Momentum: $\vec{p} = m\vec{v}$

$p_x = m v_x$

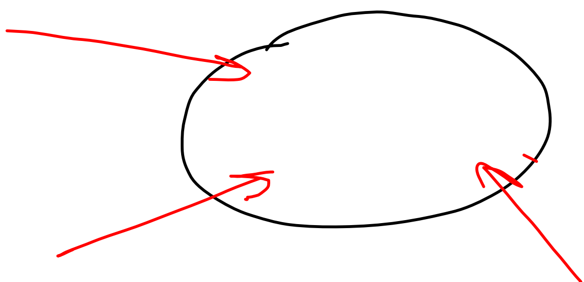
$p_y = m v_y$

Chap 9

Theorems

Systems of particles

$\vec{R} = \frac{1}{M} \sum m_i \vec{r}_i$



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

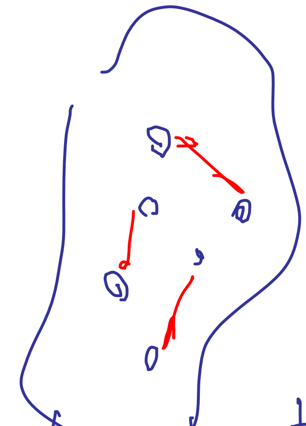
Also: $\vec{F}_{\substack{net\\ext}} = \frac{d\vec{P}}{dt} = M\vec{a}_{cm}$

Special case

$\vec{F}_{net\ ext.} = 0$

$\vec{P} = \sum m_i \vec{v}$

$= \sum p_i$



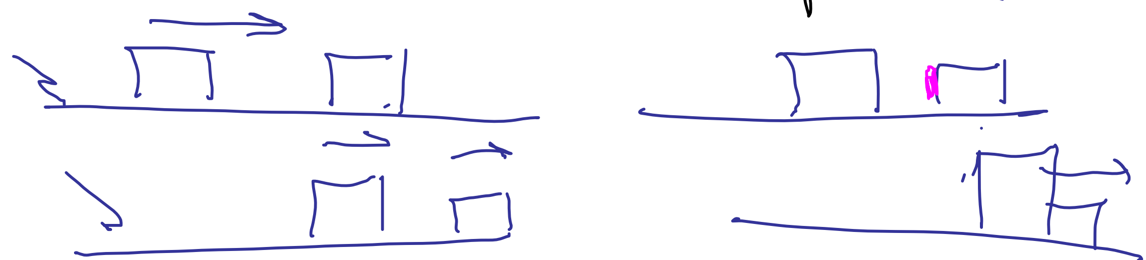
No net ext force

Isolated

$\Rightarrow \vec{P}$ is const

Same total moment before & after

Collisions

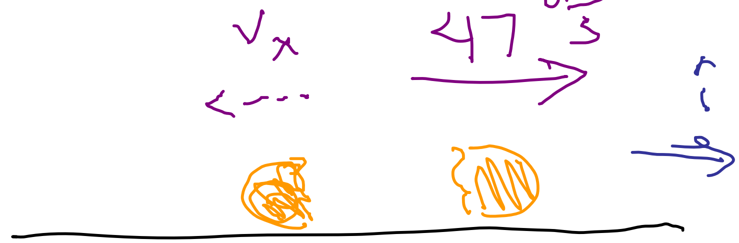


9.17 A popcorn kernel at rest in a hot pan bursts into two pieces with masses 91 mg and 64 mg. More massive piece moves horizontally at 47 $\frac{cm}{s}$. Describe motion of other piece.

$P = \text{const}$

155 mg

$P = mv_x = 0$



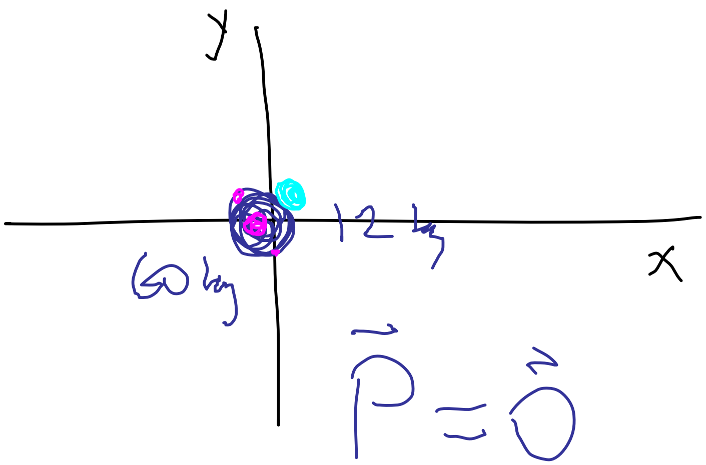
64 mg 91 mg

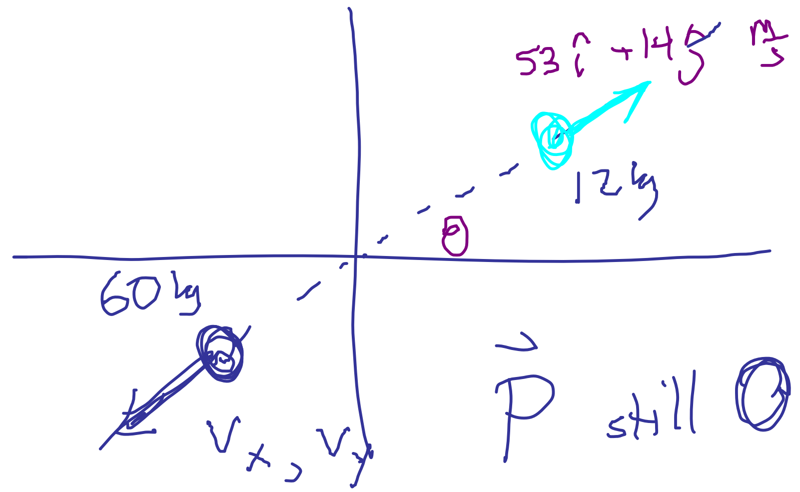
p const

$$P = (64\text{ mg})V_x + (91\text{ mg})\,47\ \frac{cm}{s} = 0$$

Solve for v_x $\quad V_x = -67\ \frac{cm}{s}\ \hat{i}$

9.18 A 60 kg skater at rest on fric'less ice tosses 12 kg snowball with velocity $\vec{v} = (53.0\,\hat{i} + 14.0\,\hat{j})\,\frac{m}{s}$ where x & y are in horiz plane. Find skater's subsequent velocity





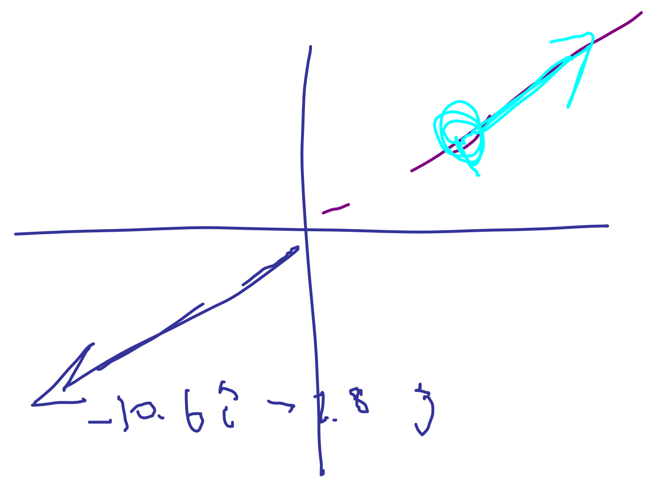
P_x, P_y sep'ly conserved

$$P_x = (60\,kg)V_x + (12\,kg)\,53\,\tfrac{m}{s} = 0$$

$$V_x = -10.6\,\tfrac{m}{s}$$

$$P_y = (60\,kg)V_y + (12\,kg)\,14\,\tfrac{m}{s} = 0$$

$$V_y = -2.8\,\tfrac{m}{s}$$



9.20 A toboggan of mass 8.6 kg is moving horizontally at 23 km/h. As it passes under free 15 kg of snow drop onto it. Find subs. speed.

$P_x =$

$(8.6\,\text{kg})(23\,\frac{\text{km}}{\text{hr}})$
$= (23.6\,\text{kg})V_x$

No ext horiz force

Ext vertical

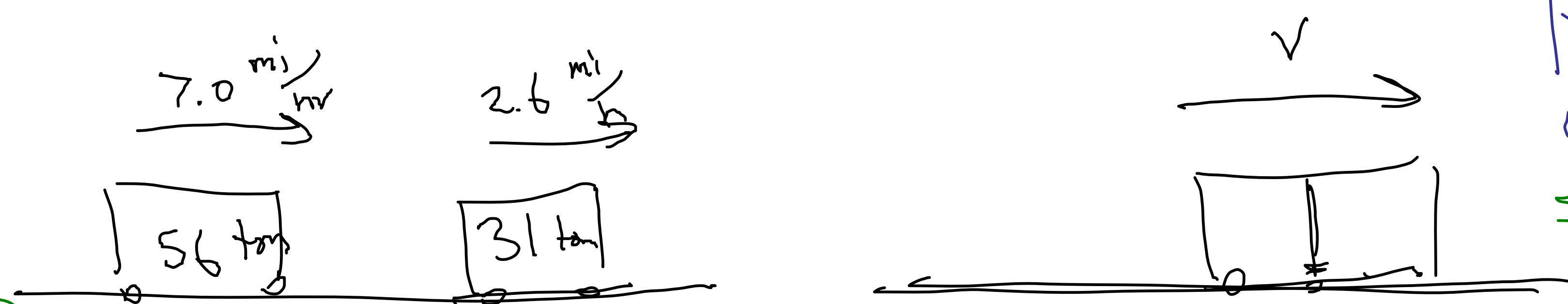
$$\boxed{P_x = \text{const}}$$

Ans: $V_x = 8.4\,\frac{\text{km}}{\text{hr}}$

9.26 In a railroad switchyard, 56-ton freight car sent at $7.0\,\frac{mi}{h}$ toward 31-ton car moving in same dir. at $2.6\,\frac{mi}{h}$. Stick together

a) Speed of cars after couple

b) What frac of initial KE was lost?



P is cons'd

Solve for V_x

$$P_\alpha = (56\,\text{ton})(7.0\,\tfrac{mi}{hr}) + (31\,\text{ton})(2.6\,\tfrac{mi}{hr}) = (87\,\text{ton})V_x \qquad V_f = 5.4\,\tfrac{mi}{hr}$$

b) Frac of init KE lost?

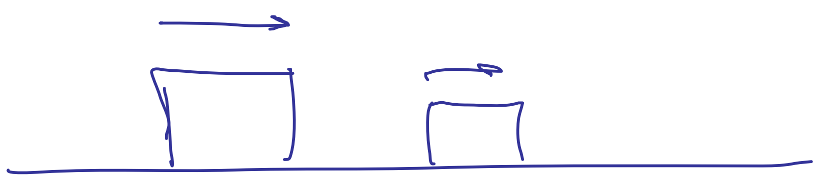
$$K_f = \frac{1}{2}(87\ \text{ton})\left(5.4\ \frac{mi}{hr}\right)^2$$

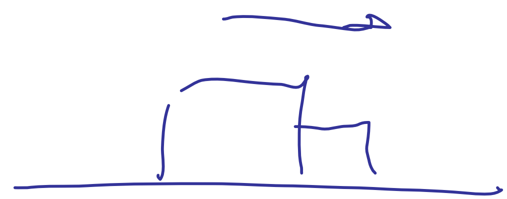
$$K_i = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$$

amount lost

units cancel

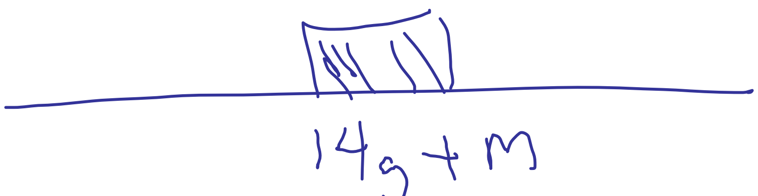
$$\text{frac} = \frac{K_i - K_f}{K_i} = 13\%$$





9.42 A firecracker initially at rest explodes into two pieces. The first, 14g moves in +x dir at $48\frac{m}{s}$. Second moves at $32\frac{m}{s}$. Find second fragment mass.

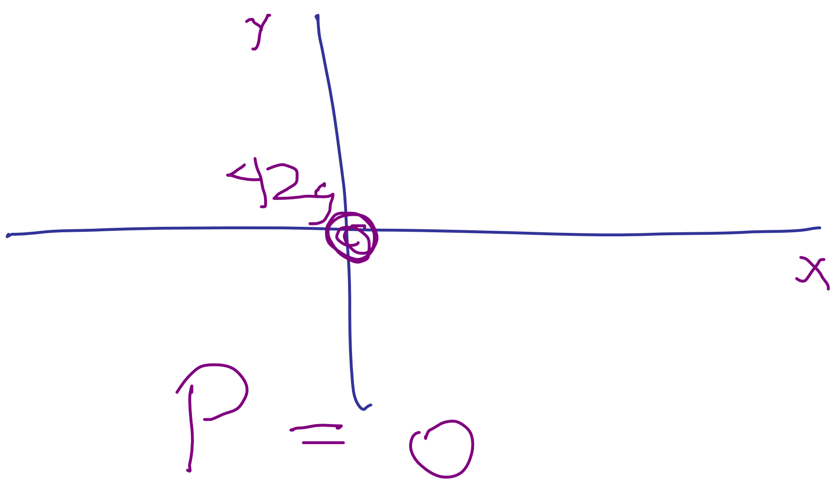
$m = 21g$

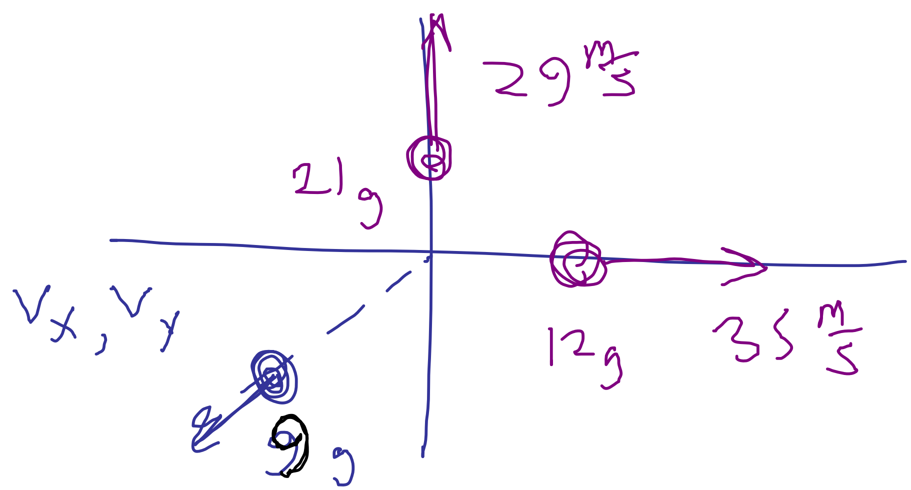


$$P = \text{const} = 0 = m\left(-32\frac{m}{s}\right) + (14g)\left(48\frac{m}{s}\right)$$

9.50 42 g firecracker at rest at origin explodes into 3 pieces. First, mass 12 g moves 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.





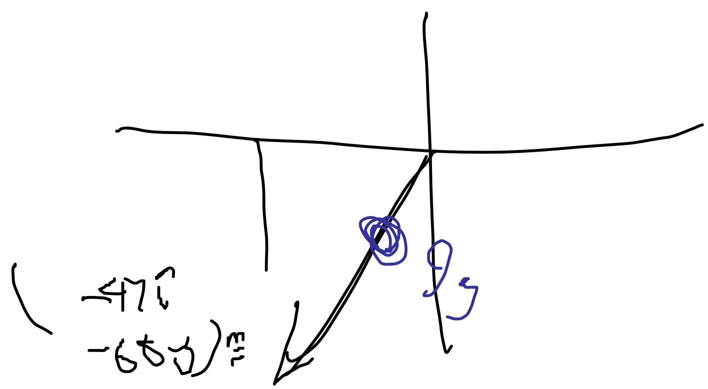
$\vec{P}$ cont'd

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

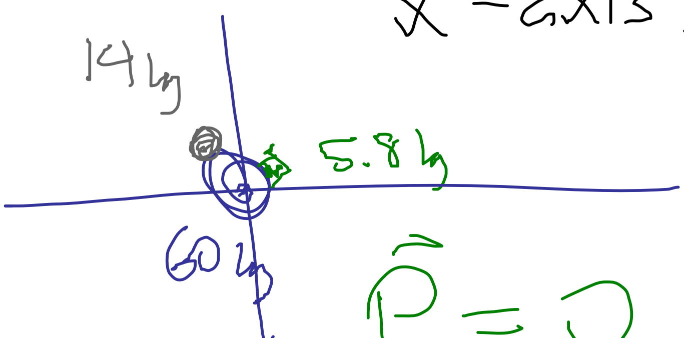
$$v_x = -47\,\tfrac{m}{s}$$

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

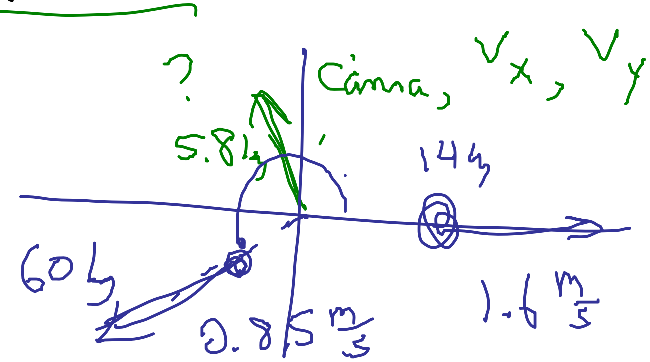
$$v_y = -68\,\tfrac{m}{s}$$



9.51 A 60 kg astronaut floating, tosses 14 kg oxygen tank and 5.8 kg camera. Tank moves in x-dir at 1.6 $\frac{m}{s}$ Astronaut recoils at 0.85 $\frac{m}{s}$ in direction 200° ccw from x-axis. Find camera velocity.



$$\vec{P} = 0$$



$$\boxed{\text{Conserve } P_x, P_y}$$

~~Get~~

$$\vec{V}_{car} = (4.4 \tfrac{m}{s})\hat{i} + (3.0 \tfrac{m}{s})\hat{j}$$

?