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MEASUREMENTS OF MOTION

PART ONE

OBJECTIVE

To use the motion sensor to measure position and velocity.

INTRODUCTION

We will use the Passport/Xplorer™ and the Motion Sensor that was used in the first lab to measure motion and changes in motion. Refer to the write up for Experiment 1 if you need to refresh your memory of the DataStudio™ software.

ACTIVITY 1

1. Start DataStudio and set up the motion sensor. Point the front screened panel of the probe directly toward you.

2. Press the Start button and wait several seconds. Press Stop. Notice that under the Position icon in the Data menu, there is now an icon called Run #1. This is your data. Interpret what it is you measured from the graph. **How far away from the probe were you? On what axis of the graph is this distance displayed? What are the units of this axis? According to your graph, did you move?** (Data sheets follow at the end of part one.)

3. Look at the other axis. **What is displayed here? What are the units of this axis? How long did your measurement last?**

ACTIVITY 2

4. Now press the Start button again. Press Stop after several seconds. Notice that the new data is displayed in the same graph. You should also observe that an icon named Run #2 appears under the Position icon in the Data menu.

5. You may wish to view Run #2 data in a separate graph. Simply drag the icon down to the Graph icon (with the image next to it). A new graph of Run #2 will appear.

6. To remove Run #2 from the first graph, click anywhere on the first graph to bring it to the front of your screen. Highlight Run #2 in the menu on the graph and press the delete button. DataStudio™ will ask if you are sure you want to remove it.

ACTIVITY 3

7. You can generate a graph that displays the *velocity* measurements of your collected data. Click on the Setup button.

8. Check the Velocity box in the window. **What are the units?** Notice that a Velocity icon appears in the Data menu with Run #1 and Run #2 below it. Close the Setup window.

ACTIVITY 4

9. You can display the Velocity data in a new graph by dropping it over the Graph icon. Try this now, using your Run #1 data. **What was the velocity for Run #1? Did it change over time or stay the same? Could you have calculated the velocity from the position versus time graph? How?**

10. You may also display the velocity vs. time graph directly under the position vs. time graph. Determine which graph shows your first run of position vs. time.

11. Once you have located the graph, determine what it is named (graph, graph 1, graph 2, etc.) by looking for its name in the top line of its toolbar. Then drag your Run #1 data from under the Velocity icon and drop it on this graph in the Displays menu. You will now see both position vs. time and velocity vs. time displayed on one graph.

12. You can align the x axes of these graphs by clicking on the Align Matching X Scales tool above the graph. **What is the benefit of viewing these two graphs simultaneously?**

ACTIVITY 5

13. Now it is your turn to have some fun. Try creating your own new graph of position vs. time. Instead of remaining stationary, move towards and away from the front of the probe. You can move your body, your hand, a book, etc. Try this now!

14. After observing how the graphs of position vs. time will appear for various types of motions, try to predict what a graph will look like for a specified motion. Choose from (1) a gradually accelerating motion away from the sensor, (2) constant velocity toward the sensor, (3) rapidly oscillating (back and forth) motion. **Draw this predicted graph on your data sheet, including axis labels and units.**

15. Now perform this motion and collect data with the motion probe. **Was your prediction correct? Print out the graph of this motion.**

16. At any time, you can delete data runs, graphs, etc. by highlighting them and pressing the delete button. Try this now.

17. Quit DataStudio without saving your activity.

SUMMARY

By now you should have a good idea of how the motion probe and the software work. As you go along, you will learn even more. Don't be afraid to try different things with the software! The best way to learn is by doing it yourself.

You are finished with this section of the lab. Feel free to go back and repeat steps if you need or want to do so. Then proceed to Part Two.

Data sheets to turn in. Name _____

MEASUREMENTS OF MOTION

PART ONE: DATA SHEETS

ACTIVITY 1

How far away from the probe were you?

On what axis of the graph is this distance displayed?

What are the units of this axis?

According to your graph, did you move?

What is displayed on the other axis?

What are the units of this other axis?

How long did your measurement last?

ACTIVITY 2

No questions in this activity.

ACTIVITY 3

What are the units of the Velocity box?

ACTIVITY 4

What was the velocity for Run #1?

Did it change over time or stay the same?

Could you have calculated the velocity from the position versus time graph?

How?

What is the benefit of viewing these two graphs simultaneously?

ACTIVITY 5

Draw this predicted graph, including axis labels and units.

Was your prediction correct?

Print out the graph of this motion and turn it in with these data sheets.

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MEASUREMENTS OF MOTION

PART TWO

OBJECTIVE

To further examine motion, especially velocity.

ACTIVITY 1

1. Connect the motion sensor to your computer. Double-click on the Measurements of Motion.ds icon to open DataStudio. Several graphs and menus should pop up as well as.

2. Open the Experiment Setup window and click on the Options button.

3. Under the Delayed Start tab check that the time is set to 3 seconds. The box beside "Start signal generator before start condition" should also be checked.

4. Click on the Automatic Stop tab and make sure the time is set to 10 seconds.

5. Press OK to close the Options window.

6. Make sure the Sample Rate is set to 10 Hz.

ACTIVITY 2

7. Examine the Position graph and answer the following questions:

   a. **How long does the data sample last?**

   b. **What do the flat horizontal sections of the graph mean?**

   c. **What do the inclined sections mean?**

   d. **What does the slope of the graph mean in physical terms?** *Hint: First write down the slope in terms of y and x (no numbers required). Then change "y" to the quantity plotted on the y-axis. Do the same for "x."*

e. **Does the graph show a scale? If so, what are the units?**

f. **What other information could we deduce from this graph or one like it?**

ACTIVITY 3

8. Now we will test your understanding of how the graphs are produced by having you match a graph.

9. Make sure the motion probe is connected to the computer via the USB link. Place the probe on your table so that it is about chest height. Position it so that you have room to walk back and forth in front of it.

10. Determine what type of motion you need to perform to duplicate the Position graph by answering these questions:

    a. How far away from the probe should you be when the timer begins?

    b. What is the maximum distance you will travel?

    c. How far away from the probe should you be when the timer ends?

11. To begin collecting data of your motion, press the start button on the toolbar. You will have a 3 second countdown to position yourself before data collection begins. A cursor will appear on the y-axis during this 3 s time period to indicate your position.

12. When ready, press Start. The timer will stop automatically at the end of 10 s.

13. The graph of your motion should be superimposed over the original graph. Repeat the process 3 times and attempt to improve your duplication of the motion each time. Multiple graphs can be displayed at the same time.

14. Keep the original data and your best trial run and delete the other runs from the graph.

15. **Print out the final graph displaying the original graph and your best trial.**

ACTIVITY 4

16. Using the graph you produced in Activity 3, **calculate the slope of several sections of your graph by hand. Then calculate the slope of the original Position graph by hand. Show all calculations.**

17. Click the slope tool on the tool bar above the graph. When the mouse is held over a portion of your graph, it will change to a hand holding a line segment with "m=value" next to it. Move this tool along your graph to determine various instantaneous slopes. **List the values of three locations. Mark these locations on your graph.**

ACTIVITY 5

18. You can also get a "best fit" line of a segment of your graph to determine the average slope. Highlight a segment of your graph by holding the mouse down at a point on the graph and moving it down and over to create a box. Practice this technique with the mouse.

19. Once you feel comfortable creating and positioning this box on the graph, create a highlighted region of your data by making a box around it. Your data will change to yellow.

20. Once you have a yellow highlighted region of your data, click on the Fit button on the toolbar of the graph. A drop down menu will appear. Choose linear. A best fit line will appear in the highlighted region of your data. This best fit line is the average slope.

21. Answer the following questions:

    a. **What does the average slope of a position vs. time graph mean in physical terms?**

    b. **Calculate an average slope by hand and compare its value with the slope of the best fit line.**

    c. **What is the difference between instantaneous slope and average slope on a position vs. time graph?**

ACTIVITY 6

22. There are 2 other sample graphs of different motions included in this lab. Repeat Activity 3 for these graphs. You should delete all data runs first by clicking on Experiment and choosing "Delete ALL Data Runs."

Data sheets to be handed in. Name _____

MEASUREMENTS OF MOTION

PART TWO: DATA SHEETS

ACTIVITY 1

No questions in this activity

ACTIVITY 2

Answer the following questions for the Position graph.

How long does the data sample last?

What do the flat horizontal sections of the graph mean?

What do the inclined sections mean?

What does the slope of the graph mean in physical terms? [*Hint: First write down the slope in terms of y and x (no numbers required). Then change "y" to the quantity plotted on the y-axis. Do the same for "x."*]

Does the graph show a scale? If so, what are the units?

What other information could we deduce from this graph or one like it?

ACTIVITY 3

Answer the following questions for the Position graph.

How far away from the probe should you be when the timer begins?

What is the maximum distance you will travel?

How far away from the probe should you be when the timer ends?

Print out the final graph displaying the original graph and your best trial.

ACTIVITY 4

Calculate the slope of several sections of your graph by hand. Then calculate the slope of the original Position graph by hand. Show all calculations.

List the values of three locations where you used the slope tool on your graph. Mark these locations on your graph.

ACTIVITY 5

What does the average slope of a position vs. time graph mean in physical terms?

Calculate an average slope by hand and compare its value with the slope of the best fit line.

What is the difference between instantaneous slope and average slope on a position vs. time graph?

ACTIVITY 6

Answer the following questions for Graph 2.

How long does the data sample last?

How far away from the probe should you be when the timer begins?

What is the maximum distance you will travel?

How far away from the probe should you be when the timer ends?

Print out the final graph with the original graph and your best trial.

Calculate the slope of several sections of your graph by hand. Then calculate the slope of the original graph by hand. Show all calculations.

Answer the following questions for Graph 3.

How long does the data sample last?

How far away from the probe should you be when the timer begins?

What is the maximum distance you will travel? (Hint: The distance traveled is the total path length.)

How far away from the probe should you be when the timer ends?

Print out the final graph displaying the original graph and your best trial.

Calculate the slope of several sections of your graph by hand. Then calculate the slope of the original graph by hand. Show all calculations.