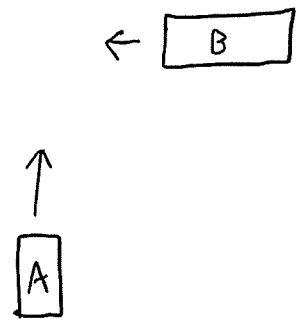
2D Collision Practice Name:_____

1. A 950 kg car (A) travelling North at 21 m/s collides with, and sticks to a 1200 kg car (B) travelling West at 14 m/s.



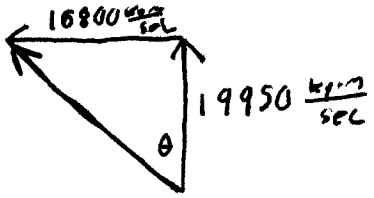
a. What is the momentum of car A before the collision?

$p = mv = 950\text{kg} \times 21\frac{m}{s} = 19\,950\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}$ North

b. What is the momentum of car B before the collision?

$p = mv = 1200\text{kg} \times 14\text{m/s} = 16800\ \frac{\text{kg}\cdot\text{m}}{\text{sec}}$ West

c. What is the total momentum before the collision?
**You have to add the momentums as vectors.



$\sqrt{16800^2 + 19950^2} = 26081\ \text{kg}\cdot\text{m/sec}$

$\tan^{-1}\left(\frac{16800}{19950}\right) = 40°$

26000, 40° West of North

d. What is the total momentum after the collision?

Same as before

e. What is the total mass of the moving object after the collision? $950\text{kg} + 1200\text{kg} = 2150\text{kg}$

f. What is the velocity (magnitude and direction) of the combined cars after the collision?

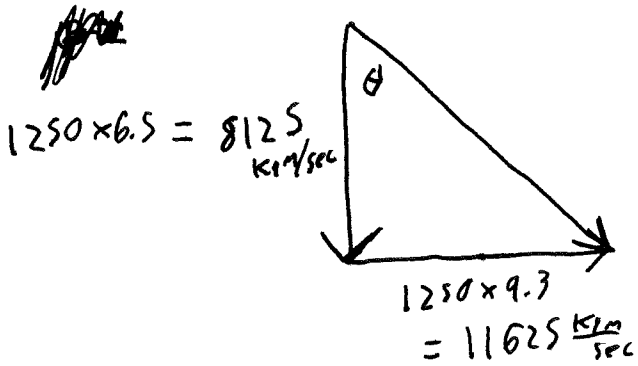
$v = \frac{p}{m} = \frac{26081\ \frac{\text{kg}\cdot\text{m}}{\text{sec}},\ 40° \text{ West of North}}{2150\text{ kg}}$

$=$ 12m/s, 40° West of North

2D Collision Practice Name:_____

2. Two 1250 kg cars collide, Car A was initially travelling at 6.5 m/s South, Car B was initially travelling 9.3 m/s East. After the collision, the cars merge and move together.

a. What is the final velocity of the combined cars?



$1250 \times 6.5 = 8125 \frac{kg\,m}{sec}$

$1250 \times 9.3 = 11625 \frac{kg\,m}{sec}$

$\sqrt{8125^2 + 11625^2} = 14183 \frac{kg\,m}{sec}$ $\quad \tan^{-1}\left(\frac{11625}{8125}\right) = 55^\circ$

momentum is $14183 \frac{kg\,m}{sec}$, 55° East of South

$$v = \frac{14183 \frac{kg\,m}{sec},\ 55^\circ \text{ East of South}}{2500\ kg} = 5.7\ m/s,\ 55^\circ \text{ East of South}$$

b. How much kinetic energy was converted into other forms during the collision?

$$E_k \text{ initial} = \tfrac{1}{2}(1250)(6.5)^2 + \tfrac{1}{2}(1250)(9.3)^2$$

$$= 80462.5\ J$$

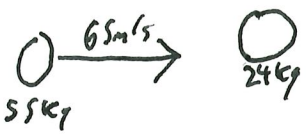
$$E_k \text{ final} = \tfrac{1}{2}(2500)(5.7)^2 = 40612.5\ J$$

$$\Delta E_k = 80462.5\ J - 40612.5\ J = 39850\ J$$

$$\approx 4.0 \times 10^4\ J$$

2D Collision Practice Name:_____

3. A 55 kg ball is moving at 65 m/s to the right when it collides with a stationary 24 kg ball. After the collision, the 24 kg ball is moving at 85 m/s, 18° above the right. What is the final velocity of the 55 kg ball?



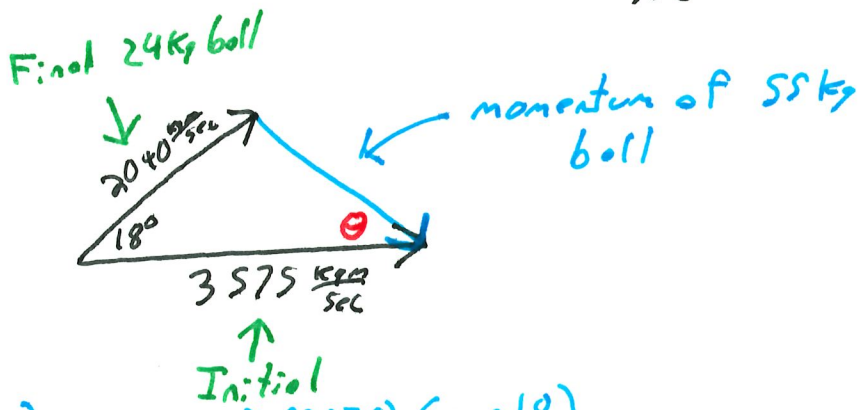
Initial momentum

$p = 55kg \times 65 \frac{m}{s}$

$= 3575 \frac{kg \cdot m}{sec}$ right

24kg ball momentum after collision $= 24kg \times 85 m/s$

$= 2040 \frac{kg \cdot m}{sec}$

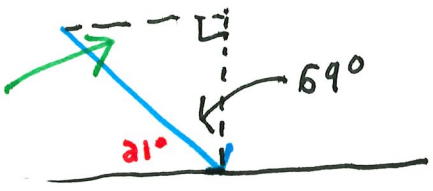


$p_{55}^2 = 2040^2 + 3575^2 - 2(2040)(3575)(\cos 18)$

$p_{55} = 1752 \frac{kg \cdot m}{sec} \rightarrow v = \frac{1752}{55} = 32 m/s$

$\theta = \frac{\sin\theta}{2040} = \frac{\sin 18^\circ}{1752.17}$ $\theta = 21^\circ$

180-90-69 $= 21^\circ$

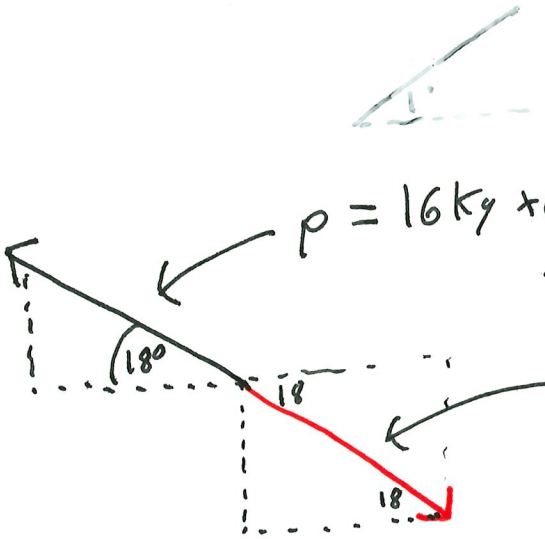


32 m/s, 21° below the right

2D Collision Practice Name:_____

4. A 25 kg bomb explodes into 2 pieces, a 16 kg piece flies away at 65 m/s, 18° North of West. What is the velocity of the other piece after the explosion?

Total momentum is zero



$p = 16\,kg \times 65\,m/s = 1040\ \frac{kg\,m}{sec}$

$p = 1040\ \frac{kg\,m}{sec}$, 18° South of East

To cancel out momentum of one piece the other must have opposite momentum

Mass of other piece = 25 − 16 = 9 kg

$$\text{Velocity} = \frac{1040\ \frac{kg\cdot m}{sec},\ 18°\ South\ of\ East}{9\ kg}$$

$= 115.6\ m/s,\ 18°$ South of East

$\approx 120\ m/s$

2D Collision Practice Name:_____

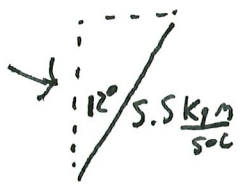
5. A 2.0 kg ball moving due North at 7.0 m/s strikes a stationary 5.0 kg ball. After the collision, the 5.0 kg ball is moving at 1.1 m/s, 12° East of the North. What is the final velocity of the 2.0 kg ball?

Initial momentum is $p = mv = 2.0\text{kg} \times 7.0\text{m/s}$
$= 14 \frac{\text{kgm}}{\text{sec}}$ North

Momentum of 5.0 kg ball after is $5.0\text{kg} \times 1.1\text{m/s}$
$= 5.5 \frac{\text{kgm}}{\text{sec}}$
12° East of North

$\sin 12 \times 5.5 = 1.1435$

$\cos 12 \times 5.5 = 5.3798$



Total North momentum is $14 = 5.3798 + p_x$ of 2kg ball
$\rightarrow 14 - 5.3798 = p_{2x}$
$8.62 = p_{2x}$

Total East/west momentum is zero, so p_{2x} must be $1.1435 \frac{\text{kgm}}{\text{sec}}$ West

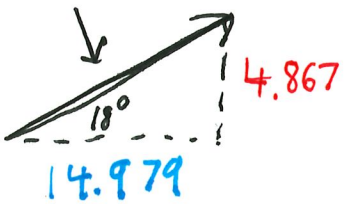
momentum of 2.0 kg block is
$\sqrt{8.62^2 + 1.14^2} = 8.695 \frac{\text{kgm}}{\text{sec}}$,
$\tan^{-1}\left(\frac{1.14}{8.62}\right) = 7.5°$ West of North

$V = 4.3\text{m/s}$, 7.5° East of North

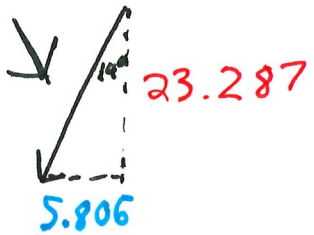
2D Collision Practice Name:_____

6. A 6.3 kg block hits a 7.5 kg block. After the collision, the 6.3 kg block is moving at 2.5 m/s, 18° North of East and the 7.5 kg block is moving at 3.2 m/s, 14° West of South. What was the initial velocity of the 6.3 kg block?

$p_{6.3} = mv = 15.75 \frac{kg \cdot m}{sec}$

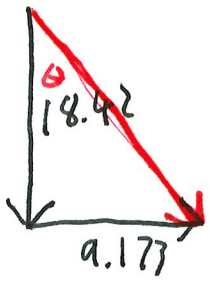


$p_{7.5} = mv = 24 \frac{kg \cdot m}{s}$



Total North/South momentum = 4.867 North + 23.287 South
= 18.42 $\frac{kg \cdot m}{sec}$ South

Total East/West = 14.979 East + 5.806 West
= 9.173 East



Total momentum is $\sqrt{18.42^2 + 9.173^2}$
= 20.58 $\frac{kg \cdot m}{sec}$

$\theta = \tan^{-1}\left(\frac{9.173}{18.42}\right) = 26°$

Initial velocity = $\frac{20.58 \frac{kg \cdot m}{sec}}{6.3\ kg}$ 26° East of South

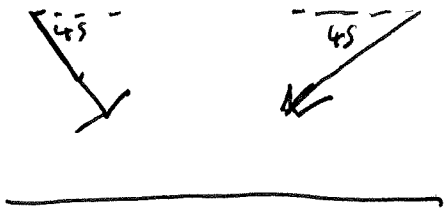
= 3.3 m/s, 26° East of South

2D Collision Practice Name:_____

7. Two cars of equal mass collide, one was travelling due North the other due West. After the collision, the cars combine and move in the direction 32° North of West. Which car was travelling faster before the collision?

Since they are moving more West than North, the West car must have been faster.

8. Two particles with the same magnitude of momentum, one moving at 45° below the left, the other moving at 45° below the right collide, give TWO different possible results of the collision in which momentum in conserved.

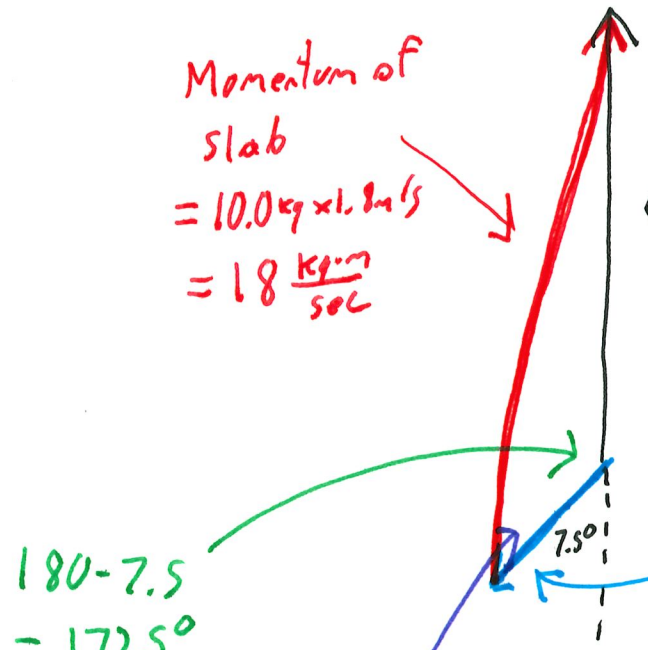


If they stick together horizontal velocities cancel out and they move straight down

2D Collision Practice Name:_____

9. A 0.041 kg bullet is fired at 320 m/s and hits a stationary 10.0 kg slab of metal. The bullet ricochets back at an angle of 7.5° off its original path, the slab of metal moves at 1.8 m/s after the collision. What is the speed of the bullet after the collision?

Momentum of bullet before collision is equal to momentum of bullet after plus momentum of metal after



Momentum of slab
$= 10.0\,kg \times 1.8\,m/s$
$= 18\ \frac{kg \cdot m}{sec}$

Momentum of bullet before collision
$= mv = 0.041\,kg \times 320\,m/s$
$= 13.12\ \frac{kg \cdot m}{sec}$

$180 - 7.5$
$= 172.5°$

momentum of bullet after collision

Use sine law to find this angle

$\frac{\sin\theta}{13.12} = \frac{\sin 172.5}{18}$

$\theta = 5.459$

Now we know angle opposite side of find bullet momentum is $180 - 172.5 - 5.459 = 2.04°$ Use sine law to find side

$\frac{x}{\sin 2.041} = \frac{18}{\sin 172.5} \rightarrow x = 4.911\ \frac{kg \cdot m}{sec}$ speed $= \frac{4.911}{0.041}$

$= 120\,m/s$