1D Kinematics

In-Person | One Week | Summary Submission

Introduction

This lab is designed to provide students with the opportunity to design an experiment to measure the (local) acceleration due to gravity (g) and then compare it with the standard value of 9.8 m/s2. This is a one-week in-person lab, and a lab summary is due one week after the usual lab time. In this lab students will (a) measure the value of the acceleration due to gravity g, (b) compare the measured value with the standard value of 9.8m/s2 and (c) practice identifying and quantifying sources of error.

Theory

Kinematics is fundamentally the study of motion in physics. This lab has been designed to allow students to explore kinematics in one-dimension (1D) when an object moves in a straight line. There are three standard equations (though not limited to three) which are used to describe a wide variety of motion. They are given as:

$$v = v_o + at$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

$$(x - x_o) = v_o t + \frac{1}{2}at^2$$

$$a_{constant} = \frac{\Delta v}{\Delta t}$$

These equations can describe most situations where objects are in motion and have a constant acceleration. You are expected to be familiar with these equations and know how to use them. The motion of a cart rolling down an incline plane is a straight-line motion along the incline. It is important to note that the object is not free-falling under gravity and the acceleration of the cart down the incline will be different (but related to) the acceleration due to gravity.

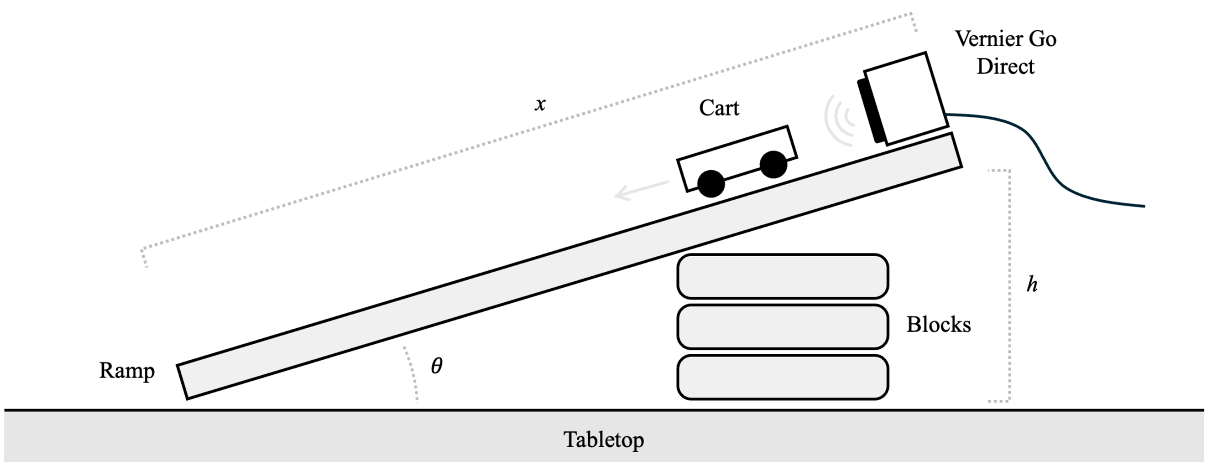
If the angle of inclination of the ramp is given as θ , then the acceleration of the cart down the ramp is given as:

$$a = g\ sin\theta$$

Procedure

For this lab, we will utilize the following equipment:

- Vernier Go Direct® Motion Detector – to measure velocity vs time of the cart going down the ramp
- Vernier Graphical Analysis™ Software Package – to obtain slope of the velocity
- A dynamics cart
- A smooth ramp
- A meter stick – to measure the length and height of the ramp
- Blocks – to change the height of the ramp
- A computer – to obtain the data from the Vernier Go Direct® Motion Detector
- Excel (or equivalent) - for data analysis and making graphs
- Word (or equivalent) - for writing the summary



Activity 1: Measuring Acceleration Using a Motion Detector

1. Spend a little time setting up your experimental design. Measure the total height and total length of the ramp. Record these values in an Excel (or equivalent) spreadsheet.

2. Place the motion detector at the top of the ramp (see diagram). Make sure the motion detector is hooked up to the Vernier Graphical Analysis™ (VGA) software package. You should hear the motion detector "clicking" when it is properly setup.

3. We want to find the *acceleration* of the cart, so make sure the axes of your graph on the VGA will allow us to find what we want (hint: you will want to use the *slope* of the graph to find the acceleration). Check with your TA if you are unsure (but only **after** you've thought about it!).

4. Do some practice runs, make sure you can get data that shows a <u>constant</u> acceleration (hint: what would your graph look like if it showed a *constant* acceleration?).

5. Select a portion of your graph that shows a *constant* acceleration, perform a linear fit and record the slope.

6. Take a screenshot of your graph for your lab summary. You will need to indicate on the graph where the *constant* acceleration portion is, and how you arrived at that conclusion.

7. Repeat steps 1-5 for different heights. How many? You choose, but the more runs you do, the better your experiment will be. Good general rule of thumb: More than 3, less than 10.

Activity 2: Measure Acceleration vs Time for Free-Fall

1. Using your acceleration values and height/length measurements for each run you performed in Activity 1, make a graph that will allow you to find the acceleration due to gravity (hint: consider the equation $a= g\sin(\theta)$).

2. Compare this value with the "true" value of g (% error).

Analysis

In your submission, you will need to include:

- One screenshot of an example VGA graph annotated as described in the procedure.

- All graphs made in Excel.

- The data tables for each run, including all measured and calculated values.

- Measured value of "g" in Activity 2.

- Comparison of the measured value of "g" to the standard value.

Discussion

As *parts* of your discussion, please make sure to include:

- Discussion of the graph obtained in Activity 1. Identify any key features and explain how it was used in data analysis.

- Discussion of the graph obtained in Activity 2. Identify any key features and explain how it was used in the data analysis process. Specifically, how did you find g from this plot.

- What value of g did you obtain? What is the error?

You must discuss the possible sources of error in your report. You should be considering what could have caused your experimental values to not match up exactly. Why would this happen? Think about systematic vs. random errors and how they could apply in this experiment. This is one of the most important aspects of performing an experiment and is integral to each lab in this course.

FAQ’s & Recommendations

How should I prepare for lab time?

You only have so much time in lab each week, so proper preparation makes a huge difference in what you’re able to accomplish! Read the handout ahead of time so that you can ask clarifying questions immediately and get started as soon as you arrive!

What goes in my lab notes?

The purpose of lab notes is to enable your or a colleague to reconstruct what was done and why after you’ve left the lab and are performing analysis or writing a submission.

- You can use any form you like to record experiment information: notebook, spreadsheet, etc.
- They don’t have to be neat, in complete sentences, etc., but they do have to be useful!
- Make sure to take detailed notes about your setup, how to use the equipment, what results you found, measurements related to the environment you may need, etc. You may not be able to get back into the lab later in the week if you miss something, so record as much detail as possible!
- When storing multiple data files while in lab, make sure to name the files clearly so they’re easy to find later.

When should I work on the experiment and analysis?

We strongly recommend doing the lab as early in the week as possible, rather than waiting until it is almost due. This is just so that, if you run into trouble and need help, you’ll have plenty of time to talk to your TA and get issues resolved before the deadline.

How do I turn in my results?

After leaving lab, performing your analysis, and completing your submission, you’re ready to turn in your work!

- Every lab session requires submission of either an assignment, summary, draft report, or report.
- Collaborate with your partners on data collection, analysis, and writing.
- Turn in a single group submission and make sure the names of all group members are included.
- Upload your submission to Canvas/Brightspace as a .pdf by the deadline in the course calendar.
- Other than the spreadsheet assignment, you will not upload any spreadsheets. Just copy and paste figures and other elements from your spreadsheet into your formal submission as needed.

Where can I get help?

Your lab TA can answer questions during the lab, by email, or by setting up a time to meet. You can also ask advice from lab partners and/or other students.

General DO’s and DON’T’s

- *DON’T* break the equipment – always be careful when using lab supplies!
- *DO* consult with your lab TA before leaving a lab session about your experimental method, the validity of your results, and any confusion you have about the analysis process.
- *DON’T* forget to record all the parameters and measurements for your experiment, including saving files.
- *DO* be creative in your experimental design and enjoy!