,kg\,m/s = 0.5\,kg\,m/s + (0.5\,kg)v$$

$$2\,kg\,m/s = (0.5\,kg)v$$

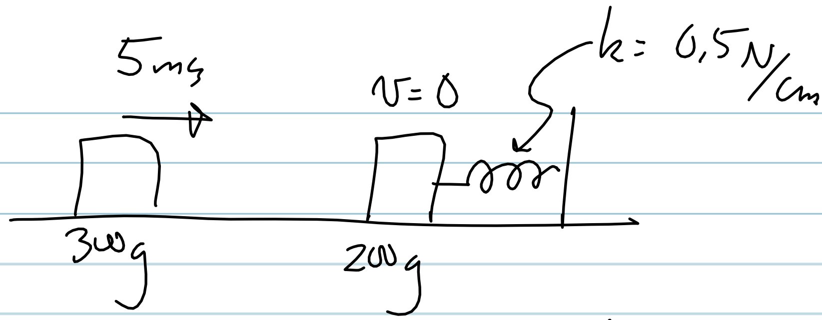
$$4\,m/s = v$$

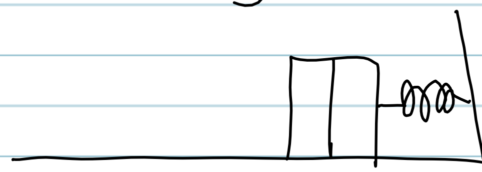
$$E_i = E_f$$

$$\frac{1}{2}\cancel{m_2}v_2^2 = \cancel{m_2}gh$$

$$\frac{v_2^2}{2g} = h = \frac{(4\,m/s)^2}{2(10\,m/s^2)} = \frac{16}{20} = \frac{8}{10} = 0.8\,m$$

## Ex 4



Spring compression $\Delta x = ?$

$p_i = (300\,g)\,5\,m/s = 1500\,g\,m/s$

$p_f = (500\,g)\,v = (500\,g)\,v$

$1500\,g\,m/s = 500\,g\,v$

$3\,m/s = v$

$E_i = E_f$

$\frac{1}{2}mv^2 = \frac{1}{2}k\Delta x^2$ $\quad 500\,g \rightarrow 0.5\,kg \quad 0.5\,N/cm = 50\,N/m$

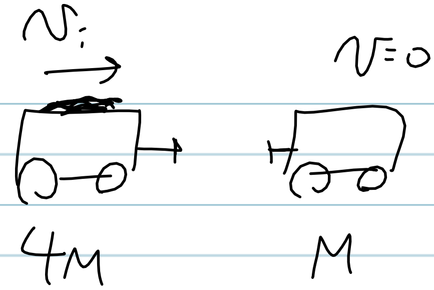
$\frac{1}{2}(0.5\,kg)(3\,m/s)^2 = \frac{1}{2}(50\,N/m)\,\Delta x^2$

$4.5 = 50\,N/m\,\Delta x^2$

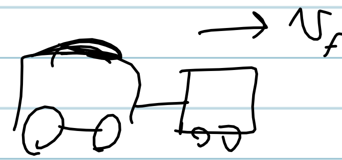
$0.09 = \Delta x^2$

$0.003\,m = \Delta x$

Ex 5




% K lost




% K kept

$$\%K_{kept} = 100\% \cdot \frac{K_f}{K_i} = \frac{\frac{1}{2} m_{1+2} v_f^2}{\frac{1}{2} m_1 v_i^2}$$

$$K_i = \frac{1}{2}(4M) v_i^2 = 2M v_i^2$$

$$K_f = ??\ \frac{1}{2}(5M)\left(\frac{4}{5}v_i\right)^2 = \frac{5}{2}M \cdot \frac{16}{25} v_i^2 = \frac{8}{5} M v_i^2$$

$$p_i = p_f$$

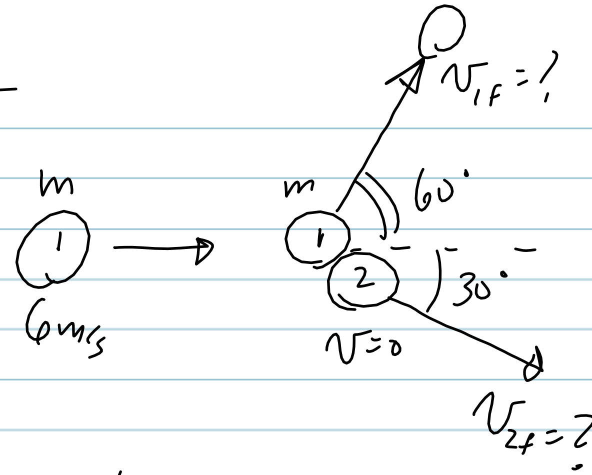
$$4Mv_i = 5Mv_f$$

$$\frac{4}{5}v_i = v_f$$

$$\%K_{kept} = 100\% \ \frac{\frac{8}{5}Mv_i^2}{2Mv_i^2} = \frac{8}{10} \cdot 100\% = 80\%$$

$$\%K_{lost} = 20\%$$

# Ex 6



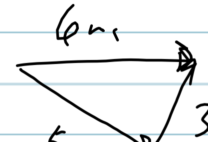


X: $p_i = m(6\,m/s)$

$p_f = m v_{1f}\cos 60 + m v_{2f}\cos 30$

$(m)\,6\,m/s = m v_{1f}\cos 60 + m v_{2f}\cos 30$

$6 = v_{1f}\cos 60 + v_{2f}\cos 30$




Y: $p_i = 0$ $\quad m v_{1f}\sin 60 = m v_{2f}\sin 30$

$p_f$ $\quad v_{1f} = \left(v_{2f}\dfrac{\sin 30}{\sin 60}\right)$

$$6 = v_{2f}\frac{\sin 30}{\sin 60}\cos 60 + v_{2f}\cos 30$$

$$6 = v_{2f}\left(\frac{\sin 30}{\tan 60} + \cos 30\right)$$

$$v_{2f} = \frac{6}{\left(\frac{\sin 30}{\tan 60} + \cos 30\right)} = \frac{6}{\left(0.866 + \frac{0.5}{1.73}\right)} = 5.2\,m/s$$

$$v_{1f} = v_{2f}\left(\frac{\sin 30}{\sin 60}\right) = (5.2\,m/s)\left(\frac{0.5}{0.866}\right) = 3\,m/s$$