Acceleration, Free Fall, Symmetry

As you work through the steps in the lab procedure, record your experimental values and the results on this worksheet. Use the exact values you record for your data to make later calculations.

Acceleration Lab - Simulation and Tools

Open the dynamics track simulation to do this lab. You will need to use the VPL Grapher to complete this lab.

Discussion

1. Complete the following sentences.

   (a) A straight-line position-time graph indicates ________________ velocity.

   (b) A straight-line, horizontal position-time graph indicates a ________________ velocity.

   (c) A steep position-time graph indicates a relatively ________________ magnitude of velocity.

2. In the table, fill in the name that we give to the slope of the velocity-time graph.

Table 1

Graph	Slope	Area
Position-time, x-t	velocity	
Velocity-time, v-t		displacement, Δx
Acceleration-time, a-t	jerk, jolt, surge, lurch	change in velocity, Δv

IA. Motion on an Incline - Position

2. Record your chosen track angle.

4. Record your chosen initial velocity, V_o.

5. Approximately, what is the starting position, x_o, of the cart?

7. Approximately, what is x_{top}?

9. For each of the following, describe the motion of the cart *and* the related shape of your graph. You should use words like rise, fall, slow, fast, slowing down, speeding up, positive direction, negative direction, steep, and ±slope.

   (a) for the trip up the ramp

(b) when the cart is *at* the top of the ramp

(c) for the trip back down the ramp

10. Upload your position vs. time prediction graph IA1a as "Accel_IA1a.png". (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

IB. Motion on an Incline - Velocity

1. The cart starts off traveling in a negative direction. Describe the cart's motion in terms of its changing velocity. Be sure to include the **direction of the velocity**, which at a given instant will be **negative, positive, or neither**. Also include the **magnitude**, which will be **large** when the cart is going fast, **small** when it's going slowly, and **zero** when it's at rest.

3. Upload your velocity vs. time prediction graph IB1a as "Accel_IB1a.png". (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

6. It seems like the v-t graph should change when the cart gets to the top of the ramp, but instead it just keeps on rising. What about the v-t graph *does* change when the cart reaches the top?

8. Clearly describe your v-t graph (**not the motion!**). You should know the details we're looking for now.

9. Consider the cart at the highest point it reaches along the track. Its velocity there is zero. Does it have this velocity of zero ***for an instant*** or ***at an instant*** at the top of its motion? Choose one of these two and explain your answer. (Look at your graph!)

IC. Motion on an Incline - Acceleration

1. How do we find acceleration from a velocity-time graph?

2. Upload your acceleration vs. time prediction graph IC1a as "Accel_IC1a.png". (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

5. Upload your screenshot of all three graphs as "Accel_rampGraphs.png". (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

8. Consider the following.

(a) When the cart is rolling up the ramp, its velocity is negative since it's moving in the negative direction. And the cart is slowing down. What is the sign of its acceleration?

(b) When the cart is rolling down the ramp, its velocity is positive since it's moving in the positive direction. And it's speeding up. What is the sign of its acceleration?

9. Record the acceleration from your acceleration vs. time graph.

10. Record the acceleration from your velocity vs. time graph.

ID. Find the Acceleration Due to Gravity, g, from the Acceleration of Our Cart on an Incline.

1. Determine the predicted maximum acceleration using the average of your two acceleration values.

2. Record the percentage error.

IE. The Area Under an Acceleration vs. Time Graph

1. Record the values (t, a) for the left-most and right-most points on the acceleration vs. time graph.

2. Record the area under the a-t graph.

3. From the v-t graph, record the coordinates of the points and Δv.

4. Compare your two values for Δv by calculating the percentage difference.

II. Free Fall

In your browser, navigate to the video clips of the vertical ball toss. The QuickTime movies in the first two frames may take a while to load. It may help to click in each of these two frames.

A Dropped Object

2. Briefly describe what you observe in the movie of a dropped billiard ball. Use physics lingo!

An Object Thrown Upward

2. How does the trip upward compare to the trip downward in the movie of a billiard ball thrown upward?

3. Notice how the **spacing** between the images and the **fuzziness** of the images varies as the ball rises and falls. What do these **two** observations indicate about the ball's motion? (There are two answers.)

5. What will be the sign (+ or −) of the acceleration in the movie of a billiard ball thrown upward?

10. From the movie of a billiard ball thrown upward, we can see that the ball is at rest ($v = 0$) at the top of its motion. How do the y-t and v-t graphs indicate this?

11. Does this mean that its acceleration is zero there? How do the v-t and a-t (sort of) graphs answer this?

12. Record the experimental value for g from your v-t graph.

13. Compare your experimental value to the accepted value by finding the percentage error between your experimental value and our accepted value.

III. Observations of Symmetry

1. How does an object's acceleration while rising compare to its acceleration while falling? Explain your answer using either the v-t graph or the a-t graph.

2. How do speeds compare at corresponding heights? State your observations for a couple of different sets of matching heights.

3. Use your position-time graph to answer the following.

   (a) Find the time the ball took to rise between a point near $y = 0.5$ m and $y = 1.5$ m.

   (b) Find the approximate time between the same positions on the way back down.

   (d) State your observations for the time intervals between similar positions on the way up and the way back down.