

Diver Speed Lab Project: Instructions and Report

Type or write in the names of all lab partners for this report in the space below.

NOTES: The Mathwright book for this project has 4 pages or screens. The first is a title page. Work will begin with the second screen. The instructions below are divided into three sections, one for each screen. To go from one screen to another, use the buttons labeled *next page* and *previous page*.

Project Instructions, SCREEN 2:

This screen simulates the motion of a diver when you click the button marked *action*. Click it now and watch as the diver falls from the diving board to the water. The two images of the diver that remain after the action stops are snapshots showing the position of the diver at times you can set using the slider bars at the top of the screen.

You will see in the Output window the average speed of the diver between the two times you choose. Initially, the diver just steps off the board and falls. But you can make the diver jump with the *more jump* button. Each time you click it, the amount of jump is increased. The *less jump* button has the opposite effect. You can also speed up or slow down the motion using buttons on the screen. At slower speeds you can see more clearly what is happening.

Note that with no jump, the diver hits the water approximately 1.414 second after stepping off the diving board.

1. Try to find a time when the diver is about half way to the water. Record the time here for future reference _____ . This time will be referred to as your middle time. What is

the average speed between the start of the jump and your middle time? _____

What is the average speed from your middle time until the diver hits the

water? _____ Find the average speed of the diver for several different short periods of time. For example, you might find the speed for the first .2 seconds (from 0 to .2), then the next .2 seconds (from .2 to .4), and so on. Write a short description of what you observe on the next page. Include all of the data you produce.

2. Based on your observations about the speed of the diver at various times, do you think the average speed over the entire jump tells how fast the diver is going when he or she hits the water? Explain.

3. Discuss with your lab partner how the simulation might be used to find a good estimate for the speed of the diver on impact with the water. Write an explanation of what you decide to do below, and then record your results. Give your best estimate of the speed of impact for the diver.

4. Change the amount of jump a few times and experiment with the action of the diver, finally choosing the amount of jump you like for this part of the project. Pick a time between when the diver leaves the board and hits the water. How fast is the diver moving at the exact time you picked? Use methods similar to those you decided on earlier to answer this question. Record your best estimate for the speed of the diver and explain how you got that estimate in the space below.

When you have completed this part of the project, use the *next page* button to go on to the next part of the lab.

SCREEN 3

In the first part of the lab, as you tried to find estimates for the speed of the diver at one time, you probably set one of the time sliders to the desired time and kept that time fixed. Then you varied the other time slider to get various estimates of the speed. In this part of the lab you will be able to see a graph of the results of these activities. Now the first time slider is used to set what we will consider to be a fixed time. That will be the time at which you are to find the exact speed. The other time slider is a variable time. Each time you set the variable time and click the action button, the average speed between the two times will be computed, and plotted on a graph. To get a feel for this, click *action* and look at both the graph and the output below the graph. Next, move the slider bar for variable time slightly, and click *action* again. Repeat this a few times until you understand how the simulation works. Then go on with the instructions below.

Using a similar approach as for screen 2, try to find the speed of the diver at some exact time. Look at average speeds for periods of time of various lengths. For example, with the fixed time set at 2.2, try a variety of variable times, some very close to 2.2 and some further away. What do you notice about the graph of the results? How might that help you determine the speed at exactly 2.2? Write a description of your observations on the next page.

Looking at the graph, what is your best estimate of the speed of the diver right at the fixed time? Explain your answer.

The simulation will not allow you to set the variable and fixed times equal to the same thing. Why? So you cannot use the simulation to put a point on the graph with the variable time equal to the fixed time. For example, if the fixed time is 2.2, you cannot put a point on the graph with the variable time set to 2.2. However, you can use the data points to compute an equation. In fact, the data points fall on a straight line, so the equation will have the form

$$\text{speed} = m(\text{variable time}) + b$$

for appropriate m and b . Use your data points to find the m and b , and then use the equation to find the speed when the variable time is exactly equal to the fixed time. Write your equation and results below.

Repeat this experiment twice, using two different fixed times. Record your results and any observations below.

This completes the second part of the lab. Use the *next page* button to go on to the next part of the lab.

SCREEN 4

In the first two parts of the lab, the motion of a diver was displayed by a simulation. For this third and last part, a different approach is used. The graph on the right side of the screen shows the diver's height above the water as a function of time. Also, in this part you will work with velocity instead of speed. The difference is somewhat technical. By definition, speed is always positive, no matter what direction the motion follows. In contrast, velocity incorporates both the rate of travel and its direction. In this simulation, the diver is either going straight up (positive velocity) or straight down (negative velocity).

As on the previous screen, you will pick a fixed time and a variable time. The average velocity between these two times is found by dividing the signed distance traveled by the elapsed time. The signed difference just means
(height at later time) - (height at earlier time).

If the diver is rising, the signed difference will be positive, and if the diver is falling the signed distance will be negative. At each time there is a corresponding point on the curve. The elapsed time is the difference between the x coordinates of these points; the signed distance traveled is the difference between the y coordinates. Therefore, computing the average velocity is just the same as computing the slope of the straight line joining the two points. This gives another way to visualize the methods used earlier to estimate speed at a fixed instant of time.

1. Pick an initial time and a variable time. You may use the values already showing on the screen if you wish. Click on the action button. Then compute the slope of the line drawn in red on the graph, compute the average velocity between the two times, and verify that the calculation of average velocity and of slope are the same. Show your work here in the lab report:

2. Use the same methods applied on the previous screen to estimate the velocity at the exact instant of the fixed time. Pick several variable times that get nearer and nearer to the fixed time, and click the "action" button for each. (You may want to "zoom in" to get a closer look at the graph when things become too crowded together.) Below, describe the visual appearance of the lines you create in this process.

3. Discuss with your partner the concept of a tangent line to a circle. Based on that concept, you should be able to picture a tangent line for the graph on the screen. Imagine that the tangent line has been drawn so that it touches the graph at the point for the fixed time. How is this tangent line related to the lines that were drawn earlier? What is the significance of the slope of this tangent line? Why? Write your answers to these questions in the space below.

4. Repeat this process for some other fixed time. You can also change the amount of jump for the diver. Do you observe the same relationships that you found for the first example?

5. Write a summary of what you have learned in this lab project. Give your own explanation of what is (or should be) meant by the velocity at a single instant of time. Tell how to find this kind of velocity. Relate your explanation to a graph showing distance traveled as a function of elapsed time.