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ACCELEROMETER

PART I: ACCELERATION IN THREE DIMENSIONS

OBJECTIVE

To understand the operation of the Pasco acceleration probe.

INTRODUCTION

The accelerometer, or acceleration probe, operates by measuring the force on a small mass attached to a crystal inside the probe. When the probe is at rest, the gravitational force on the mass exerts a compression (or tension) force on the crystal that generates an electric signal proportional to that force. Your computer senses the voltage generated. When the probe is accelerated, the inertia of the mass against the crystal again generates an electric signal that is sensed by the computer.

You can imagine the probe to be a small box lying upright on the table with a crystal inside and on the bottom and a small mass affixed on top of the crystal. In that case the gravitational force on the mass causes a compression of the crystal. Similarly, if the box is accelerated in the upward direction, the bottom of the box pushes on the crystal and again a compressional force is exerted on it. Consequently, if up is chosen as the positive direction, the negative gravitational force is seen to have the same effect as an upward acceleration.

In some situations you will want to include the gravitational acceleration in your data. There may be other times when you will want to zero out the gravity effect so that you only observe real accelerations. You can do so by following the instructions in the activity section. **Caution:** Once you select the zero option, you will have to close the program and reopen it to return to the initial (non-zero) condition that shows the effect of gravity.

ACTIVITY 1

1. Place the accelerometer (the sensor labeled “Acceleration”) flat on your lab table with the green button facing up.

2. Examine the probe and determine the directions of the three axes. Notice that the positive z-axis points straight up (perpendicular to the probe).

3. **What are the forces acting on the probe? In which direction are the forces acting?**

ACTIVITY 2

4. Position the probe so the connector is facing towards you. The accelerometer should still have the green button facing upwards.

5. **Describe the directions of the positive x- and y-axes. Repeat for the negative x- and y-axes.**

6. **In which direction is the positive z-axis? The negative z-axis?**

7. With the probe positioned as above, **predict along which axis/axes the probe will detect the force of gravity.**

ACTIVITY 3

8. Connect the accelerometer to the extension cable. Connect the extension cable to the USB link. Connect the USB link to your laptop.

9. Open the Accelerometer.ds file and check the Setup parameters. The Sample rate should be set to 50 Hz. Check all boxes except the Acceleration, Resultant box. *Also, make sure that the "Zero Automatically on Start" box is unchecked. Do **NOT** press the Zero button next to this box. If you do press this button accidentally, close DataStudio without saving changes. Then reopen the Accelerometer.ds file*.

10. Create a graph displaying all three accelerations.

ACTIVITY 4

11. Press Start (on the DataStudio toolbar) and rotate the probe about the x-axis in 90-degree increments. Hold each position for about 5 s. After completing one full revolution, press Stop. Rescale your graph so that the all acceleration axes range from $-25\ m/s^2$ to $+25\ m/s^2$.

12. Rename your graph "X Rotations" and **print it.**

13. Observe the graph and **answer the following questions**:

a. When did you observe an acceleration along the x-axis from the graph? State the position and orientation of the probe, describing the direction of the probe's x-axis.

b. When did you observe an acceleration along the y-axis from the graph? State the position and orientation of the probe, describing the direction of the probe's y-axis.

c. When did you observe an acceleration along the z-axis from the graph? State the position and orientation of the probe, describing the direction of the probe's z-axis.

d. Along which axis did you observe zero acceleration?

e. When was the acceleration along the x-axis positive? Negative? What was the magnitude of the x-axis acceleration in each position of the probe?

f. When was the acceleration along the y-axis positive? Negative? What was the magnitude of the y-axis acceleration in each position of the probe?

g. When was the acceleration along the z-axis positive? Negative? What was the magnitude of the z-axis acceleration in each position of the probe?

ACTIVITY 5

14. Press Start and rotate the probe about the y-axis in 90-degree increments. Hold each position for about 5 s. After completing one full revolution, press Stop. Rescale your graph so that all acceleration axes range from $-25\ m/s^2$ to $+25\ m/s^2$.

15. Rename your graph "Y Rotations" and **print it.**

16. Observe the graph and **answer the questions from step 13.**

ACTIVITY 6

17. Press Start and rotate the probe about the z-axis in 90-degree increments. Hold each position for about 5 s. After completing one full revolution, press Stop. Rescale your graph so that all acceleration axes ranges from $-25\ m/s^2$ to $+25\ m/s^2$.

18. Rename your graph "Z Rotations" and print it.

19. Observe the graph and **answer the questions from step 13.**

Hand in. Name ____________________

ACCELEROMETER

PART I DATA SHEETS

ACTIVITY 1

What are the forces acting on the probe?

In which direction are the forces acting?

ACTIVITY 2

Describe the directions of the positive x- and y-axes. Repeat for the negative x- and y-axes.

In which direction is the positive z-axis? The negative z-axis?

Predict along which axis/axes the probe will detect the downward force of gravity under the present conditions.

ACTIVITY 4

Rename your graph “X Rotations” and print it.

When did you observe acceleration along the x-axis of the graph?

When did you observe acceleration along the y-axis of the graph?

When did you observe acceleration along the z-axis of the graph?

Along which axis did you observe zero acceleration?

When was the acceleration along the x-axis positive? Negative? What was the magnitude of the x-axis acceleration in each position of the probe?

When was the acceleration along the y-axis positive? Negative? What was the magnitude of the y-axis acceleration in each position of the probe?

When was the acceleration along the z-axis positive? Negative? What was the magnitude of the z-axis acceleration in each position of the probe?

ACTIVITY 5

Rename your second graph “Y Rotations” and print it.

When did you observe acceleration along the x-axis of the graph?

When did you observe acceleration along the y-axis of the graph?

When did you observe acceleration along the z-axis of the graph?

Along which axis did you observe zero acceleration?

When was the acceleration along the x-axis positive? Negative? What was the magnitude of the x-axis acceleration in each position of the probe?

When was the acceleration along the y-axis positive? Negative? What was the magnitude of the y-axis acceleration in each position of the probe?

When was the acceleration along the z-axis positive? Negative? What was the magnitude of the z-axis acceleration in each position of the probe?

ACTIVITY 6

Rename your graph "Z Rotations" and print it.

When did you observe acceleration along the x-axis of the graph?

When did you observe acceleration along the y-axis of the graph?

When did you observe acceleration along the z-axis of the graph?

Along which axis did you observe zero acceleration?

When was the acceleration along the x-axis positive? Negative? What was the magnitude of the x-axis acceleration in each position of the probe?

When was the acceleration along the y-axis positive? Negative? What was the magnitude of the y-axis acceleration in each position of the probe?

When was the acceleration along the z-axis positive? Negative? What was the magnitude of the z-axis acceleration in each position of the probe?

ACCELEROMETER

PART II: ELEVATOR

OBJECTIVE

To use the accelerometer to measure the accelerations in an elevator.

ACTIVITY 1

1. Consider collecting acceleration data with the accelerometer for an elevator ride from the bottom floor to the top floor and back down to the bottom floor again. **What do you think will be the best position for the accelerometer on the elevator to collect acceleration data? Why?**

2. **When will you experience net acceleration? When will the acceleration be upward and when will it be downward?**

ACTIVITY 2

3. Connect the accelerometer to the laptop using the USB link.

4. Open the Setup menu and check the box for Zero Automatically on Start. Set the Sampling Rate to 50 Hz. Make sure to check the boxes for Acceleration in the X, Y, and Z directions.

5. Place the accelerometer flat on your lab table with the green button facing up. Press Start. **What do you observe on your graph?** (*Hint*: Compare with what you observed at the beginning of Part I: Acceleration in Three Dimensions.)

ACTIVITY 3

6. Remove the USB link from the laptop. Disconnect the accelerometer from the USB link. Connect the accelerometer to the extension cable and the extension cable to the Xplorer.

7. Take the accelerometer to the elevator and place it flat on the floor with the green button facing up.

8. Press the Start button (the big green button on the Xplorer—it has a blue triangle on it).

9. Press the button on the elevator to the top floor. When you reach the top floor, press the button on the elevator to take you back to your floor.

10. When you reach your floor again, press the Stop button (same as Start) on the Explorer.

ACTIVITY 4

11. Return to your computer and connect the Xplorer USB cable to the Xplorer. Connect the other end of the cable to the computer.

12. DataStudio will ask if you want to retrieve data. Click "Retrieve Now."

13. Observe the graph and answer the following questions:

    1. **Where in the elevator ride did your graph indicate acceleration?**

    2. **In which direction was the acceleration?**

    3. **When was the acceleration positive? When was it negative?**

    4. **What was the magnitude of the acceleration in each case?**

14. Rename your graph "Elevator" and print it out. **Turn it in with your data sheets.**

Tear out and hand it. Name ____________________

ACCELEROMETER

PART II: ELEVATOR WORK SHEET

ACTIVITY 1

What do you think will be the best position for the accelerometer on the elevator to collect acceleration data? Why?

When will you experience net acceleration? When will the acceleration be upward and when will it be downward?

ACTIVITY 2

What do you observe on your graph? Hint: Compare it to what you observed at the beginning of Part I: Acceleration in Three Dimensions.

ACTIVITY 4

Where in the elevator ride did your graph indicate acceleration?

In which direction was the acceleration?

When was the acceleration positive? When was it negative?

What was the magnitude of the acceleration in each case?

Don't forget to attach your graph "Elevator."