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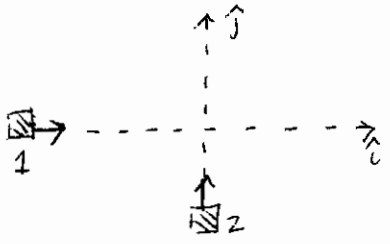
Quiz 3, Feb. 12



Given.

$m_1 = 400\ kg$ $\quad$ $m_2 = 750\ kg$

$v_1 = 15\ m/s$ $\quad$ $v_2 = 10\ m/s$

direction: W to E, ∥ to $\hat{i}$ $\quad$ direction: S to N, ∥ to $\hat{j}$

a.) Determine momentum vectors, $\vec{p}_1$ and $\vec{p}_2$, before collision

Car 1 has velocity solely in the $\hat{i}$ direction. Thus $\vec{p} = m\vec{v}$ determines its momentum to be

$$\vec{p}_1 = m_1\vec{v}_1 = (400\,kg)(15\,m/s)\,\hat{i}$$

$$\boxed{\vec{p}_1 = 6000\ kg\ \tfrac{m}{s}\ \hat{i}}$$

Similarly, car 2 moves only parallel to the $\hat{j}$ direction so

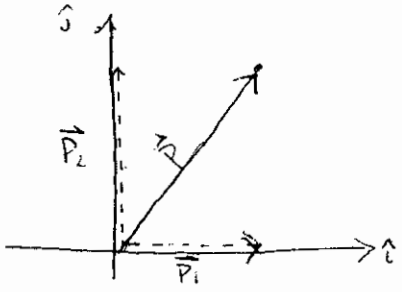
$$\vec{p}_2 = m_2\vec{v}_2 = (750\,kg)(10\,m/s)\,\hat{j}$$

$$\boxed{\vec{p}_2 = 7500\ kg\ \tfrac{m}{s}\ \hat{j}}$$

b) Determine the total initial momentum: $\vec{P} = \vec{p}_1 + \vec{p}_2$

By properties of vector addition,

$$\vec{P} = [(p_1)_i + (p_2)_i]\,\hat{i} + [(p_1)_j + (p_2)_j]\,\hat{j}$$
$$= (6000\ kg\ \tfrac{m}{s})\,\hat{i} + (7500\ kg\ \tfrac{m}{s})\,\hat{j}$$



$\hat{i}$ - component: $\boxed{(\vec{P})_i = 6000\ kg\ \tfrac{m}{s}}$

$\hat{j}$ - component: $\boxed{(\vec{P})_j = 7500\ kg\ \tfrac{m}{s}}$

The magnitude of $\vec{P}$ is determined by Pythagorean Thm:

$$|P|^2 = (\vec{P}_i)^2 + (\vec{P}_j)^2$$

$$|P| = \sqrt{(6000\ kg\ m/s)^2 + (7500\ kg\ m/s)^2}$$

$$\boxed{|P| = 9605\ kg\ m/s}$$

c.) After the collision, the cars "stick" together and move with velocity $\vec{u}$. If the ground is frictionless, what is vector u?

The final momentum of the cars is

$$\vec{P}_f = (m_1+m_2)\vec{U} = (m_1+m_2)[(\vec{U})_i\,\hat{i} + (\vec{U})_j\,\hat{j}]$$

because the masses now move as one body at velocity $\vec{U}$. By conservation of momentum, initial and final momenta must be equal. So

$$\vec{P}_{initial} = \vec{P}_f.$$

Using our solution from part (b) and final momentum above, this requires $\hat{i}$ and $\hat{j}$ components to satisfy

$\hat{i}$: $(P_{initial})_i = (P_{final})_i \Rightarrow 6000\ kg\frac{m}{s} = (400+750\ kg)\cdot U_i$

$$\boxed{U_i = 5.22\ m/s\ \hat{i}}$$

$\hat{j}$: $(P_{initial})_j = (P_{final})_j \Rightarrow 7500\ kg\frac{m}{s} = (400+750\ kg)\,U_j$

$$\boxed{U_j = 6.52\ m/s\ \hat{j}}$$

Finally, by Pythagorean's Thm we again find the magnitude to be

$$|U| = \sqrt{U_i^2 + U_j^2}$$

$$= \sqrt{(5.22\frac{m}{s})^2 + (6.52\frac{m}{s})^2}$$

$$\boxed{|u| = 8.35\ m/s}$$

Point Breakdown

a) Know $\vec{p} = m\vec{v}$	20
Correctly find $\vec{p}_1$	7.5
Correctly find $\vec{p}_2$	7.5
include vector notation	10
b) Find (P_i) - $\hat{i}^{th}$ component	7.5
Find (P_j) - $\hat{j}^{th}$ component	7.5
Magnitude $\lvert\vec{P}\rvert = \sqrt{(P_i)^2 + (P_j)^2}$	5
c) $\vec{P} = (m_1+m_2)\vec{U}$ for inelastic	10
Find $\hat{i}^{th}$ velocity component, U_i	7.5
" $\hat{j}^{th}$ "	7.5
Magnitude $\lvert\vec{U}\rvert = \sqrt{(U_i)^2 + (U_j)^2}$	5

+10 points for units