2016

# Uniform Acceleration (In-lab Instructions)

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# Uniform Acceleration? Name: ________________

In-lab instructions and notes sheets

## The big question:

Is a cart traveling up and then down a ramp an example of constant acceleration?

## Procedure:

1. Make the video of the motion using Vernier's Video Physics app on the iPad. Some suggestions for making video that's easy to analyze follow. Make sure that

   - the cart shows up well against the background
   - the iPad camera is stationary
   - the iPad is held parallel to the track
   - the cart's motion fills a majority of the screen (use landscape orientation for the iPad). You may need to practice your initial push before shooting video to get good video on the first try
   - The angle is not too big- pictures get blurry if the cart moves too fast

   Measure the angle your track makes with the horizontal. Don't use a protractor- it's more accurate to use a ruler to measure some distances and apply your knowledge of trig. Briefly record the angle of the ramp and how you figured it out in the space below:

   | Angle of ramp (and supporting data, diagrams) |
   |---|
   | |

   **Note:** Video analysis requires relating distances in the video (measured in pixels) to real-world distances. This is done using a reference object. For this lab, you will use the cart as your reference object. Measure the length of your cart and record it here:

   | Length of cart = ________________ |
   |---|

2. Open up Video Physics and view your video. Check to make sure it's good enough for analysis. Is the object clear (not blurry)? Is there a spot on the object that's easy to mark? Does the motion fill most of the screen? Is the action all in a plane that's parallel to the iPad? If your video isn't good, now's the time to reshoot it.

3. Once you think your video is good enough, it's time to take data:

   - Record the position of the cart at many different times in the video. Video Physics records 30 pictures per second. However, you only need about 30 well-chosen data points to get a good graph. So, you are encouraged to skip frames when recording the cart's position. You do not need to skip the same number of frames each time, either. When the cart is moving slowly, you can skip more frames than when the cart is moving quickly.

# Uniform Acceleration? Name: __________________

In-lab instructions and notes sheets

- o Adjust the axes so the motion of the object is along the x-axis (on the “Origin & Scale” tab).
- o Input the information about the reference object (using the “Origin & Scale” tab). Tap-drag along the length of the cart and enter the cart’s length when the dialog box appears.
- o Check your graphs in Video Physics to make sure that y-velocity and y-acceleration are both zero throughout the motion. (If not, adjust your axes slightly and recheck).

4. Once you’ve marked the motion of the object, check the quality of the graphs. Do the graphs show a consistent trend? Is there enough data in all parts of the graph? This is your last chance to revise your data before exporting the data to the Graphical Analysis app.
5. Tap on the Share icon, choose “Data File”, “Open in…” and “Copy to Graphical.”
6. Analyze the motion using Vernier’s Graphical Analysis app on the iPad. ***Only consider the part of the motion where the cart is moving freely***- that is, from *just after* the cart is released until *just before* it is caught.

   a) Analyze the velocity-time graph to answer the following questions:

   - Sketch the velocity-time graph on the axes below. On the graph, indicate when the cart turns around.


   - Compare the graph above to your prelab prediction. Describe and account for any differences.

   - Is velocity ever zero? If so, when? Explain how you can tell from the velocity graph.

   - Is acceleration ever zero? If so, when? Explain how you can tell from the velocity graph.

   - Does acceleration ever change sign? If so, when? Explain how you can tell from the velocity graph.

# Uniform Acceleration? Name: ________________

In-lab instructions and notes sheets

- Is acceleration constant throughout the motion? Explain how you can tell from the velocity graph. [Hint: Check to make sure that the acceleration on the way up is the same as the acceleration on the way down].

- What is the numerical value of acceleration? (If the acceleration is changing, describe the changes and calculate appropriate numbers). Explain how you calculated the acceleration value(s) from the velocity graph curve fit(s) you used.

b) ***Export the velocity graphs*** with all of your analysis (linear fits, etc.) as an ***image file***. ***Share*** this file with yourself and your lab partners. (Your instructor will tell you how to do this).

c) Analyze the position-time graph to answer the following questions.

- Sketch the position-time graph on the axes below. On the graph, indicate when the cart turns around.


- Is acceleration constant throughout the motion? Explain how you can tell from the position graph. [Hint: Check to make sure that the acceleration on the way up is the same as the acceleration on the way down].

- What is the numerical value of acceleration? (If the acceleration is changing, describe the changes and calculate appropriate numbers). Show how you calculated the value(s) from the position graph curve fit(s) you used.

- Compare the acceleration value(s) obtained from the position graph to those obtained from the velocity graph. Are they similar? Exactly the same? (If they are vastly different, redo your analysis-something's wrong!)

d) ***Export the position graphs*** with appropriate fits as an ***image file***. ***Share*** this file with yourself and your lab partners. (Your instructor will tell you how to do this).

## Thinking about the results:

7. If gravity is the only thing responsible for the cart's acceleration, theory predicts that the cart's acceleration will be the same on the way up and as on the way down. A "gravity-only" model also predicts that $a_{up} = a_{down} = g \sin\theta$, where θ is the ramp angle.

a) Based on your results, does a "gravity-only" model correctly explain the cart's movement? Explain.

b) Calculate $g \sin\theta$, based on your ramp angle. Compare your results for $a_{up}$ and $a_{down}$ to $g \sin\theta$.

c) If you've done everything right, your value for $a_{down}$ is slightly more than $g \sin\theta$ and your value for $a_{up}$ is slightly less than $g \sin\theta$. Could a "gravity-and-friction" model help explain the results better than a "gravity-only" model? Support your answer with a few sentences.

8. Write the report, using your analysis according to your instructor's guidelines. Make sure you have the image files from Graphical Analysis to include in your report.