River Crossing Lab

Directions and Suggestions for Teacher

Purpose:

This lab is designed to introduce students to the most basic idea of multidimensional motion, independence of components. In this lab students will be launching a toy boat across a steadily flowing river. The boat will be launched perpendicular to the banks of the river. Students will be able to change the speed the boat would have in still water by changing the setting on the boat's motor. Students will examine how the speed of the boat affects how far the boat will drift downstream while traveling across the river. Once they have their graphs they will use the graph(s) to create a mathematical model and then use the model to make predictions.

Virtual Part:

(https://www.thephysicsaviary.com/Physics/Programs/Labs/RiverCrossingWithPredictionLab/)

This lab is one of the few in this collection that does not have a live counterpart. The idea presented in this lab is very important and I don't think this lab should be skipped, but you should count on this entire lab to be completed in a single forty minute class period.

Measuring Speed:

There will be a speed bar below the boat that will give students the ability to get nearly any speed they want between 0 m/s and 10 m/s. The speed displayed on the bar at the exact moment they click on the boat will be the speed the boat will move across the water. Remember, the boat has an additional speed down river based on the river current. Encourage students to use a wide range of different boat speeds to get the most clear relationship when they graph their data. If any speed is so small that the boat drifts off the end of the viewing area, have the students repeat the trial with a slightly higher speed.

Measuring Drift Distance:

They will be measuring the distance the boat has moved along the far shore of the river. Again, if the boat drifted off the viewing area, have the students repeat the trial with a higher speed.

Working Through the Lab:

There are technically an infinite number of different boat speeds that the students could use in the virtual program. I would suggest students do at least five very different speeds. It is a good practice to collect more data to have greater confidence in your results. The program will randomize the river width and the river current, 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:

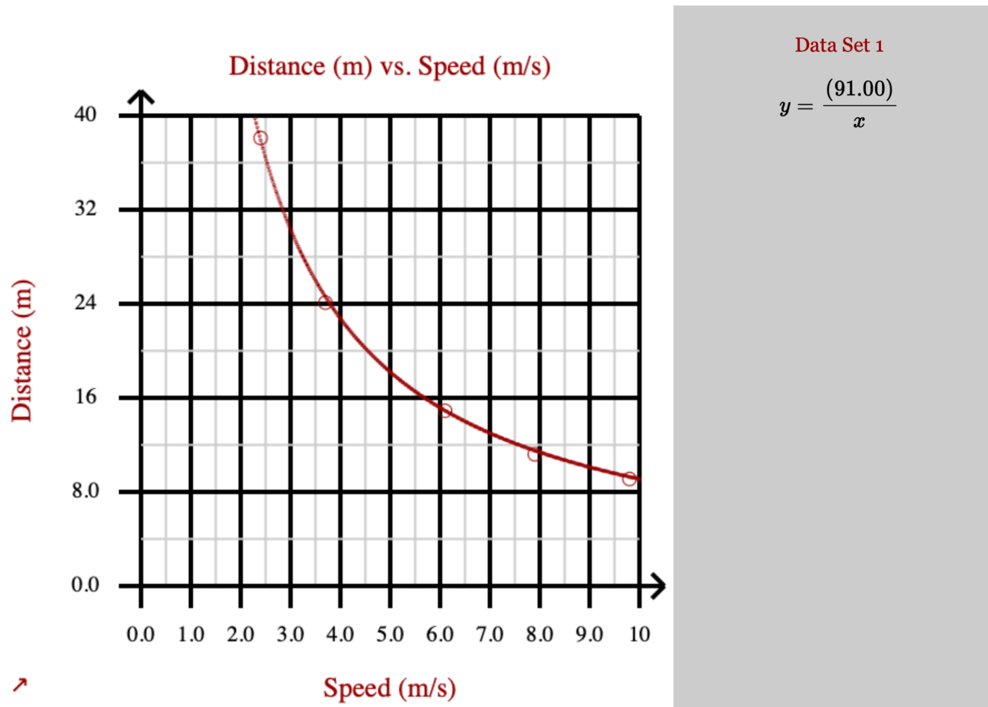
Speed (m/s)	Distance (m)
9.8	9.1
7.9	11.2
6.1	14.9
3.7	24.1
2.5	38.1

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. The across river speed of the boat (m/s) is the independent variable and should be placed on the x-axis and the downstream drift distance (m) should be on the y-axis. This graph should come out to be an inverse graph.

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



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Equation:

For this graph students get an inverse relationship between the variables. This indicates to them that a larger boat speed will cause a smaller drift distance.

The equation for an inverse relationship is given below.

$$y = (\text{graph constant})/x$$

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 downstream drift distance in meters and the x is the across river speed of the boat in m/s. So the equation becomes:

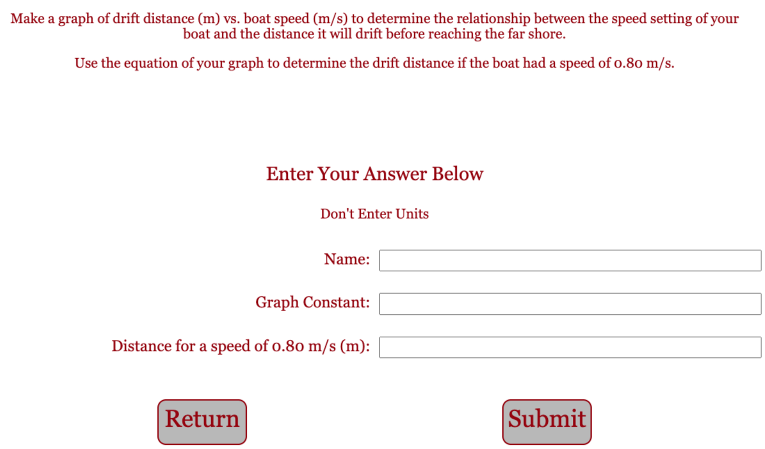
$$\text{Drift distance} = (\text{graph constant})/(\text{boat speed})$$

Based on this squared relationship, a doubling of the boat speed would cause the drift distance to be cut in half.

Checking their work:

Once the students have reached the point where they have graphed and created an equation, 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 graph constant that they found when graphing their data with an inverse relationship. They will then be told a boat speed that they didn’t collect data for and they are to use their mathematical equation to predict the drift distance for that speed.


Make a graph of drift distance (m) vs. boat speed (m/s) to determine the relationship between the speed setting of your boat and the distance it will drift before reaching the far shore.

Use the equation of your graph to determine the drift distance if the boat had a speed of 0.80 m/s.

Enter Your Answer Below

Don't Enter Units

Name:

Graph Constant:

Distance for a speed of 0.80 m/s (m):

Return

Submit

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. If you did want to try something live or at least filmed, you might see if you could use a treadmill with a small motorized car trying to move directly across it. I am not super hopeful for your results and you should be very careful doing this and not encourage students to try something like this.

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 speed of the river is constant in all parts of its flow. This is highly unlikely to be the case and we would only expect to get great results with this type of system in a highly controlled environment.

Going Further

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

1. Have them think about how their graph would be different if the river was not as wide. You can have them graph a second curve on their graph in a different color that would occur if everything stayed the same except the river was not as wide.

2. Have them think about how their graph would be different if the river was flowing faster. You can have them graph a second curve on their graph in a different color that would occur if everything stayed the same except the river was flowing faster.