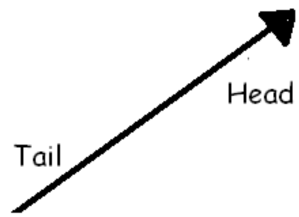
Name, Period________________________________

Virtual Lab – *Vectors & Vector Operations*

Setup

1. Make sure your calculator is set to degrees and not radians.
2. Go to https://phet.colorado.edu/sims/html/vector-addition/latest/vector-addition_en.html
3. Click the play arrow and double click "explore 2D."
4. From the box at the bottom right, drag out vector a. If you ever want to clear the screen, click the yellow eraser icon at the bottom
5. You can adjust the direction and length of the arrow by click-dragging the arrow head. Play with this until you are comfortable.
6. Make sure the grid box is checked. This will make it easier to adjust the arrow lengths.



Part A: Right Triangle

7. Drag out vector a, 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 (|a|) of 25.
8. Look at the chart at the top of the page. Here is an explanation of what each number represents:
   a. **|a|** 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. **a_x** is called the **X-component** of the vector. This is the length of the vector in the X-direction only.
   d. **a_y** is called the **Y-component** of the vector. This is the length of the vector in the Y-direction only.
9. For the first vector you dragged out, fill in the chart at right.

|a|	θ	a_x	a_y

10. Now, drag out vector b 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 15. Fill in the table for this vector here:

|b|	θ	b_x	b_y

11. If you were to walk this path, at the end you would be 29.2 units away from the origin. You can show this by clicking the button that says **Sum**. A dark blue vector should pop up. This represents the vector sum, or **resultant,** of the first two arrows.
12. 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 dark blue vector and fill in the chart for this vector here:

|s|	θ	s_x	s_y

13. Compare the s_x and s_y values for the dark blue vector to the |a| & |b| values from the first two light blue vectors. What do you notice about these values?

Part B: Single Vector, Magnitude 50

14. Erase the screen. Next, create a vector with an a_x of 25 and an a_y of 15 and place the tail at the origin. Fill in the chart for this vector.

$\lvert a \rvert$	θ	a_x	a_y

15. Compare the chart values of this vector to those of the dark blue resultant vector from #13. How do these values compare?

16. Next, click the **components button** to the right of the eye. This is a way to visualize any vector as a sum of horizontal and vertical components.

17. Adjust vector a until it has an a_x value of 15 and an a_y value of 25. Fill in the chart for this vector:

$\lvert a \rvert$	θ	a_x	a_y

18. Has the **magnitude** (that is, |a|) of this vector changed, compared to #14? If so, how?

19. Has the **direction** (that is, **θ**) of this vector changed, compared to #14? If so, how?

20. Figure out a way to adjust the magnitude and direction of this vector until it has a magnitude of 29.2, just like before, but points in a different direction ($0^\circ < \theta < 90^\circ$). Fill in the chart for this vector, and **draw your vector below**.

$\lvert a \rvert$	θ	a_x	a_y

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

    b. Show, using SOHCAHTOA, that $a_x = |a| \cos \theta$.

    c. Show, using SOHCAHTOA, that $a_y = |a| \sin \theta$.

22. Erase all. Imagine a vector with magnitude $|a| = 28$ and angle $\theta = 55^\circ$.

    a. Use SOHCAHTOA to determine the X- And Y- components (that is, find a_x and a_y). Show your work below.

    b. Check your answer by constructing this vector.

Part C –Applications of Vector Components

Show your work!

23. A plane is taking off with a speed of 46.8 m/s and climbing at an angle of 20.0°.

    a. Using trigonometry, find the horizontal- or x-component and the vertical- or y-component of its velocity. Verify your results with the computer simulation. (Note – you can drag the corner of the window the simulation is in to make it bigger.)

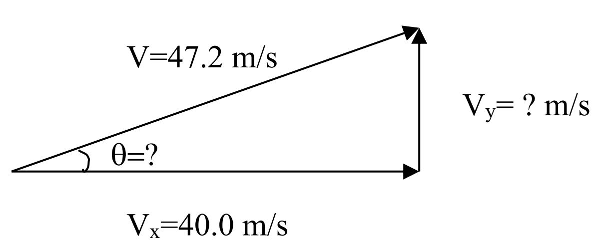
       horizontal-component _________

       vertical-component _________

    b. How long will it take the plane to reach an altitude of 400.0 m at this velocity? (Hint – 400.0 m is your vertical displacement. Which component of the velocity should you use in the formula $v=\Delta x/t$?)

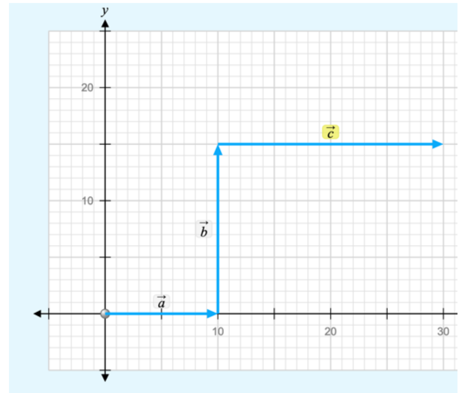
    c. How far will the plane go horizontally in the time it takes to get to the altitude in part b? (Hint – you are finding your horizontal displacement and you already have the time from part b.)

24. The sun is directly overhead. The shadow of a plane is moving at 40.0 m/s along the ground (which is horizontal). The plane's velocity is 47.2 m/s. Using trig, determine the angle at which the plane is climbing and the vertical- or y-component of its velocity. Verify your results with the computer simulation.



Part D– Several Vectors

25. Create 3 vectors, as shown at right. The length of a, b and c should be 10, 15 and 20, respectively.



26. Check the sum box. Fill in the chart for this resultant.

|s|	θ	s_x	s_y

27. A useful way to keep track of vector sums is to create a chart. Complete the chart below, using the 3 vectors you've constructed, and then add the columns to get the sums.

Vector	x-comp	y-comp
a	10	0
b		
c		
SUM		

28. How do the s_x and s_y from the chart in #26 compare to the sums of the x- and y-components in question #27?

29. Using the Pythagorean Theorem and the x- and y-components for the sum in question #27, determine value of the resultant which is the hypotenuse. Compare this number to the |s| value from #26.

30. Using the x- and y-components for the sum and some trig, determine the direction or angle of the resultant. Compare this number to the θ value from #26.