GreatHearts Irving

Remote Learning Packet

NB: Please keep all work produced this week. Details regarding how to turn in this work will be forthcoming.

April 13-17, 2020

Course: 11 Physics
Teacher: Miss Weisse natalie.weisse@greatheartsirving.org
Resource: *Miss Weisse's Own Physics Textbook* — new pages found at the end of this packet

Weekly Plan:

Monday, April 13
- ☐ Read & Understand Notes on the Conservation of Momentum in Two-Dimension (pages 31-38)
- ☐ Complete Unit 8 Worksheet 4 Problems #1-2
- ☐ Email Miss Weisse with Questions & to Get Solutions!

Tuesday, April 14
- ☐ Reread & Understand Notes on the Conservation of Momentum in Two-Dimension (pages 31-38)
- ☐ Complete Unit 8 Worksheet 4 Problems #3-5
- ☐ Email Miss Weisse with Questions & to Get Solutions!

Wednesday, April 15 *and* Thursday, April 16
- ☐ Complete Unit 8 Worksheet 5 Problems #1-6
- ☐ Email Miss Weisse with Questions & to Get Solutions!

Friday, April 17
- ☐ Review All Momentum Notes (pages 1-38)
- ☐ Complete Momentum "Quiz 2"

Statement of Academic Honesty

I affirm that the work completed from the packet is mine and that I completed it independently.

____
Student Signature

I affirm that, to the best of my knowledge, my child completed this work independently

____
Parent Signature

Monday, April 13

- ➔ Read Pages 31-38 of *Miss Weisse's Own Physics Textbook*
  - ◆ *Have a piece of paper out and work through each example problem as you read the notes. This will help your understanding so much more than just reading through my math.*

- ➔ Complete the following problems on a sheet of paper with a full heading — Unit 8 Worksheet 4

1. A 2.0 kg ball, A, is moving with a velocity of 5.0 m/s due east. It collides with a stationary ball, B, with a mass of 3.0 kg. After the collision, ball A moves off at 3.0 m/s 30^{o} south east. Find the final velocity of ball B.

2. A 0.7 kg block, initially at rest on a frozen, frictionless surface, is struck by a 0.4 kg mass that is initially moving in the positive x-direction with a speed of 3 m/s. After the collision, the 0.4 kg mass has a velocity of 1 m/s, 32^{o} above the positive x-axis. Find the velocity of the 0.7 kg block after the collision.

Tuesday, April 14

- ➔ Reread Pages 31-38 of *Miss Weisse's Own Physics Textbook.*

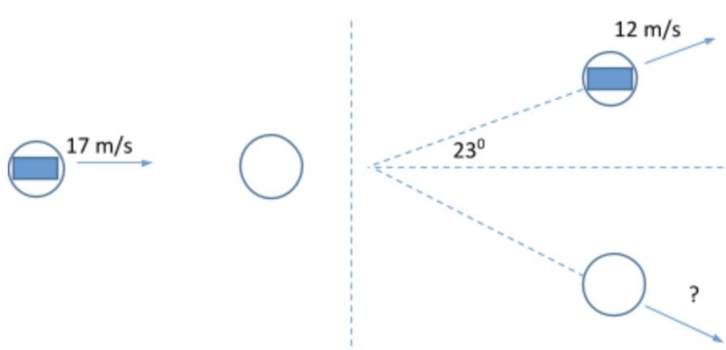
- ➔ If you haven't already, email Miss Weisse for yesterday's solutions so you can check your work before attempting more problems of the same type.

- ➔ Complete the following problems on the same sheet as yesterday — Unit 8 Worksheet 4

3. A hockey player (m = 70 kg) traveling at 5 m/s to the right collides with his opponent (m = 75 kg) traveling at 1 m/s in the same direction. Surprised by the collision, the opponent travels at a speed of 4 m/s 15^{o} north of his original path. At what speed does the 70 kg hockey player travel after he slams into his opponent?

4. Deciding you're going to take physics labs into your own hands, you find two bowling balls (10kg and 6 kg) and a frictionless surface (at home, of course, because that's the only place you are allowed to be). You roll the two balls toward each other, the 10 kg ball moving at 4 m/s to the right and the 6 kg ball moving 8 m/s to the left. When the two bowling balls collide, the 10 kg ball recoils so it is traveling south west at an angle of 60^{o} below the horizontal, and the 6 kg ball recoils so it is traveling north east at an angle of 30 degrees above the horizontal. What is the final velocity of each bowling ball?

5. A 2 kg striped ball moving to the right at 17 m/s strikes a stationary 3 kg cue ball. If the final velocity of the striped ball is 12 m/s at 23.0° above the horizontal, determine the final velocity of the cue ball.



Wednesday, April 15 *and* Thursday, April 16

➔ Complete the following problems on a sheet of paper with a full heading — Unit 8 Worksheet 5

Directions: For the following problems, the cue ball has a mass of 3 kg and any regular billiards ball has a mass of 2 kg.

1. Charlie hits the cue ball so that it travels with a speed of 3 m/s toward the solid billiard ball sitting on the table. After the balls collide the cue ball has no velocity. What is the velocity of the solid ball?

2. Nick, Charlie's opponent in this game of pool, hits the cue ball so that it travels with a speed of 2.5 m/s toward a striped ball sitting on the table. After the balls collide the striped ball has a speed of 8 m/s. How fast is the cue ball now moving?

3. After hitting the striped ball, the cue ball bounces off the side of the table so the striped ball and cue ball are now rolling toward each other. After they collide, the cue ball has a velocity of 5 m/s in the direction perpendicular to its motion before the collision. What is the velocity (speed and direction) of the striped ball?

4. As the striped ball rolls across the table it collides with a solid ball traveling at 1.5 m/s in the same direction. When the two collide, the striped ball begins to travel at an angle of 15^{o} to the left of its original trajectory and the solid ball at an angle of 20^{o} to the right of its original trajectory. What is the velocity of the two billiard balls traveling together?

5. Sana, secretly a pool shark, decides to join the game to show these lovely gentlemen how the game is really played. She breaks and the billiard balls go everywhere. One striped ball bounces off the side and rolls with a speed of 4 m/s toward a solid ball moving perpendicular to the striped ball at a speed of 4 m/s. When the two balls collide, they travel together. At what velocity (speed and direction) do they travel?

6. Redo problem 5, but with the striped ball traveling with a speed of 2 m/s while the solid ball travels with a speed of 4 m/s.

Friday, April 17

➔ Review All Momentum Notes

➔ Complete the following problems on a sheet of paper with a full heading — Unit 9 QUIZ 2
- ◆ Who knows if this will be graded like a quiz, but, treat it like a quiz! Review problems you've done this week, then, when you're ready, put them away and attempt these problems.

1) A vehicle that weights 400 N on the surface of the Earth is traveling in outer space at a speed of 400 m/s . It can be stopped by applying a constant force of 20 N for
   a. 2 seconds.
   b. 4 seconds.
   c. 80 seconds.
   d. 400 seconds.
   e. 800 seconds.

2) Which of the following has the largest momentum relative to the Earth's surface?
   a. a tightrope walker crossing Niagara Falls
   b. a pickup truck speeding along a highway
   c. a Mack truck parked in a parking lot
   d. the Science building on campus
   e. a dog running down the street

3) It is correct to say that impulse is equal to
   a. momentum.
   b. the change in momentum it produces.
   c. the force multiplied by the distance the force acts.
   d. velocity multiplied by time.

4) The conservation of momentum is most closely related to
   a. Newton's 1st law.
   b. Newton's 2nd law.
   c. Newton's 3rd law.
   d. Newton's 4th law

5) A rifle recoils while firing a bullet. The speed of the rifle's recoil is small because the
   a. force against the rifle is smaller than against the bullet.
   b. momentum is mainly concentrated in the bullet.
   c. rifle has much more mass than the bullet.
   d. momentum of the rifle is smaller.

6) Two objects have the same size and shape, but one is much heavier than the other. When they are dropped simultaneously from a tower, they reach the ground at the same time, but the heavier one has a greater
   a. speed.
   b. acceleration.
   c. momentum.
   d. all of these
   e. none of these

7) To catch a ball, a baseball player extends the hand forward before impact with the ball and then lets it ride backward in the direction of the ball's motion. Doing this reduces the force of impact on the player's hand principally because the
   a. force of impact is reduced.
   b. relative velocity is less.
   c. time of impact is increased.
   d. time of impact is decreased.
   e. none of these

8) Padded dashboards in cars are safer in an accident than non padded ones because an occupant hitting the dash has
   a. increased time of impact.
   b. decreased time of impact.
   c. decreased impulse.
   d. increased momentum.

9) A 4 kg ball has a momentum of 12 kg m/s. What is the ball's speed?
   a. 3 m/s
   b. 4 m/s
   c. 12 m/s
   d. 48 m/s
   e. none of these

10) According to the impulse-momentum equation Ft = change in (mv), a person will suffer less injury falling on a wooden floor which "gives" than on a more rigid cement floor. The "F" in the above equation stands for the force exerted on the
   a. only the person.
   b. only the floor.
   c. either the force on the person or the force on the floor
   d. the sum of the force on the person and the force on the floor

11) You're driving down the highway and a bug splatters into your windshield. Which undergoes the greater change in momentum during the time of contact?
   a. the bug
   b. your car
   c. both the same

12) A sandbag is motionless in outer space. A second sandbag with 3 times the mass moving at 12 m/s collides with it. They stick together and move at a speed of
   a. 3 m/s.
   b. 4 m/s.
   c. 6 m/s.
   d. 8 m/s.
   e. None of the above

13) Two automobiles, each of mass 1000 kg, are moving at the same speed, 20 m/s, when they collide and stick together. In what direction and at what speed does the wreckage move
   a. If one car was driving north and one south?
   b. If one car was driving north and one east?

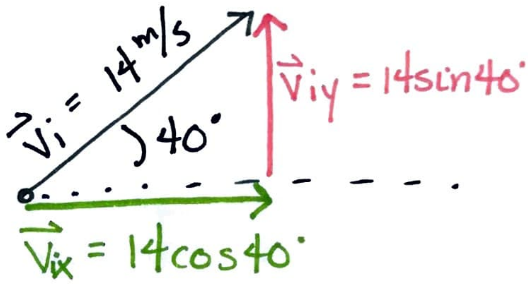
Miss Weisse's Own

Physico Textbook

Conservation of Momentum in Two-Dimensions

By now, we are familiar with (and becoming comfortable with?) dealing with vectors in 2-Dimensions.

For example, if we have a projectile, originally at an angle of 40° from the horizontal, with an initial velocity of 14 m/s, we know we have to break this ininitial velocity into x and y components.



To break a diagonal vector into components we use TRIGONOMETRY. The total vector is the hypotenuse and the x and y components are the perpendicular sides of a right triangle.

For the CONSERVATION OF MOMENTUM in any situation, momentum has to be conserved IN EVERY DIRECTION. To simplify these problems, we'll break all velocities (and ∴ momentums ⇒ $\vec{p} = m\vec{v}$) into x and y components and show that momentum is conserved in both the x and y dimensions.

We are now going to jump into examples. I encourage you to do the work yourself on a piece of paper to ensure you understand each step.

** Red Pen is my explanations ** ** Black Pen is Work**

Example 1: A ball (Ball A) rolls west with a speed of 3 m/s, and has a mass of 1.0 kg. Ball B has a mass of 2.0 kg and is stationary. Ball A collides with Ball B and moves south at 2 m/s. Calculate the momentum and velocity of Ball B after the collision.

[We begin by listing the m, $\vec{v}$, and $\vec{p}$ before and after the collision, but we're also going to include x and y components in our lists]

Before:

Ball A	Ball B
$m = 1.0\,kg$	$m = 2.0\,kg$
$\vec{V}_i = 3\,m/s$ west	$\vec{V}_i = 0\,m/s$
$V_{xi} = -3\,m/s$	$V_{xi} = 0\,m/s$
$V_{yi} = 0\,m/s$	$V_{yi} = 0\,m/s$
$\vec{p}_i = (1\,kg)(-3) = -3$	$\vec{p}_i = 0$
$p_{xi} = (1)(-3) = -3$	$p_{xi} = 0$
$p_{yi} = (1)(0) = 0$	$p_{yi} = 0$

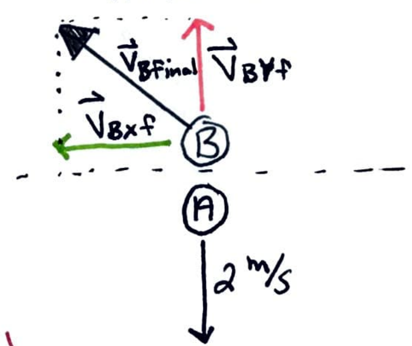
After:

Ball A	Ball B
$m = 1.0\,kg$	$m = 2.0\,kg$
$\vec{V}_f = 2\,m/s$ south	$\vec{V}_f = ?$
$V_{xf} = 0\,m/s$	$V_{xf} =$
$V_{yf} = -2\,m/s$	$V_{yf} =$
$\vec{p}_f = (1)(-2) = -2$	$\vec{p}_f = (2)(V_f)$
$p_{xf} = (1)(0) = 0$	$p_{xf} =$
$p_{yf} = (1)(-2) = -2$	$p_{yf} =$

[Draw a Picture!]

Before Collision

After Collision



[the only momentum to begin with is in the negative x-direction, which means the total final momentum must also be in the -x-direction]

[Ball A has momentum in the -y-direction so we know this has to be cancelled by Ball B. Also, Ball B has to have an equal amount of horizontal $\vec{p}$ that ball A originally had]

[Now we <u>SEE</u> that we must calculate our conserved momentum in the vertical and horizontal directions.

To do so, we'll use the same $\vec{p}_i = \vec{p}_f$ equations, but once for the x-direction and again for y-direction]

x-direction

$\vec{p}_{ix} = \vec{p}_{fx}$

$p_{aix} + p_{bix} = p_{afx} + p_{bfx}$

$-3 + 0 = 0 + p_{bfx}$

$\boxed{-3 = \vec{p}_{bfx}}$

y-direction

$\vec{p}_{iy} = \vec{p}_{fy}$

$p_{aiy} + p_{biy} = p_{afy} + p_{bfy}$

$0 + 0 = -2 + p_{bfy}$

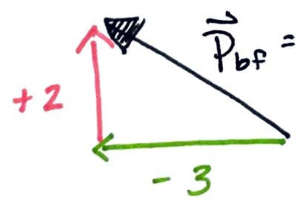
$+2 \qquad +2$

$\boxed{2 = \vec{p}_{bfy}}$

[We now have the COMPONENTS that we can use to find the total final momentum of Ball B. To do this calculation we'll use the Pythagorean Theorem.]

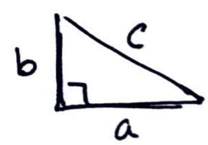
$\rightarrow a^2+b^2=c^2$

$\sqrt{a^2+b^2} = c$



$\vec{p}_{bf} = \sqrt{(2)^2+(-3)^2}$

$= \boxed{3.6\ \frac{kg \cdot m}{s} = \vec{p}_{bf}}$



Here are your answers!

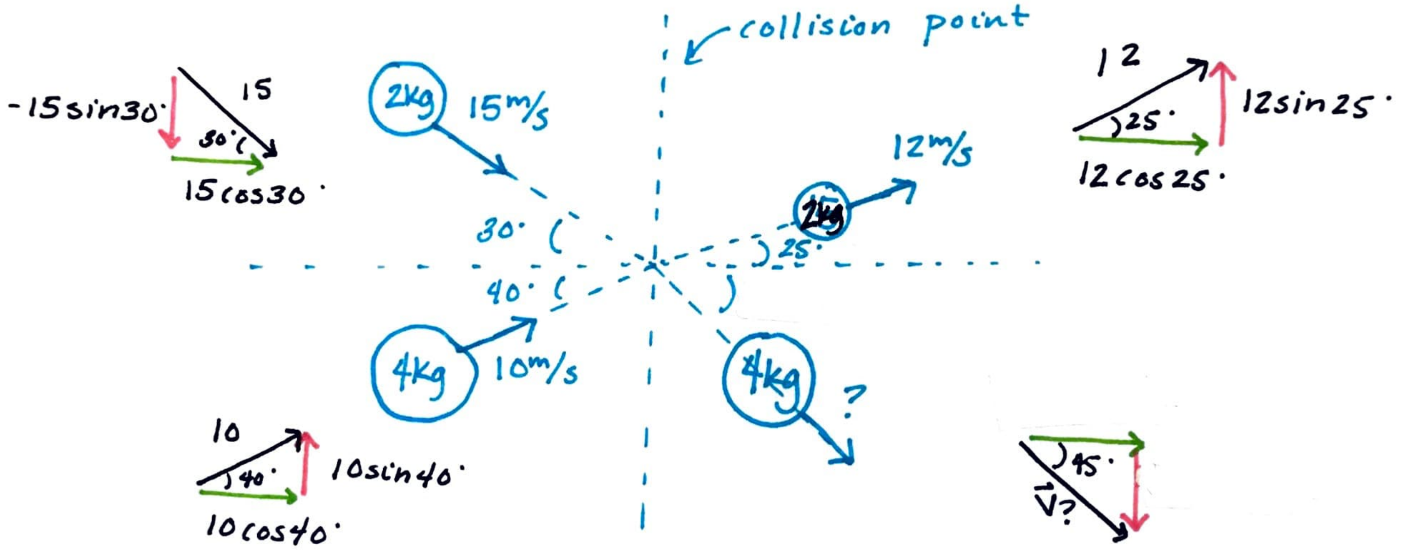
You could also find the velocity components if you like...

$\vec{p}_{BF} = m \cdot \vec{V}_{BF}$

$\frac{3.6}{2.0} = \frac{\cancel{2.0}^{1}}{\cancel{2.0}} \cdot \vec{V}_{BF}$

$\boxed{\vec{V}_{BF} = 1.8\ m/s}$

Example 2: While passing the time in quarantine, you and a family member decide to kick around some balls in the backyard. You decide to try to kick the balls at just the right speeds so they collide, then you delight in watching momentum being conserved as they follow new trajectories at new speeds. Use the diagram below to find the final velocity of the 4kg ball.



[The first thing you are going to want to do is find the components of every velocity using trig.]

SEE ABOVE

[Second, ~~#~~ we make our lists, including all components.]

2 kg ball

$m = 2\,kg$

$V_i = 15$

$V_{xi} = 15\cos 30° = 12.99$

$V_{yi} = -15\sin 30° = -7.5$

$P_i = 30$

$P_{xi} = 25.98$

$P_{yi} = -15$

4 kg ball

$m = 4\,kg$

$V_i = 10$

$V_{xi} = 10\cos 40° = 7.66$

$V_{yi} = 10\sin 40° = 6.43$

$P_i = 40$

$P_{xi} = 30.64$

$P_{yi} = 25.71$

2 kg ball

$m = 2\,kg$

$V_f = 12$

$V_{xf} = 12\cos 25° = 10.88$

$V_{yf} = 12\sin 25° = 5.07$

$P_f = 24$

$P_{xf} = 21.75$

$P_{yf} = 10.14$

4 kg ball

$m = 4\,kg$

$V_f =$

$V_{xf} =$

$V_{yf} =$

$P_f =$

$P_{xf} =$

$P_{yf} =$

[And now we conserve momentum in the x and y directions separately.]

x-direction

$$\vec{P}_{ix} = \vec{P}_{fx}$$

$$P_{2k,i} + P_{4k,i} = P_{2k,f} + P_{4k,f}$$

$$25.98 + 30.64 = 21.75 + P_{4k,f}$$

[rearrange to solve]

$$\vec{P}_{4k,fx} = 25.98 + 30.64 - 21.75$$

$$= 34.87 \ \frac{kg \cdot m}{s}$$

y-direction

$$\vec{P}_{iy} = \vec{P}_{fy}$$

$$P_{2k,i} + P_{4ki} = P_{2kf} + P_{4k,f}$$

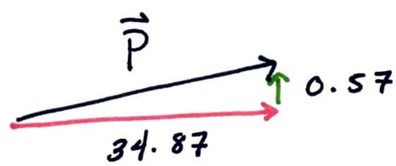
$$-15 + 25.71 = 10.14 + P_{4k,f}$$

[rearrange to solve]

$$\vec{P}_{4k,fy} = -15 + 25.71 - 10.14$$

$$= 0.57 \ \frac{kg \cdot m}{s}$$

[Now we use the pythagorean theorem to find the overall final momentum of the 4kg ball.]



$$\vec{P}_{4kg,f} = \sqrt{(34.87)^2 + (0.57)^2}$$

$$= 34.87 \ \frac{kg \cdot m}{s}$$

[Use this momentum to find the final velocity.]

$$\vec{P} = m \cdot \vec{V}$$

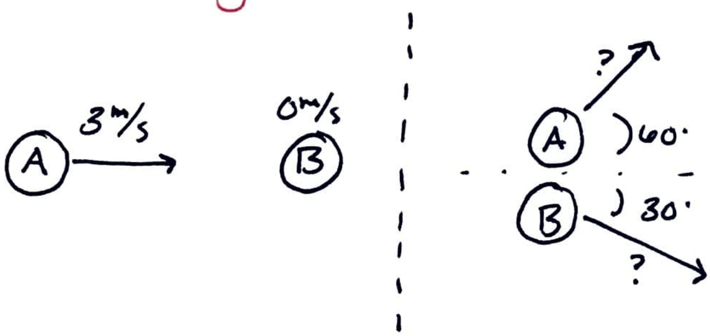
$$\frac{\vec{P}_f}{4} = \frac{(4kg)\vec{V}_f}{4}$$

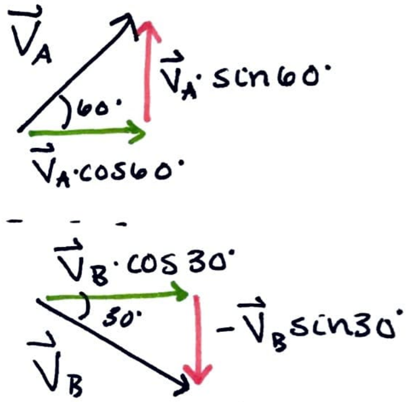
$$\vec{V}_f = \frac{34.87}{4}$$

$$\boxed{\vec{V}_f = 8.72 \, m/s}$$

Example 3: A 6.0kg object, A, moving at a velocity of +3.0 m/s, collides with a 6.0 kg object, B, at rest. After the collision, A moves off in a direction 60° above the horizontal and object B moves off in a direction 40° below the horizontal. Find the final velocities of both objects. (Although not explicitly said, object A is originally moving horizontally).

[Begin by drawing a picture.]





[Now find the x and y components of the velocities after the collision.]

SEE ABOVE TO THE LEFT

[Make your lists including all components.]

Object A	Object B	Object A	Object B
m = 6.0 kg	m = 6.0 kg	m = 6.0 kg	m = 6.0 kg
V = 3 m/s	V = 0	V_A = ?	V_B = ?
V_x = 3 m/s	V_x = 0	$V_x = V_A \cos 60° = 0.5\vec{V}_A$	$V_x = 0.87\vec{V}_B$
V_y = 0	V_p = 0	$V_y = V_A \sin 60° = 0.87\vec{V}_A$	$V_y = -0.5\vec{V}_B$
P = 18	P = 0	P =	P =
P_x = 18	P_x = 0	$P_x = (6)(.5)\vec{V}_A = 3\vec{V}_A$	$P_x = 6(.87)\vec{V}_B = 5.2\vec{V}_B$
P_y = 0	P_y = 0	$P_y = (6)(.87)\vec{V}_A = 5.2\vec{V}_A$	$P_y = 6(-.5)\vec{V}_B = -3\vec{V}_B$

[At this moment you might be thinking this is overwhelming. Stick to it! I believe in you!

Let's now write our conservation of momentum equations for the x and y directions.]

x- direction

$$\vec{P}_{ix} = \vec{P}_{fx}$$

$$P_{Aix} + P_{Bix} = P_{Afx} + P_{Bfx}$$

$$18 + 0 = 3\vec{V}_A + 5.2\vec{V}_B$$

$$18 = 3\vec{V}_A + 5.2\vec{V}_B$$

[hmmm... not looking good, let's move on to y-direction]

y- direction

$$\vec{P}_{iy} = \vec{P}_{fy}$$

$$P_{Aiy} + P_{Biy} = P_{Afy} + P_{Bfy}$$

$$0 + 0 = 5.2\vec{V}_A - 3\vec{V}_B$$

$$3\vec{V}_B = 5.2\vec{V}_A$$

[DO YOU SEE WHAT I SEE?! 2 Equations and 2 UNKNOWNS. A SYSTEM OF EQUATIONS!]

[I am going to solve this system of equations by substitution. I'll start by rearranging by y-equation.]

y:

$$\frac{3\vec{V}_B}{3} = \frac{5.2\vec{V}_A}{3}$$

$$\vec{V}_B = 1.73\vec{V}_A$$

x:

$$18 = 3\vec{V}_A + 5.2(\vec{V}_B)$$

$$18 = 3\vec{V}_A + 5.2(1.73\vec{V}_A)$$

$$18 = \vec{V}_A(3 + (5.2)(1.73))$$

$$\frac{18}{11.996} = \frac{\vec{V}_A(11.996)}{11.996}$$

$$\boxed{\vec{V}_A = 1.50\,m/s}$$

substituting $\vec{V}_A$ back into my y-equation

$$\frac{3\vec{V}_B}{3} = \frac{5.2(1.50)}{3}$$

$$\boxed{\vec{V}_B = 2.6\,m/s}$$