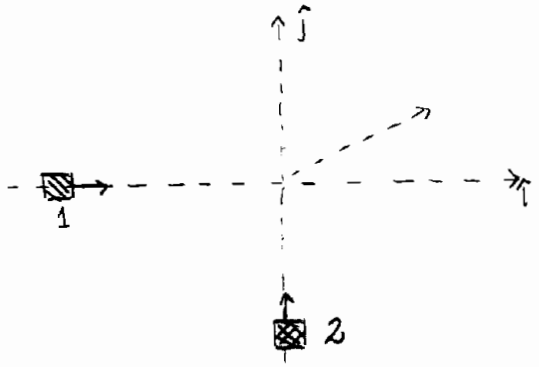
Quiz # 4 : Feb. 25, 2009

Kristen Basiaga



Given:

$m_1 = 400\ kg$ $\quad v_{1i} = 15\ m/s\ \hat{i}$

$m_2 = 750\ kg$ $\quad v_{2i} = 10\ m/s\ \hat{j}$

$\vec{P}_i = 6000\ kg\frac{m}{s}\hat{i} + 7500\ kg\frac{m}{s}\hat{j}$

$U_f = 5.217\ m/s\ \hat{i} + 6.522\ m/s\ \hat{j}$

$\Delta t = 0.16\ s$

a) Determine the force that car 1 applied to car 2 ($F_{1\to 2}$) during the 0.16s collision

Equation 4.2 gives: $\boxed{\vec{F}_{net} = \frac{d\vec{P}}{dt}} = \frac{d\vec{P}_1}{dt} + \frac{d\vec{P}_2}{dt}$

Since the force applied by car 1 is the only force that acts on car 2, we see

$$\vec{F}_{1\to 2} = \frac{d\vec{P}_2}{dt} = \frac{\vec{P}_{2f} - \vec{P}_{2i}}{\Delta t}$$

$$\vec{F}_{1\to 2} = \frac{(750\ kg)(5.217\ m/s\ \hat{i} + 6.522\ \hat{j}) - (750\ kg)(10\ m/s\ \hat{j})}{0.16\ s}$$

$$\boxed{\vec{F}_{1\to 2} = (2.45\times 10^4\ N)\hat{i} - (1.63\times 10^4\ N)\hat{j}}$$

The answer makes sense b/c clearly car 2 starts with no $\hat{i}$-component velocity but has gained some through the collision. Further, it has less velocity in the $\hat{j}$-direction after the collision, which explains the (−) sign on the $\hat{j}$-component. The magnitude is

$$|\vec{F}_{1\to 2}| = \sqrt{(2.45\times 10^4\ N)^2 + (-1.63\times 10^4\ N)^2}$$

$$\boxed{|\vec{F}_{1\to 2}| = 2.94\times 10^4\ N}$$

b) Discuss WHY total momentum $\vec{P}$ was the same before + after the collision.

Momentum is conserved during this collision because it occurs in a system closed to external forces. Therefore, the only forces are internal forces such that

$$\vec{F}_{net} = \frac{d\vec{P}}{dt} = 0$$

Since $\frac{dp}{dt} = 0$, the total momentum must be constant with respect to time. Thus, total momentum is conserved.

Quiz 4: Point Breakdown

a)
- Force-momentum relation, $\vec{F} = \frac{d\vec{p}}{dt}$ — 5 pts
- $\vec{F}_{1\to 2}$ must change $\vec{p}_2$, $\vec{F}_{1\to 2} = \frac{d\vec{p}_2}{dt}$
- Recall/Recalculate $\vec{p}_{2i}$
- Find $\vec{p}_{2f} = m_2 \vec{v}_f$
- Determine $\hat{i}$ component of force
- " $\hat{j}$ "
- Magnitude w/ Pythagorean Thm
- Units of Newtons — 5 pts

$(\times 8) = 40$ pts.

b) Question asked "WHY" is momentum conserved. If you answered:
- because of momentum conservation, you did not answer the question
- by describing what may have happened, you did not explain why it did
- because of conservation of energy, force, or velocity, this is fundamentally incorrect

} 0/10

- because it was an inelastic collision, momentum is not conserved for all inelastic
- correctly: because the system is closed to external forces, 10/10 pts
- partially-correct: gave correct answer but then showed misunderstandings 5/10 pts