Homework Solution "Momentum"

1) Problem: If two equal mass billiard balls collide and ball one had an initial velocity of 3.00 m/s find the velocity of ball two if:

A) ball one goes of at 45 degrees with a velocity of 2.13 m/s
B) ball one goes off at 60 degrees with a velocity of 1.5 m/s
C) ball one comes to a stop

1A) Solution: Momentum must be conserved in both the X and Y directions independently. Use the conservation of momentum equations in X and Y components to solve for the final velocity of ball two.

X component

$$P_{1ox} + P_{2ox} = P_{1fx} + P_{2fx}$$
$$mv_{1ox} + 0 = mv_{1fx} + mv_{2fx}$$
$$v_{1ox} = v_{1fx} + v_{2fx}$$
$$v_{1ox} - v_{1fx} = v_{2fx}$$
$$3.00\frac{m}{s} - 2.13\frac{m}{s}Cos45° = 1.49\frac{m}{s} \therefore v_{2fx} = 1.49\frac{m}{s}$$

Y component

$$P_{1oy} + P_{2oy} = P_{1fy} + P_{2fy}$$
$$0 + 0 = mv_{1fy} + mv_{2fy}$$
$$v_{1fy} = -v_{2fy}$$
$$2.13\frac{m}{s}Sin45° = 1.51\frac{m}{s} \therefore v_{2fy} = -1.51\frac{m}{s}$$

Now find the magnitude and direction of the velocity of ball two.

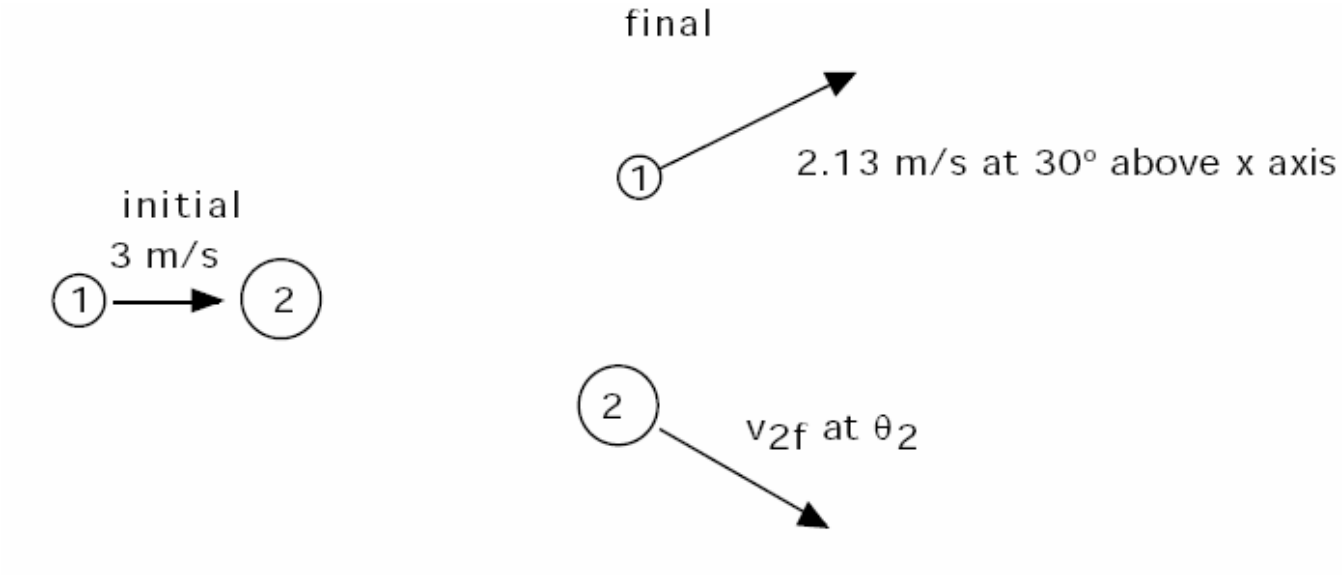
$$\left|v_{2f}\right| = \sqrt{\left(1.49\frac{m}{s}\right)^2 + \left(-1.51\frac{m}{s}\right)^2} = 1.12\frac{m}{s}$$
$$\theta = \boldsymbol{tan}^{-1}\left(\frac{-1.51}{1.49}\right) = -45.4°$$

So ball two has a velocity of 1.12 m/s at 45.4 degrees below the X axis.

1B) Solution: Use the general solution found above, plug in the new values.
Ball two has a velocity of 2.6 m/s at 30 degrees below the X axis.

1C) Solution: Use the general solution found above, plug in the new values or recall what we did in lab. Ball two has a velocity of 3.0 m/s along the X axis.

2) Problem: Two billiard balls collide. Ball two has a mass 2 times that of ball one. Ball one has an initial velocity of 3 m/s. Find the velocity of ball two if ball one goes off with a velocity of 2.13 m/s at an angle of 30 degrees.



2) Solution:

X component

$$P_{1ox} + P_{2ox} = P_{1fx} + P_{2fx}$$
$$mv_{1ox} + 0 = mv_{1fx} + 2mv_{2fx}$$
$$v_{1ox} = v_{1fx} + 2v_{2fx}$$
$$\frac{v_{1ox} - v_{1fx}}{2} = v_{2fx}$$
$$\frac{3.00\frac{m}{s} - 2.13\frac{m}{s}Cos30°}{2} = 0.58\frac{m}{s} \therefore v_{2fx} = 0.58\frac{m}{s}$$

Y component

$$P_{1oy} + P_{2oy} = P_{1fy} + P_{2fy}$$
$$0 + 0 = mv_{1fy} + 2mv_{2fy}$$
$$\frac{v_{1fy}}{2} = -v_{2fy}$$
$$\frac{2.13\frac{m}{s}Sin30°}{2} = 0.53\frac{m}{s} \therefore v_{2fy} = -0.53\frac{m}{s}$$

Now find the magnitude and direction of the velocity of ball two.

$$\left|v_{2f}\right| = \sqrt{\left(0.58\frac{m}{s}\right)^2 + \left(-0.53\frac{m}{s}\right)^2} = 0.79\frac{m}{s}$$
$$\theta = \boldsymbol{tan}^{-1}\left(\frac{-0.53}{0.58}\right) = -41.9°$$

So ball two has a velocity of 0.79 m/s at 41.9 degrees below the X axis.