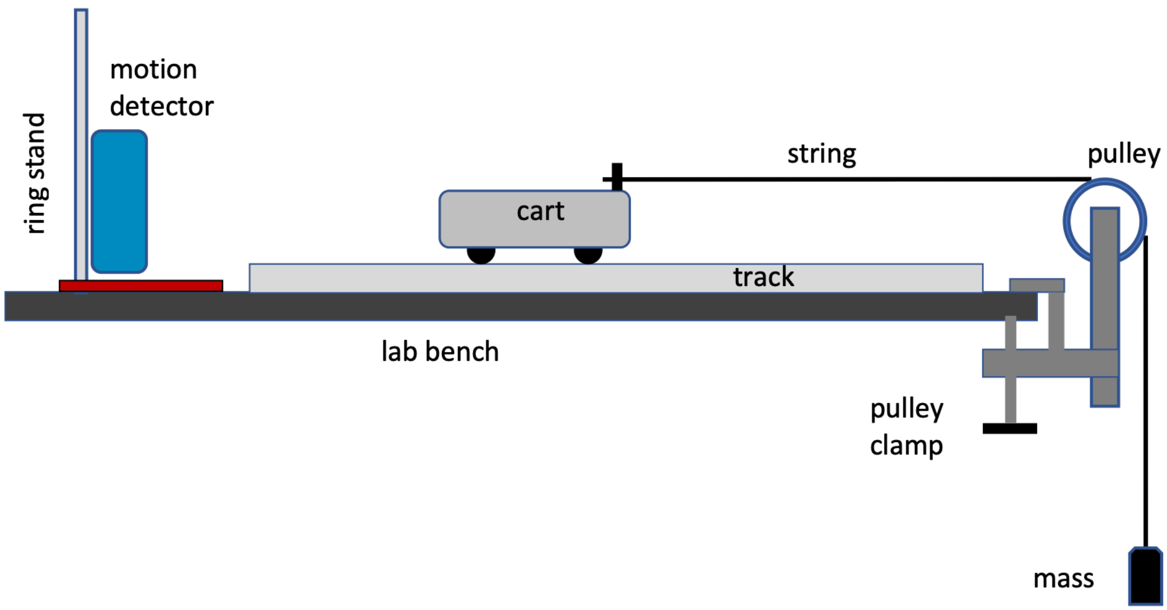
Lab 1: Accelerating Cart

Introduction: We've been exploring kinematic equations of motion and graphs of motion -- mostly theoretically. This lab will give you the chance to take some real-world data to determine the acceleration of an object graphically and using an equation, as well as introduce you to using LoggerPro software and motion sensors.

Materials: Motion detector, LabPro, LoggerPro software, low-friction cart, track, pulley, hanging masses, 1m length of string, ring stand



Procedure:

Setting up the lab equipment:

1. Attach the clamp to the table, securing the end of the ramp to the table. Slide the bar of the Smart Pulley into the hole so the pulley can rotate perpendicular to the edge of the table. Tighten the small screw so the pulley doesn't move.
2. Attach the motion sensor using its clamp to a ring stand, and place it at the other end of the track, about 30 cm away from the track's end. Make sure the motion detector is oriented such that its field of view is directly along the line of the cart, not above or below or to the side.
3. If you don't already have a long enough string in your lab kit, cut a piece of string long enough to connect the cart to the hanging mass, and tie loops on either end. Attach one loop to the cart plunger, and hang the string over the pulley (don't put the mass on yet). Make sure the string is level with the track.

Setting up the computer and LabPro/LoggerPro:

4. Open up the laptop. If the computer isn't already on, turn it on using the small button on the left side. Login into the Student account using the password "poly".

5. Connect the LabPro power cord to the LabPro and plug into the wall–after a few moments, you should hear a few beeps.
6. Plug one end of the USB connector into the LabPro and the other end into a USB port on the laptop.
7. Plug the motion detector cord into the "Dig/Sonic1" port on the LabPro. Do not force the cord into the wrong spot!
8. On the laptop, open LoggerPro using the icon on the desktop. You should see blank *position vs. time* and *velocity vs. time* windows, a blank data table, and a green oval icon right above the table. Click that green oval icon to configure the LabPro unit.
9. Right-click the *velocity* graph and then "delete"—we're not using the velocity graph for this experiment. Select the *position* graph, and use the square handle at the lower edge to expand it into the full window.
10. Set up the graph for data collection by right-clicking (or double-finger tap on the track pad) and choosing "graph options." Under "Title," type in the names of your group. Also, under the Appearance column, select the box that says "Point Symbols." Then click "Done."

Data collection:

11. With someone holding the cart and/or using something to keep the cart steady, hang a 50 g mass on the free end of the string. Do not let the cart roll yet.
12. When ready, make sure the hanging weight is motionless (not swinging), and click the green "Collect" button at the top of the LoggerPro window. Wait until the button turns RED before you release the cart and allow it to start moving. Release the cart and allow it to roll the length of the track. Click the "STOP" button on data collection just before the cart reaches the pulley and before the mass hits the ground, and have someone catch the cart before it hits the pulley and damages it, or goes flying. DO NOT LET THE CART HIT THE PULLEY OR THE MASS GO FLYING.
13. You should see a *position vs. time* graph! If there is no clear, smooth curve in the middle (you will likely have noise right at the start and at the very end), run another trial.
14. Click the "Autofit" icon at the top of the graph window (looks like an *A* inside axes). This will resize the data to take up the whole window.
15. Select the part of the graph that shows a smooth curve by clicking and dragging left-to-right, bottom-to-top, so that the curve portion of the graph is highlighted in gray. With that section highlighted, click the "curve fit" icon at the top (looks like a parabola with two upside down parabolas beneath it). Choose the quadratic option, then click "try fit." If numbers show up in the ABC boxes, click "OK." You should see a box pop up on the graph with the autofit equation. If needed, adjust the brackets on the graph to make sure you are ONLY fitting the curve and NOT the noise on either end.

16. Note the values in the table on the left that have been highlighted in gray (you may need to scroll the table view to find these values). These are the data points included in your best fit. Write down on your handout the **initial time, position, and velocity values and the final time and position values for the highlighted section.**
17. Go to File → **Print Graph**. Click OK. Print enough copies for each person in your group. If the printer isn't working, save as PDF or take a screenshot and email it to yourselves. Once you've printed, add the initial and final values you recorded from the table at those points on the graph.
18. Close the LoggerPro program. Do NOT save changes.
19. Return all equipment to where you found it: computer in the box with charger plugged in, lab equipment in the appropriate drawer. Please keep cords attached to the appropriate sensor.

Analysis:

1. Let's evaluate your best-fit line (note that each part here needs its own blurb!):
   a. Using the values given from your printed graph, what is the equation that describes your graphed data? Write the equation with numeric values for A, B, and C and the appropriate symbols to match your graph (remember that your x-axis is time, and your y-axis is position).
   b. Which kinematic equation has the same form as the best-fit line you wrote above? Once you identify that equation, what do A, B, and C represent in your best-fit line?
   c. Determine the acceleration of the car from your best-fit line equation. Clearly explain HOW and WHY you get your answer.
2. Now, use the initial and final time, position, and initial velocity values you took from the graph to calculate the acceleration of your car using the kinematic equation you identified in 1b. Show all your work/explain your reasoning.

Discussion and error:

3. Calculate the % difference between your two acceleration values from 1c and 2 above. Recall that % difference compares two measured results to see how far apart they are, using the following equation:

$$\%\ difference = \frac{|measured\ value\ 1 - measured\ value\ 2|}{\left(\frac{value\ 1 + value\ 2}{2}\right)} \times 100$$

4. Comment on your % difference above: what does it mean? Do your two values agree or not? Which value do you think is more accurate and why?

5. Describe at least two sources of error for this lab: what happened? Why? How did it affect the data (both magnitude and specifically what about the data/analysis)? How could this be mitigated in the future?

Write-up information:

This is your first formal lab write-up for Honors Physics this year, following the guidelines shared in class and on MyPoly. Your write-up (and all future write-ups) should be done on the green engineering pad provided in class, on the front side of the page only.

This particular write-up should include the following sections (you can omit any not listed here). Don't forget to **blurb** what each question/part is asking you to do! We'll talk about blurbs in class before the write up. Each section (except the header) should clearly be marked (e.g. **Data** above your graph, or **Analysis** above your answers to the questions).

Header (all parts are always required)
Objective (hint: sum up the introduction in a sentence or two)
Data (tape in your graph printout with best fit line equation and two points marked)
Analysis (answers to the questions above)
Discussion and error (answers to the questions above)

This lab, like most "formal" lab write-ups, is worth 30 points. The grading for write-ups can be found in the guidelines linked above, and on our course expectations document.