

Vector Exploration Lab

Directions and Suggestions for Teacher

Purpose:

This lab is designed to introduce students to the most basic idea of trigonometry, the idea that if the angle of a vector doesn't change, the ratio of the sides of the vector triangle also will not change. The results of this lab are meant to give students an understanding of the terms sine and cosine. Once they have their graphs they will use the graphs to create a mathematical model and then use the model to make predictions.

Virtual Part:

[\(https://www.thephysicsaviary.com/Physics/Programs/Labs/VectorLabWithPredictions/\)](https://www.thephysicsaviary.com/Physics/Programs/Labs/VectorLabWithPredictions/)

This lab is one of the few in this collection that does not have a live counterpart. The ideas presented in this lab are important, but still, this lab can be skipped without a major disruption to the flow of the course. The lab's sole purpose is to give students a better understanding of the meanings of our trigonometry terms.

Measuring Magnitude:

The magnitude of the velocity vector will be given to them directly and no measurements are required.

Measuring Velocity Components:

There will be gauges for both the x-component and the y-component. Students should read the gauges as carefully as possible and estimate the values of the components to the nearest 0.01 m/s.

Working Through the Lab:

There are technically an infinite number of magnitudes for the velocity vector that the students could use in the virtual program. Students will change the magnitude of the vector by clicking on the soccer ball. Each time they click a new random magnitude will be generated. I would suggest students do at least five very different magnitudes. It is a good practice to collect more data to have greater confidence in your results. The program will randomize the angle of the vector when the program first opens, so all students will get different results. Students should not refresh the website while working or it will generate new values and thus make all the old data irrelevant. Below is a sample of what potential data might look like.

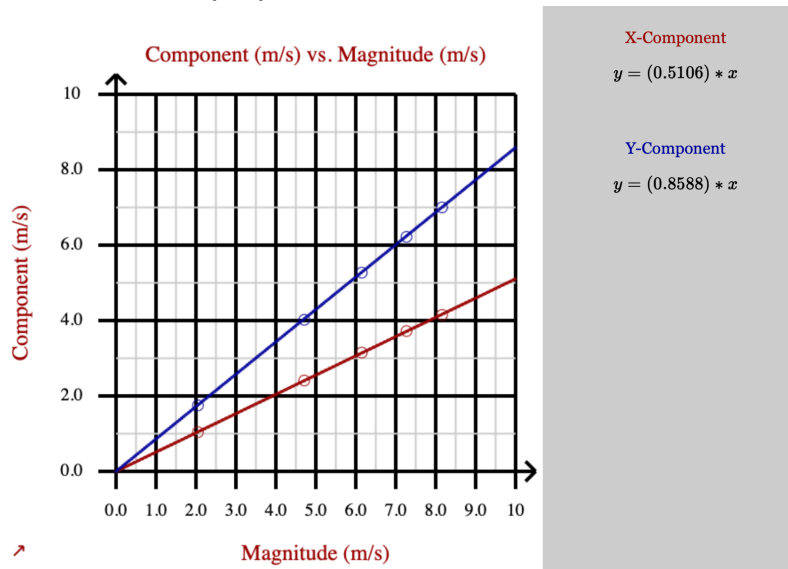
Data:

Magnitude (m/s)	x-component (m/s)	Y-component (m/s)
8.16	4.15	7.00
7.27	3.72	6.22
6.15	3.15	5.27
4.71	2.41	4.02
2.05	1.04	1.75

Graphing Data:

(<https://www.thephysicsaviary.com/Physics/Programs/Tools/Graphing/>)

Once students have finished collecting data, they should graph it and find a relationship between the variables. I suggest titling the y-axis "Component (m/s)" and the x-axis "Magnitude (m/s)". I would then do one data set for the x component and one data set for the y component. This will create one graph with both data sets included. These graphs should come out to be proportional.



I prefer always having the students transfer their graph onto their lab sheet by hand.

Equation:

For this graph students get a proportional relationship between the variables. This indicates to them that a larger magnitude for the vector will cause larger components.

The equations for a proportional relationship is given below.

$$y = (\text{slope}) * x$$

We want to continue to emphasize to them the idea that each of these letters has real physical significance. Looking at the axes, they should see that the y is the component speed in m/s and the x is the magnitude of the velocity vector in m/s. So the equation becomes:

$$\text{component Speed} = (\text{slope})(\text{magnitude of velocity})$$

Since we have two different components, we get to different equations. They are given below:

$$v_x = (\text{slope})(\text{velocity})$$

and

$$v_y = (\text{slope})(\text{velocity})$$

The two equations will have different slopes. The slopes are determined by the angle of the vector. By the end of this lab, they should know that the slope of the x-component graph is equal to the cosine of the vector's angle and the slope of the y-component graph is equal to the sine of the vector's angle.

Checking their work:

Once the students have reached the point where they have graphed and created equations, they will then be able to check their work. They should simply hit “Finished” on the program to be brought to a form they can fill out to see if they did everything correctly. Remind students that they all will be getting different answers and that they shouldn't worry if their answers differ from those of their classmates.

Students will be entering the slopes for each of two graphs. They will then be told a vector magnitude that they didn't collect data for and they are to use their mathematical equations to predict the components for that magnitude velocity.

Make two graphs, one of x-component vs. magnitude and one of y-component vs. magnitude.

Use the equations of your graphs to determine the components if the magnitude of the vector was 24.7 m/s.

Enter Your Answer Below
Don't Enter Units

Name:

Slope for x-component Graph:

Slope for y-component Graph:

x-component for magnitude of 24.7 m/s (m/s):

y-component for magnitude of 24.7 m/s (m/s):

[Return](#)

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I would normally offer a small amount of extra credit added to the lab grade if they get all their answers correct. I would have them show me their completion certificate so I could record that they earned the extra credit. If a student doesn't get everything correct, you can have them redo the lab by refreshing their page if time permits.

Live Part:

I usually suggest a live lab counterpart to any virtual lab that you do with your students. Unfortunately, this lab doesn't lend itself to many live counterparts. Because of this, I would recommend allotting just a single forty minute class period to the conduct and discussion of this lab.

Conclusion:

I personally like to have students write out a conclusion by hand after they are done with the entire lab (live part and virtual part). Some things you can have students include in the conclusion.

1. Restatement of the purpose.

- a. This is a great way to open the conclusion
- b. It helps to reinforce the reason we were doing the lab.

2. Brief Summary of the steps

- a. I don't want too much here but I do want students to transition from the purpose to the results with a sentence or two summary of the steps.
- b. This part of the conclusion should paint with a very broad brush what type of data we were collecting and what remained constant when collecting data.

3. Results

- a. I want students to clearly state what type of relationship existed between the two variables we were examining.
- b. I want them to clearly explain what this means in simple to understand terms.
- c. Basically, they will be making sense of the equation they have discovered in the lab.

4. Error

- a. They should talk about their percentage of error from the lab (you can have them do this for the live part or the virtual part or both).
- b. They should brainstorm at least one possible source of that error and how it can be minimized if they redid the lab.

5. Limitations to the model

- a. Whenever possible I want them to think about when the mathematical model for the lab would break down and no longer apply.
- b. For instance, with this lab, our model assumes that the angle of the vector doesn't change. If they want to find the values for the components of a vector on a different angle, the equations they found in the lab will need different slopes than the ones found in this lab.

Going Further

If you have the time, you could challenge the students with the following types of things.

1. Talk about the origins of trigonometry and show them how trig tables were used.
2. Show them how they can use these same ideas with other vectors like force, acceleration, or momentum.