Phys 2110-3 10/22/10

Note Title 10/22/2010

Chap 9 Systems of Particles

CM, $\vec{F}_{\substack{net \\ ext}} = M\vec{a}_{cm}$

Isolated system $\vec{F}_{\substack{net \\ ext}} = 0 = \frac{d\vec{P}}{dt}$

$\Longrightarrow \vec{P} = \text{const}$

$\boxed{\text{Conservation of Momentum}}$

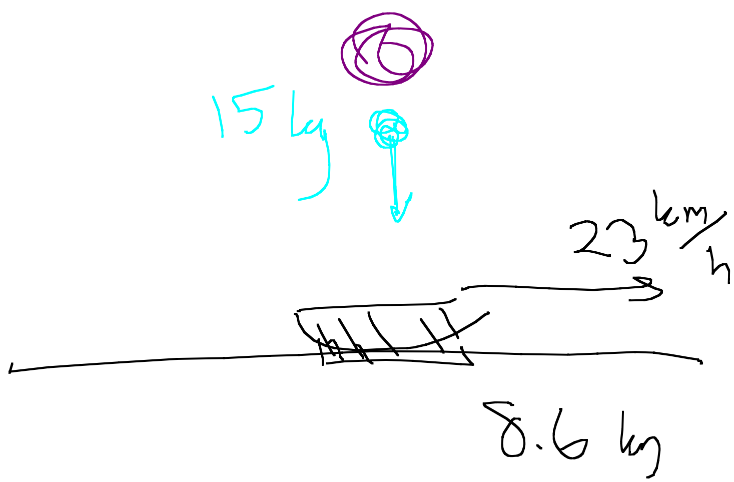
$\vec{p} = m\vec{v}$ vector

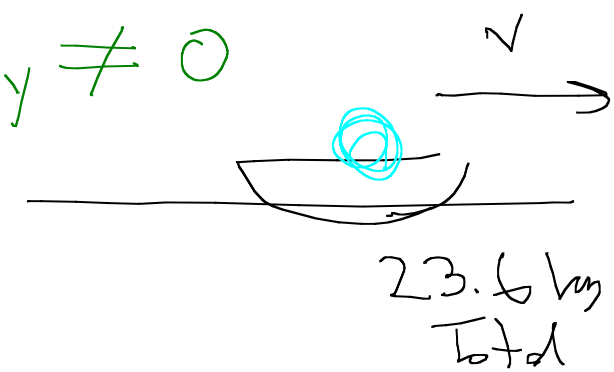
9.21 A runaway toboggan of mass 8.6 kg is moving horizontally at 23 $\frac{km}{h}$. Passes under tree 15 kg of snow drops onto it. What is subsequent speed.

No horizontal forces on sled

y-momentum <u>not</u> cons'd.

$F_{ext,y} \neq 0$





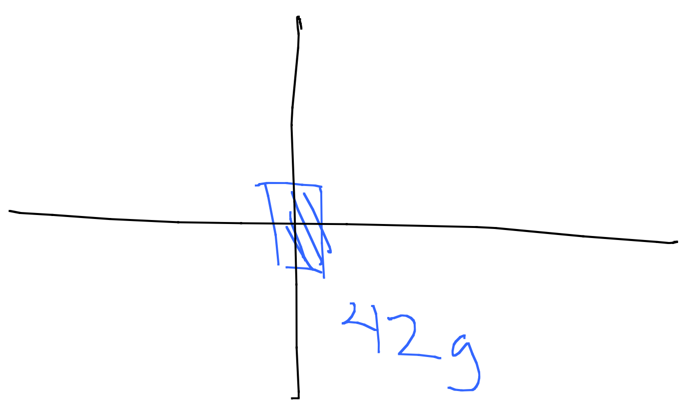
No net $F_{ext,x}$ P_x is conserved

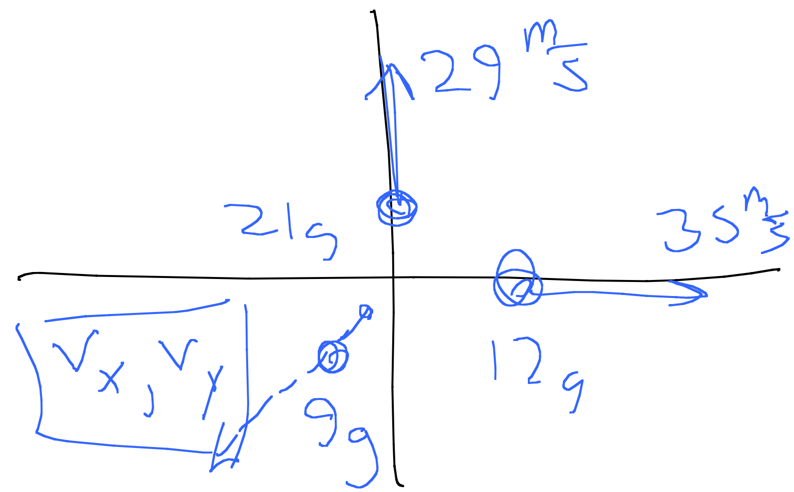
$$P_{x,init} = (8.6\,kg)\left(23\,\frac{km}{h}\right)$$

$$= P_{x,final} = (23.6\,kg)\,V_x$$

$$\boxed{V_x = 8.38\,\frac{km}{h}}$$

9.47 A 42 g firecracker is at rest at origin, explodes into 3 pieces. First mass 12 g move along x-axis at 35 $\frac{m}{s}$. Second mass 21 g moves along y axis at 29 $\frac{m}{s}$. Find velocity of 3rd piece.





x-momentum $\qquad P_{x,i} = P_{x,f}$

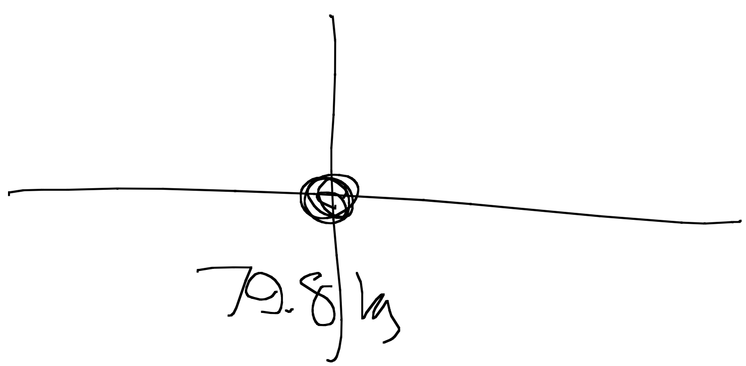
$$0 = (12g)(35\,\tfrac{m}{s}) + (9g)v_x$$

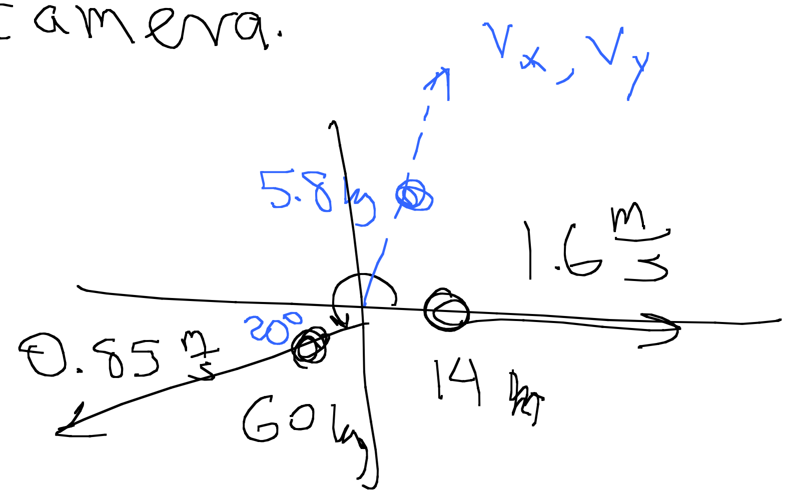
$$v_x = -46.7\,\tfrac{m}{s}$$

$$0 = (21g)(29\,\tfrac{m}{s}) + (9g)v_y$$

$$v_y = -67.7\,\tfrac{m}{s}$$

9.48 60 kg astronaut floating in space tosses 14 kg tank & 5.8 kg camera. Tank moves in x direction at 1.6 $\frac{m}{s}$. Astronaut recoils at 200° from x axis at 0.85 $\frac{m}{s}$. Find velocity of camera.





x-mom is conserved:

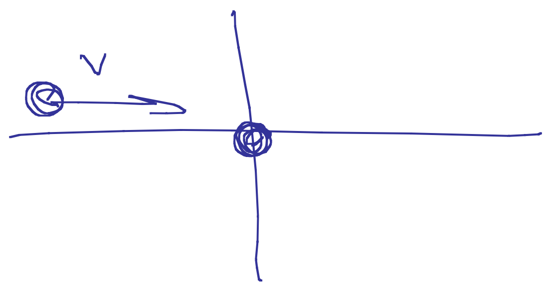
$$P_{x,i} = 0 = P_{x,f} = (14\,kg)(1.6\,\tfrac{m}{s}) + (60\,kg)(0.85\,\tfrac{m}{s})(-\cos 20^\circ) + (5.8\,kg)\,V_x$$

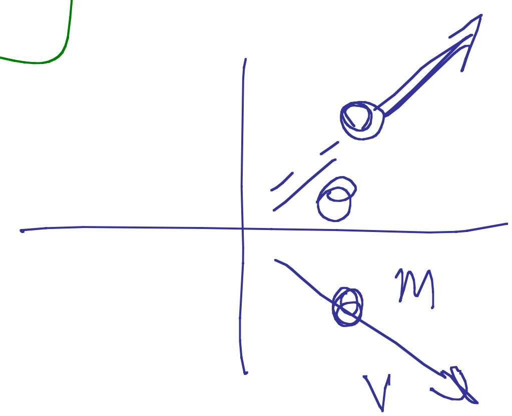
etc.

for y direction

$$\boxed{V_x = 4.4\,\tfrac{m}{s} \qquad V_y = 3.01\,\tfrac{m}{s}}$$

Explosions





9.29 Two identical trucks have mass 5500 kg when empty. One truck carries 9500 kg load & moves $65 \frac{km}{h}$. Collides inelastically w/ second truck init. at rest. Pair moves off at $40 \frac{km}{hr}$. Find load in second truck

5500
$+9500$
$= 15000$

Momentum is conserved

$$(1500\,\text{kg})\left(65\,\frac{\text{km}}{\text{hr}}\right) = (1500 + 5500 + M)\left(40\,\frac{\text{km}}{\text{h}}\right)$$

In each of these

mom conserved (not nec energy)

$$K_i = \sum_i \frac{1}{2} m_i v_{i,\,\text{init}}^2 \neq K_f = \sum_i \frac{1}{2} m_i v_{i\,\text{final}}^2$$

but... discuss energy

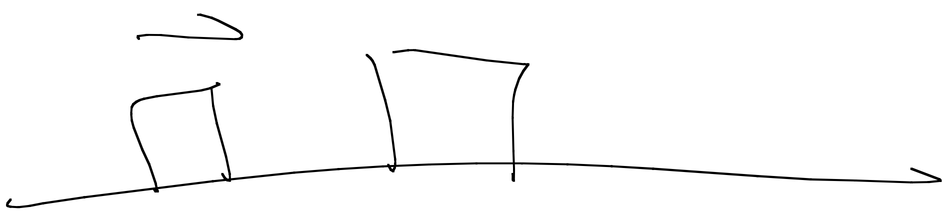
Wolfson show $K_i = \sum \frac{1}{2} m_i v_i^2 = \frac{1}{2} M v_{cm}^2 + \frac{1}{2} \sum m_i v_{i\,\text{rel}}^2$

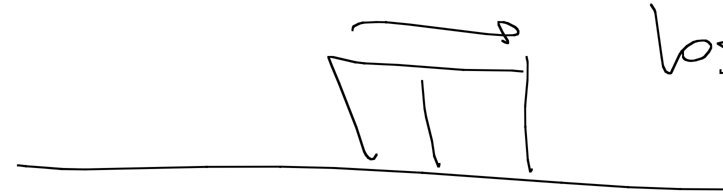
$\vec{v}_{rel}$ = velocity rel to cm

$$\vec{v} = \vec{V}_{cm} + \vec{v}_{rel}$$

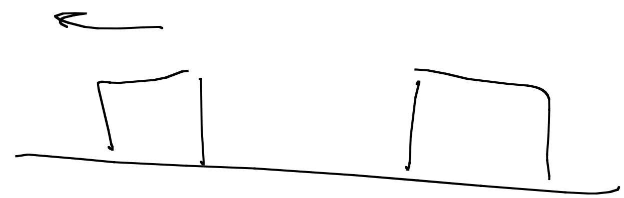
Energy in collision

Lots of KE lost





springy things



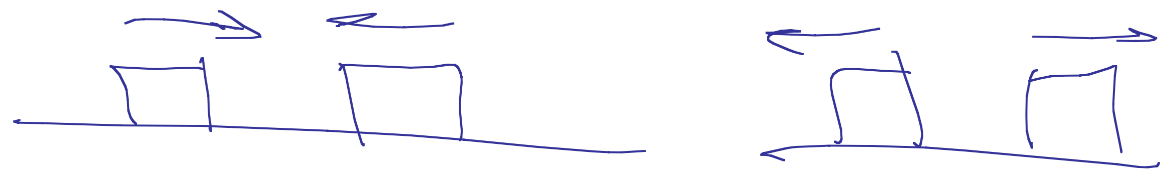
Very nearly all energy is conserved.

Energy conserved: Elastic collision.

Energy not conserved: Inelastic collision

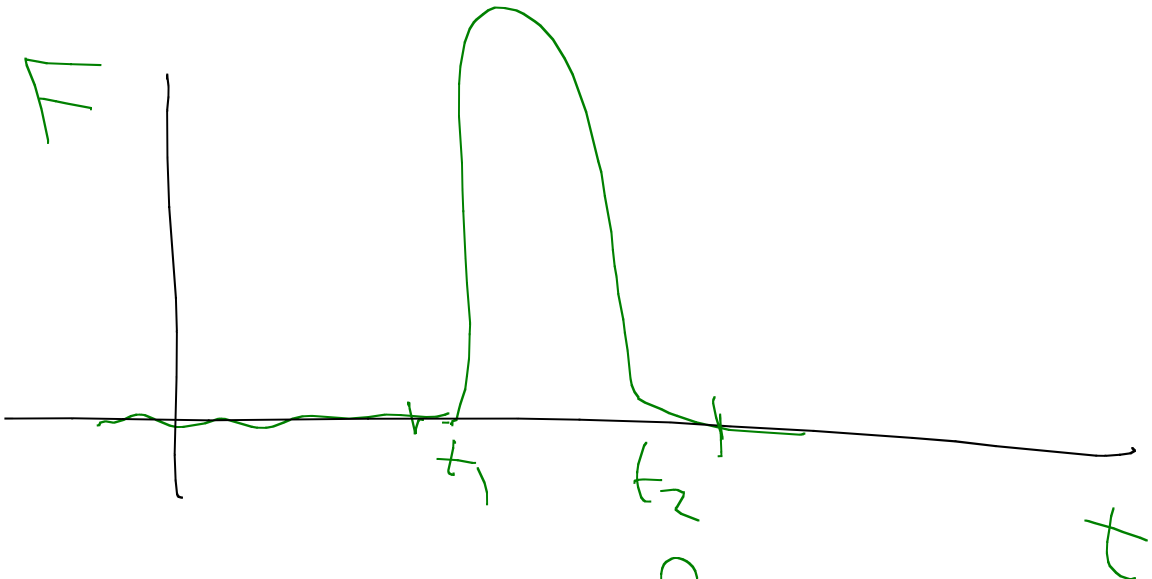
Totally inelastic: Stick.

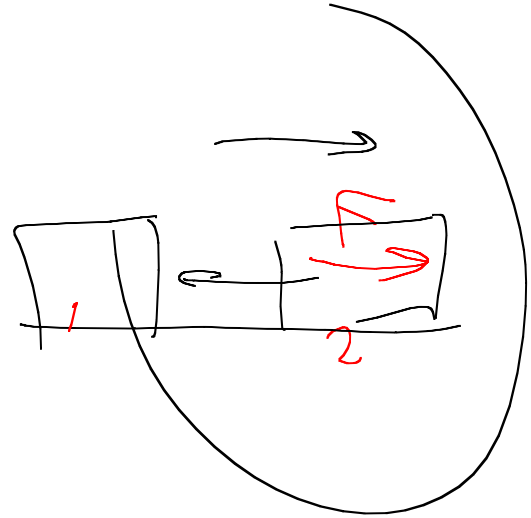
Impulse



$\vec{J} = \Delta\vec{p}$ change in momentum

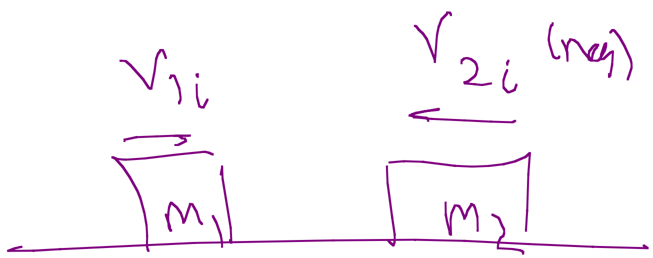
$$\vec{F}_{net} = d\vec{p}/dt = m\frac{d\vec{v}}{dt} = m\vec{a} \qquad \Delta\vec{p} = \int_{t_1}^{t_2} \vec{F}\,dt$$

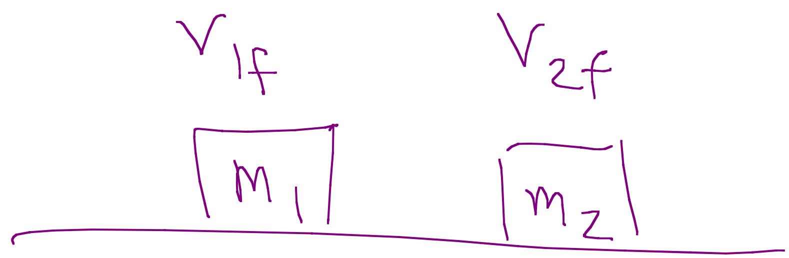




$$\Delta p_2 = \int F\,dt = \text{impulse.}$$

Elastic collision in 1 Dim





Elastic Collision

get conditions on final velocities