PHYSICS LABORATORY: Graphing Kinematics

Adapted from: Vernier Physics

<u>Background Information and Purpose</u>

Lots of objects go back and forth; that is, they move along a line first in one direction, then move back the other way. An oscillating pendulum or a mass on a spring are examples of things that go back and forth. Graphs of the position *vs.* time and velocity *vs.* time for such objects share a number of features. In this experiment, you will observe a number of objects that change speed and direction as they go back and forth. Analyzing and comparing graphs of their motion will help you to apply ideas of kinematics more clearly. In this experiment you will use a Motion Detector to observe and contemplate the motion of the following objects:

- Oscillating pendulum
- Ball rolling up and down an incline
- Mass oscillating at the end of a spring

Additionally, you will become familiar with motion (kinematics) graphs in this lab.

<u>Data Processing and Collection (DCP)</u>

Part I Oscillating Pendulum

1. Connect the Motion Detector to the DIG/SONIC 1 channel of the interface. If the Motion Detector has a switch, set it to Normal.

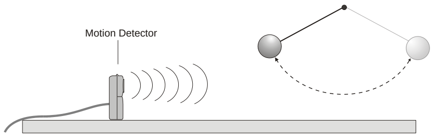


Figure 1

2. In LoggerPro, open the file “02 Pendulum” from the *Physics with Vernier* folder. Sketch a prediction of the position *vs.* time and velocity *vs.* time graphs of a pendulum bob swinging back and forth. Ignore the small vertical motion of the bob and measure position along a horizontal line in the plane of the bob’s motion. Think: based on the shape of your velocity graph, do you expect the acceleration to be constant or changing? Why? Will it change direction? Will there be a point where the acceleration is zero?

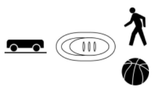
3. Place the Motion Detector near a pendulum with a length of 1 to 2 m. The Motion Detector should be level with the pendulum bob and about 1 m away when the pendulum hangs at rest. The bob should never be closer to the detector than 0.15 m.

4. Pull the pendulum about 15 cm toward the Motion Detector and release it to start the pendulum swinging.

5. Click ▶ Collect to begin data collection.

6. If you do not see a smooth graph, the pendulum was most likely not in the beam of the Motion Detector. Adjust the aim and repeat Steps 5–6.

Part II Ball on an Incline



1. If the Motion Detector has a switch, set it to Normal.

2. Place the Motion Detector at the top of an incline that is around 1 m long. The angle of the incline should be between 5° and 10°.

3. Open the experiment file “02 Cart.” Two graphs will appear on the screen. Sketch your prediction of the position *vs.* time and velocity *vs.* time graphs for a ball rolling freely up an incline and then back down. The ball will be rolling up the incline and toward the Motion Detector initially. Think: will the acceleration be constant? Will it change direction? Will there be a point where the acceleration is zero?

4. Hold the ball at the base of the incline. Click ▶ Collect to begin taking data. When you hear the clicking, give the ball a push up the incline. Make sure that the ball does not get closer than 0.15 m to the Motion Detector and keep your hands away from the track as the ball rolls.

5. Zoom in on the portion of each graph that represents the time that the ball was freely rolling. To do this, use the mouse to drag a rectangle around the useful portion of the data, then click the Zoom In button, .

Part III A Mass Oscillating at the End of a Spring

1. If the Motion Detector has a switch, set it to Normal.

2. Place the Motion Detector so it is facing upward, about 1 m below a mass suspended from a spring.

3. Open the experiment file "02 Spring." Sketch your prediction for the position *vs.* time and velocity *vs.* time graphs of a mass hanging from a spring as the mass moves up and down. Think: will the acceleration be constant? Will it change direction? Will there be a point where the acceleration is zero?

4. Lift the mass about 10 cm (and no more) and let it fall so that it moves up and down.

5. Click ▶ Collect to begin data collection.

6. If you do not see a smooth graph, the mass most likely was not in the beam of the Motion Detector. Adjust the aim or look for interfering objects and try again.

7. Zoom in on the portion of each graph that represents one cycle of the mass. To do this, use the mouse to drag a rectangle around the useful portion of the data and click the Zoom In button, . Answer the Analysis questions for Part IV before proceeding to Part V.

<u>Conclusion and Evaluation (CE)</u> **(***All questions 1 mark each)*

Part I Oscillating Pendulum

1. Provide the position and velocity graphs for the motion of the pendulum.
2. Was there any point in the motion where the velocity and/or acceleration was zero? Explain.
3. Where was the pendulum bob when the acceleration was greatest? Explain why.

Part II Ball on an Incline

4. Provide the position and velocity graphs that represent the time that the ball was going up and down the incline.
5. Use a tangent line and the velocity graph to determine the acceleration of the ball when it was on the way up, at the top, and on the way down the incline. What did you discover?
6. Was there any point in the motion where the velocity and/or acceleration was zero? Explain.

Part III Mass Oscillating on a Spring

7. Provide the position and velocity graphs for the vibration of the mass.
8. Was there any point in the motion where the velocity and/or acceleration was zero? Explain.
9. Where was the mass when the acceleration was greatest? Explain why.

Parts I-III

10. State two features that the three *position graphs* had in common, and two ways they were different from one another.
11. State two features that the three *velocity graphs* had in common, and two ways they were different from one another.