Name: _____ Phys 12

4.4 Conservation of Momentum in 2D

Recall from last year that momentum *p* is conserved before and after impact. When dealing with collisions that occur in a 2D (*xy*) plane, **momentum *p* is conserved in both the *x* and the *y* direction.**

Key point: the total momentum before and after a collision is the same for both the x and the y direction.

$$x: \quad p_{1i_x} + p_{2i_x} = p_{1f_x} + p_{2f_x}$$
$$y: \quad p_{1i_y} + p_{2i_y} = p_{1f_y} + p_{2f_y}$$

AND

for 2 objects 1 and 2

where *p* is momentum (kg·m/s OR N·s)

Ex. 1: A 750 kg smart car traveling at 21m/s west collides with a 680kg Car2Go traveling at 18m/s South. If the two cars become entwined, what is their total final velocity? (ANS: 14m/s 38° S of W)

$p_{1i} = m_1 v_{1i}$ + $p_{2i} = m_2 v_{2i}$ = $p_f = (m_1 + m_2) v_f$

$p_{1i} = 750(21)$, $p_{2i} = 680(18)$, p_f

$\tan\theta = \frac{p_{2i}}{p_{1i}}$

$\theta = \tan^{-1}\left(\frac{p_{2i}}{p_{1i}}\right) = \frac{680(18)}{750(21)} = 38°$ S of W

$p_f = \sqrt{p_{2i}^2 + p_{1i}^2} = \sqrt{[680(18)]^2 + [750(21)]^2} = 19946.9\ N\cdot s$

$v_f = \frac{19946.9\ N\cdot s}{750 + 680} = 14\ m/s$

Ex. 2: A 4.0 kg bowling ball is moving east at an unknown velocity when it collides with a 6.1 kg frozen cantaloupe at rest. After the collision, the bowling ball is traveling at a velocity of 2.8m/s 32° N of E and the cantaloupe is traveling at a velocity of 1.5m/s 41° S of E. What was the initial velocity of the bowling ball? (ANS: 4.1m/s East)

What are 2 methods to solve this?

Vector addition

$p_i = p_f$

$p_{1i} = p_{1f} + p_{2f}$

$p_{1f} = m_1 v_{1f} = 4(2.8) = 11.2$, $\theta = 32°$

$p_{2f} = m_2 v_{2f} = 6.1(1.5) = 9.15$, $\theta = 180° - 41° - 32° = 107°$

$p_{1i} = \sqrt{p_{1f}^2 + p_{2f}^2 - 2 p_{1f} p_{2f} \cos 107°}$

$= \sqrt{[4(2.8)]^2 + [6.1(1.5)]^2 - 2(4)(2.8)(6.1)(1.5)\cos 107°}$

$= 16.4\ldots\ N\cdot s = p_{1i} = m_1 v_{1i}$

$v_{1i} = \frac{16.4\ldots\ N\cdot s}{4.0\ kg} = 4.1\ m/s$ East

Component method

$x: \quad m_1 v_{1i} = m_1 v_{1f_x} + m_2 v_{2f_x}$

$m_1 v_{1i} = m_1 v_{1f}\cos 32 + m_2 v_{2f}\cos 41$

$v_{1i} = \frac{4(2.8)\cos 32 + 6.1(1.5)\cos 41}{4}$

$= 4.1\ m/s$ East

$y: \quad 0 = m_1 v_{1f_y} + m_2 v_{2f_y}$

Which way was easier? Will this method work ALL the time? If not, when won't it work as well?

Component method will ALWAYS works. Vector addition might be tricky when you have >2 mass involved or >3 momenta to deal with.

HW: Worksheet 4.4 ALL