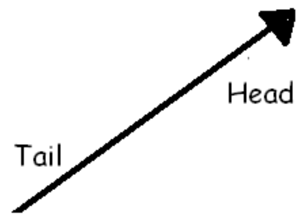
Name, Date, Period________________________

Virtual Lab – *Vectors & Vector Operations*

Setup

1. Make sure your calculator is set to degrees and not radians. Sign out a laptop and power cord. Plug in the laptop and leave it plugged in and on.
2. Do a Google (or Blackle!) search for "PhET" and then go to the PhET website.
3. From the menu at the left, click "Math Tools" and then select the **Vector Addition** simulation.
4. Once you get to the **Vector Addition** page, there should be a green button below the picture that says "Run Now!" Click this button.
5. In the basket at the top right, you can drag out a vector arrow. If you ever want to get rid of a vector, drag it to the trash can at the bottom right. If you want to start over, click "Clear All."
6. You can adjust the direction and length of the arrow by click-dragging the arrow head. Play with this until you are comfortable.
7. Click the "Show Grid" button. This will make it easier to adjust the arrow lengths.



Part A: 3-4-5 Triangle

8. Drag out a vector, and move it until the tail is located at the origin. Click on the head of the vector, and drag it until it is completely horizontal, points to the right, and has a magnitude (|R|) of 40.
9. Look at the chart at the top of the page. Here is an explanation of what each number represents:
   a. **|R|** represents the length of the arrow. This is usually called the **magnitude** of the vector.
   b. **Θ** represents the direction the arrow points. This is simply called the **direction** of the vector. The magnitude AND direction will completely define a vector.
   c. **R_x** is called the **X-component** of the vector. This is the length of the vector in the X-direction only.
   d. **R_y** is called the **Y-component** of the vector. This is the length of the vector in the Y-direction only.
10. For the first vector you dragged out, fill in the chart at right.

|R|	Θ	R_x	R_y

11. Now, drag out a second vector and place its tail at the head of the first, as shown at right. Adjust this second vector until it points vertically upward and has a length of 30. Fill in the table for this vector here:

|R|	θ	R_x	R_y

12. As you saw in the previous activity, if you were to walk this path, at the end you would be 50 units away from the origin. You can show this by clicking the button that says **Show Sum**. A green vector should pop up. This represents the vector sum, or **resultant,** of the first two arrows.
13. Drag this vector over so that the tail is at the origin, and use it to form the hypotenuse of a right triangle. Notice that the head of this vector ends exactly where the second vector ends. Click on the green vector and fill in the chart for this vector here:

|R|	θ	R_x	R_y

14. Compare the R_x and R_y values for the green vector to the |R| values from the first two red vectors. What do you notice about these values?

<u>Part B: Single Vector, Magnitude 50</u>

15. Hit the **Clear All** button to erase the screen. Next, create a vector with an R_x of 40 and an R_y of 30. Fill in the chart for this vector here:

|R|	Θ	R_x	R_y

16. Compare the chart values of this vector to those of the green resultant vector from #13. How do these values compare?

17. Next, click the **Style 2** button on the "Component Display" menu. This is a way to visualize any vector as a sum of horizontal and vertical components.

18. Adjust this vector until it has an R_x value of 30 and an R_y value of 40. Fill in the chart for this vector:

|R|	θ	R_x	R_y

19. Has the **<u>magnitude</u>** (that is, |R|) of this vector changed, compared #15? If so, how?

20. Has the **<u>direction</u>** (that is, θ) of this vector changed, compared to #15? If so, how?

21. Figure out a way to adjust the magnitude and direction of this vector until it has a magnitude of 50, just like before, but points in a different direction from the first 2. Fill in the chart for this vector, and **<u>show your vector to your instructor</u>**.

|R|	θ	R_x	R_y

22. Looking at this vector, it is easy to imagine a right triangle, made from R_x, R_y and |R|. In this case, |R| would be the hypotenuse, and R_x & R_y would be the legs.
    a. Show, using the Pythagorean Theorem, that $|R|^2 = R_x^2 + R_y^2$.

    b. Show, using SOHCAHTOA, that $R_x = |R| \cos \theta$.

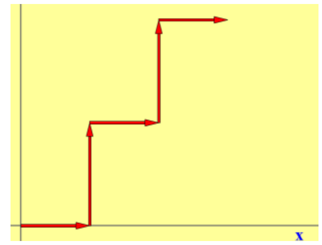
    c. Show, using SOHCAHTOA, that $R_y = |R| \sin \theta$.

23. Clear All. Imagine a vector with magnitude $|R| = 28$ and angle $\theta = 45^o$.

    a. Use SOHCAHTOA to determine the X- And Y- components (that is, find R_x and R_y). Show your work to your instructor.

    b. Check your answer by constructing this vector.

Part C – Several Vectors



24. Create 5 vectors, as shown at right. The length of each of the horizontal vectors should be 10, and the length of the vertical vectors should be 15.

25. Click on the "Show Sum" button. Fill in the chart for this resultant.

|R|	θ	R_x	R_y

26. A useful way to keep track of vector sums is to create a chart. Complete the chart below, using the 5 vectors you've constructed, and then add the columns to get the sums. Show your instructor when finished.

Vector #	Rx	Ry
1	10	0
2		
3		
4		
5		
SUM		

27. How do the R_x and R_y sums from the previous chart compare to the R_x and R_y values from question #25?

28. Using the Pythagorean Theorem, determine the resultant |R| value. Compare this number to the |R| value from #25. Show instructor when finished.

29. Clear All. Construct the following 4 vectors:
- $|R| = 20$, $\theta = 0^o$
- $|R| = 20$, $\theta = 90^o$
- $|R| = 20$, $\theta = 180^o$ (or -180^o)
- $|R| = 20$, $\theta = 270^o$ (or -90^o)

30. What is the sum (or resultant) of these vectors?

|R|	θ	R_x	R_y

31. What is the sum of these vectors if the first vector is 10 units long rather than 20?

|R|	θ	R_x	R_y

32. When finished, close all Explorer windows. You can leave the laptop on and plugged in.

Extension Questions

1. A student, following instructions on her treasure map, starts at the origin and walks the following routes:
   →36 meters North ($\theta = 90^o$)
   →15 meters West ($\theta = 180^o$)
   →20 meters South ($\theta = 270^o$ or -90^o)
   →27 meters East ($\theta = 0^o$)

   a. Fill in the chart below, which represents the horizontal and vertical components of the routes. Also determine the X and Y sums.

Vector #	Rx	Ry
1	0	36
2		
3		
4		
SUM		

   b. After the student has finished walking, what is her horizontal displacement? (R_x sum)

   c. What is her vertical displacement? (R_y sum)

   d. Using the Pythagorean Theorem, and your answers from (b) and (c), how far is she from the origin? (In other words, what is her resultant |R|?)

   e. Using SOHCAHTOA, what is her direction, as measured from the origin? (In other words, what is θ?)

2. A helicopter flies 25 km North, then 35 km East, then 5 km South, then 15 km West.

   a. What is the resultant displacement (|R|) of the helicopter, measured from the origin?

   b. What is the direction (θ) of the helicopter, measured from the origin?

3. An airplane is flying North with a velocity of 200 m/s. A strong wind is blowing East at 50 m/s. What is the airplane's resultant velocity (magnitude and direction)?