Experiment
2

Motion

Lots of objects go back and forth; that is, they move along a path first in one direction, then move back the other way. In this experiment, you will observe objects that change speed and direction as they go back and forth:

- Student jumping into the air
- Ball tossed into the air

PRELIMINARY QUESTIONS

1. What do a student jumping and a ball tossed in the air have in common?

2. Define acceleration

3. Describe the velocity for an object that has constant acceleration.

4. Sketch the shape of a velocity vs. time graph for constant acceleration.

5. Sketch an acceleration vs. time graph for constant acceleration.

6. Consider a ball thrown straight upward. It moves up, changes direction, and falls back down. What is the acceleration of the ball on the way up?

7. What is the acceleration when it reaches its top point?

8. What is the acceleration on the way down?

Copy all of your graphs to Word for use later in the analysis. Save often!

PROCEDURE

Part I Student Jumping in the Air

1. Open the experiment file "02 Jump" in the Physics With Vernier folder.

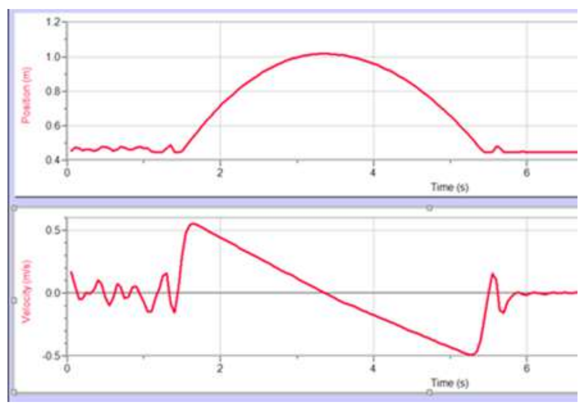
2. Place your motion detector on the floor pointing up

3. Sketch your predictions for the position *vs.* time and velocity *vs.* time graphs for a student jumping straight up and falling back down. Will the acceleration be constant? [yes / no] Will it change direction? [yes / no] Will there be a point where the acceleration is zero? [yes / no]

4. With a book held parallel to the floor, stand next to the Motion Detector so that the signal reflects off the book's surface. Hold your arms as still as possible and jump. Collect data for this jump until you see a smooth upside-down U on the position graph and a straight line for the corresponding part of the velocity graph. If both graphs are not smooth, try again.

5. Highlight the portion of the graph representing the jump (only the part when you're in the air). To do this, use the mouse to drag a rectangle around the useful portion of the data and click Zoom In.

Mark the following on the example graph on the right:



- Where the acceleration is constant
- Where the student changes direction
- Anywhere the acceleration is zero (if that ever happens)

What does the slope of the velocity graph tell us about the motion of the jump?

6. Logger Pro can display the slope of the line. To turn on this function, click on "m="

This function can calculate the slope for any position on the graph. You are going to use it to find the slope of the velocity graph at three points: When the jumper is on the way up, when they are at their highest point, and when they are on their way back down:

Note: It helps to look at the position graph to find these points in time, but be sure to use the slope from the velocity graph.

- Slope of **velocity** graph when the jumper is on the way up, just before reaching the top: ___________
- Slope of **velocity** graph on the way down, just after reaching the top: ___________
- Slope of **velocity** graph when the jumper is at the top: _______________

7. When the student was airborne, was the acceleration constant or changing? How can you tell?

8. Was there any point in the motion (while the student was airborne) where the velocity was zero? Explain.

9. Was there any point in the motion (while the student was airborne) where the acceleration was zero? Explain.

10. Highlight the straight line section of the **velocity** graph with a smooth slope (leave out any curved portions of the graph). Click on R= to get the equation of this line. Copy and paste your graph into Word. Record the slope of this section, including units:

____

Part II Ball Tossed into the Air

1. Place the Motion Detector on the floor. Open the experiment file "02 Ball" in the Physics With Vernier folder.

2. Sketch your predictions for the position *vs.* time and velocity *vs.* time graphs of a ball thrown straight up into the air. Will the acceleration be constant? Will it change direction? Will there be a point where the acceleration is zero?

3. Hold the ball with your hands on either side, about 0.5 m above the Motion Detector.

4. Click ▶ Collect to start data collection.

5. When you hear the Motion Detector clicking, gently toss the ball straight up over the Motion Detector. Move your hands quickly out of the way so that the Motion Detector tracks the ball rather than your hand. Catch the ball before it reaches the motion detector. **DO NOT LET THE BALL HIT THE MOTION DETECTOR.** You should again get a smooth upside-down U on the position graph and a straight line for the corresponding part of the velocity graph. If both graphs are not smooth, try again.

6. Zoom in on the portion of each graph that represents the time that the ball was in the air. To do this, use the mouse to drag a rectangle around the useful portion of the data and click Zoom In, .

7. Copy the portions of the position and velocity graphs that represent the time the ball was in the air. Compare these to your predicted graphs and comment on any differences.

8. Use the “m=” button again to determine the slope of the velocity graph. It helps to look at the position graph to find these points in time, but be sure to use the slope from the velocity graph:

- Slope of **velocity** graph when the ball is on the way up, just before reaching the top: ____________
- Slope of **velocity** graph on the way down, just after reaching the top: ___________
- Slope of **velocity** graph when the ball is at the top: _______________

9. Highlight the straight line section of the **velocity** graph with a smooth slope (leave out any curved portions of the graph). Click on R= to get the equation of this line. Copy and paste your graph into Word. Record the slope of this section, including units:

____

Conclusion:

In your Word document, type a conclusion that addresses the following:

- What was the cause of the acceleration you observed in the lab? What value should this acceleration have had?
- Did your calculated values of acceleration match the values you expected? Why or why not?
- Should the values of acceleration for the ball and the jumper been the same? Were they?
- Was the acceleration you measured constant or changing? How do you know?
- Was there any point in the motion where velocity was zero? Where acceleration was zero?

When you finish, share your Word document with your instructor via email or Google Drive.