AP Physics - Momentum - 2D Collisions

Note Title 10/23/2007

By this point, it should be easy to solve 1-D conservation of momentum problems, where the general equation $\vec{P}_{before} = \vec{P}_{after}$ becomes, for two objects:

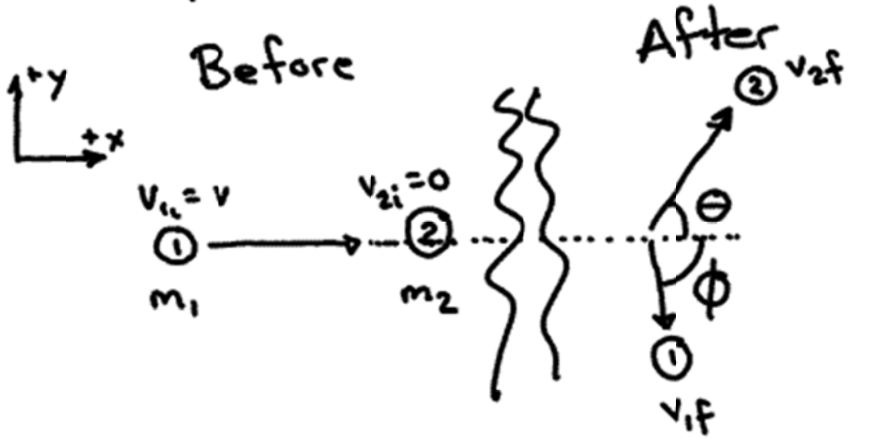
$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$$

But how do we deal with situations where the objects don't hit each other "straight-on." This situation is called "glancing collisions."

Glancing Collisions

We know from before that conservation of momentum is always true, assuming there is no external force on the system. In two or three dimensions, this means that the sum of all the vector components in the x and y (or x, y, and z for 3-D) before the collision equals the sum of those same components after the collision.

Example: 2 balls of uneven mass collide



θ: Angle at which ball 2 leaves

ϕ = Angle at which ball 1 leaves

	Before P_x	Before P_y	After P_x	After P_y
1	$m_1 v_i$	0	$m_1 v_{1f} \cos\phi$	$-m_1 v_{1f} \sin\phi$
2	0	0	$m_2 v_{2f} \cos\theta$	$m_2 v_{2f} \sin\theta$
ΣP	$m_1 v_i$	0	$m_1 v_{1f} \cos\phi + m_2 v_{2f} \sin\theta$	$-m_1 v_{1f} \sin\phi + m_2 v_{2f} \sin\theta$

$$\Sigma P_{x\,before} = \Sigma P_{x\,after}$$

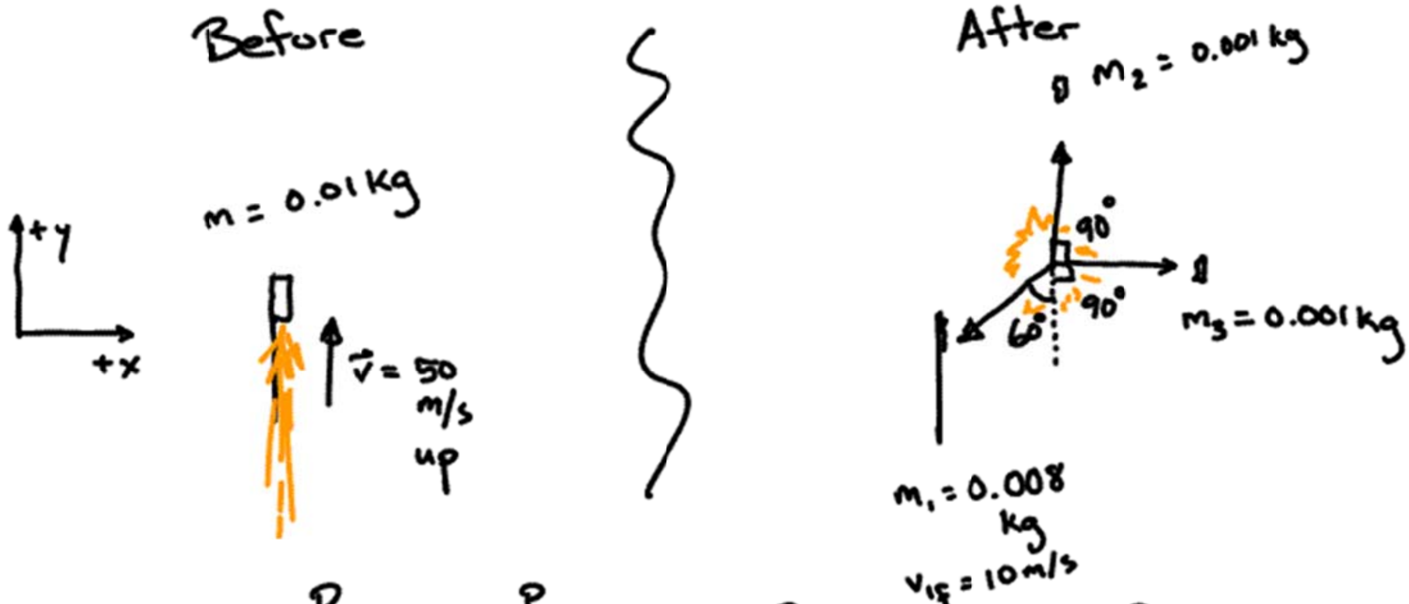
$$m_1 v_{1i} = m_1 v_{1f} \cos\phi + m_2 v_{2f} \cos\theta$$

$$\Sigma P_{y\,before} = \Sigma P_{y\,after}$$

$$0 = -m_1 v_{1f} \sin\phi + m_2 v_{2f} \sin\theta$$

Note that in two dimensions, you will usually have 2 equations and 2 unknowns. $\longrightarrow$ Use substitution!

Example: A bottle rocket, while flying straight up, explodes into 3 pieces. Find the velocity of piece #3.



	Before P_x	Before P_y	After P_x	After P_y
1	X	X	$-(0.008)(10)\sin 60°$ $-0.069\ \frac{kg\,m}{s}$	$-(0.008)v_1\cos 60°$ $-0.04\ \frac{kg\,m}{s}$
2	X	X	0	$0.001 v_2$
3	X	X	$0.001 v_3$	0
ΣP	0	$mv = 0.5\ \frac{kg\,m}{s}$	$0.001 v_3 - 0.069$	$0.001 v_2 - 0.04$

We can find the answer by setting $\Sigma P_{x\,before} = \Sigma P_{x\,after}$

$$0 = 0.001 v_3 - 0.069$$

$$\boxed{v_3 = 69.3 \text{ m/s in the +x direction!}}$$