

Vectors Investigation

Score: \_\_\_\_\_/15

Getting Started:

Go to the following site: <https://phet.colorado.edu/en/simulation/vector-addition>

To get a vector, grab an arrow from the bucket. The length of the vector is found in the  $|R|$  box. The angle of the vector is in the  $\theta$  box. Place the vectors you wish to add **head to tail**. To get the resultant vector, hit the big "SUM" button. Move the green sum vector so that the tail touches the tail of your first vector.

Questions:

Select "Style 2" and "Show Grid". These settings will not change for the rest of the activity. Answer all questions in complete sentences.

- Drag a vector into the grid.
  - What does  $R_x$  represent?
  - What does  $R_y$  represent?
  - What does  $\theta$  represent?
  - What does  $|R|$  represent?
- Why does the vector have an arrowhead? What does that arrowhead indicate?
- Reshape your first vector so that it is completely horizontal. Move the tail of the vector to  $(0,0)$ . What is the value of  $R_x$ ?  $R_y$ ?  $\theta$ ?  $|R|$ ?

$R_x =$  \_\_\_\_\_       $R_y =$  \_\_\_\_\_       $\theta =$  \_\_\_\_\_       $|R| =$  \_\_\_\_\_

- Drag another vector into the grid. Reshape it so it is completely vertical. Move that vector so that the tail of the arrow is touching the tip of the first vector on your screen. For this new vector, what is the value of  $R_x$ ?  $R_y$ ?  $\theta$ ?  $|R|$ ?

$R_x =$  \_\_\_\_\_       $R_y =$  \_\_\_\_\_       $\theta =$  \_\_\_\_\_       $|R| =$  \_\_\_\_\_

5. Draw what you see on the screen TO SCALE on the grid paper included with the investigation.

6. Click on the "Sum" button. A new vector appears on your screen. Drag it so that the tail of the vector is at (0,0). What is the value of  $R_x$ ?  $R_y$ ?  $\theta$ ?  $|R|$ ? How does it compare to the vectors drawn in #3 & #4?

$R_x =$  \_\_\_\_\_       $R_y =$  \_\_\_\_\_       $\theta =$  \_\_\_\_\_       $|R| =$  \_\_\_\_\_

7. Drag all of your vectors to the trash. Create a new vector that starts at (0,0) and is not completely horizontal or completely vertical. What are the values of  $R_x$ ?  $R_y$ ?  $\theta$ ?  $|R|$ ?

$R_x =$  \_\_\_\_\_       $R_y =$  \_\_\_\_\_       $\theta =$  \_\_\_\_\_       $|R| =$  \_\_\_\_\_

8. Create another vector that is not completely horizontal or completely vertical. Drag it so that its tail is touching the tip of the vector from #7. What are the values of  $R_x$ ?  $R_y$ ?  $\theta$ ?  $|R|$ ?

$R_x =$  \_\_\_\_\_       $R_y =$  \_\_\_\_\_       $\theta =$  \_\_\_\_\_       $|R| =$  \_\_\_\_\_

9. Add the vector from #8 to your picture. Be sure to draw it TO SCALE on your grid paper. Click the "Sum" button. Move the new vector so that its tail is at (0,0). Draw this vector to scale on the drawing you made in #7 and 8.

10. For your newest vector, what are the values of  $R_x$ ?  $R_y$ ?  $\theta$ ?  $|R|$ ?

$R_x =$  \_\_\_\_\_       $R_y =$  \_\_\_\_\_       $\theta =$  \_\_\_\_\_       $|R| =$  \_\_\_\_\_

11. For your newest vector, how was  $R_x$  determined? How was  $R_y$  determined? How was  $|R|$  determined? Try to verify the results the computer gave you by calculating the  $|R|$  yourself. SHOW ALL YOUR WORK! (Hint: Use Pythagorean Theorem)

12. In general, if you know the measurements of the horizontal parts (components) of vectors and you know the measurements of the vertical components of vectors, how can you find their sum (resultant)?

13. You go for a walk and take 20 steps in the north direction ( $90^\circ$ ). Use the simulation to represent your path. Draw and label your vector on your grid paper.

a) Explain why this vector could also represent traveling at 20 km/h in the north direction.

b) Next, you turn left and walk 10 steps to the west. Add this vector to your diagram. Sum the two vectors using the "sum" button. How far from where you started did you end up?

c) In math,  $2+3=3+2$ . Does this property hold for vector addition? Try it with the scenario above by first walking 10 steps west and then walking 20 steps north. Compare the result to the sum in part b).

14. You are going for a drive, but a detour takes you out of the way of your destination. You drive north for 10 km, turn right and drive east for 5 km, turn to the north and drive for 3 km, drive west for 10 km, and arrive at your destination.

a) How far from where you started did you end up?

b) If you wanted to travel directly to your destination without following the streets, what angle would you take? What direction would a compass read?

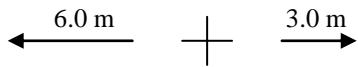
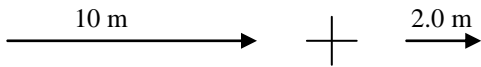
c) Now try adding the vectors in a different order. For example, start with the 5 km east, then 3 km north, etc., as long as you add all four vectors. Compare the result to the sum in part a). Draw the vectors in the order you used.

#### Additional Questions

1) How are vectors and scalars different?

2) Generally which direction is positive for horizontal vectors and vertical vectors?

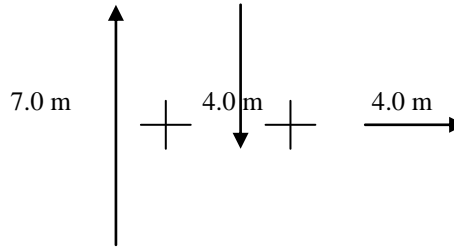
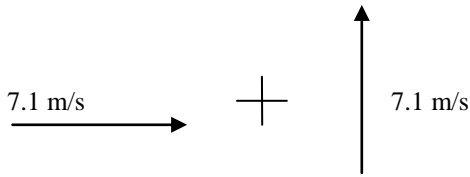
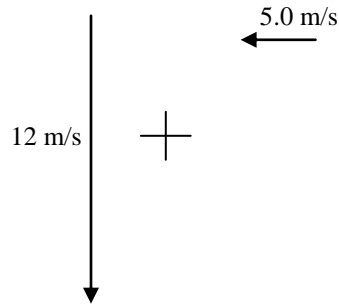
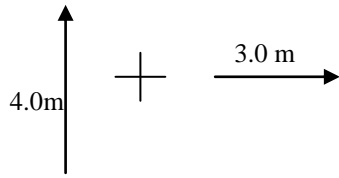
- 3) How should all vector diagrams be drawn when adding vectors?
- 4) What is the name for the number portion (size) of a vector?
- 5) What is the name of the answer when adding vectors?
- 6) Add the following vectors and express angles in your answer:



7.0 m/s north + 6.3 m/s south + 2.0 m/s north

9.2 m [E] + 7.4 m [W] + 3.2 m [E]

7) Add the following vectors, express appropriate angles in your answer



Answers:

- 1) vectors have direction 2) right (horizontal), up (vertical) 3) tip-to-tail  
 4) magnitude 5) resultant 6a) 12.0 m [E] 6b) 3.0 m [W]  
 6c) 2.70 m/s [N] 6d) 5.0 m [E] 7a) 5.0 m at 53° N of E 7b) 13 m at 67° S of W  
 7c) 10 m/s at 45° N of E 7d) 5.0 m at 53° E of N