# Lab 1: Accelerating Car

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**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 the video analysis software Tracker.

**Materials:** Pull-back truck with marker dot, meter sticks, phone camera and laptop, tape, markers

## Procedure:

*Data collection:*

1. Mark a starting line on the ground with tape. Make sure there are several meters of clear, flat floor in front of the starting point.
2. Place a meter stick on the floor parallel to your track -- you will need this for your video analysis. It does not have to be aligned with the starting line, merely parallel to your car's path and in view of your camera.
3. On whomever's phone you will be taking video, to go Settings → Camera and set your video speed to 60 fps (your default is likely 30 fps; you can change this back after taking video if you wish).
4. Prepare to take video by holding the phone horizontally above the car's path, looking down onto the car's path. You should be able to see the entirety of the meter stick, the starting line, and at least 2 m of track without moving the phone. Do not move the phone once you start taking data (video).
5. Start the car's run by placing it about 30 cm in front of the start line, then pulling it back so that the marker dot on the top of the car is on the starting line. Hold it there and start videorecording, then release the car and let it run. If it veers off too far from a straight line, redo this step.
6. Stop recording video, and transfer to each group member's laptop. Replace all materials and clean up any debris.

*Tracker analysis:*

7. If you have not yet downloaded the Tracker software onto your laptop, please go to https://physlets.org/tracker and install the proper version. Alternately, you can use the "Tracker online with sample collection" link to use a browser version, but it may not save your work locally.
8. Open the Tracker program, and go to File → Open → File Chooser. Find and select your group's data video. It may take a few moments for the video to load.

*A video version of the following instructions can be found in the "How To" resources Topic on MyPoly, if that would be helpful. However, make sure you read through these specific instructions here for THIS lab, even if you watch the video!*

9. **Set the start/end of the video to analyze:**
    a. Use the slide-cursor along the bottom of the video to identify where the motion starts (the moment you let go of the car). With the slide-cursor at that point, Control-Click on the cursor and select "set start frame" in the window that pops up. Then Control-Click again and select "set time" and when it says "0.0," hit OK. That will set the start of your video to this frame.
    b. Identify where you want to end your analysis interval. With the slide cursor at that point, Control-Click on the cursor and select "set finish frame."
    c. If you wish, you can change the number of frames per interval by clicking on the red number to the right of the slide-cursor -- 3 or 5 should work for most videos.
10. **Set the scale and coordinate system:**
    a. In the ribbon at the top, click the Axes icon (under "Track"). A set of axes should pop up on the screen. Drag the origin to your starting point, and use the rotation ability to set the x axis parallel to your car's actual path.
    b. In the ribbon, click on the Calibration Tools icon, then New → Calibration Stick. Drag the ends of the blue calibration stick to the ends of your meter stick in the video. You may want to zoom in in order to be as accurate as possible. Make sure the "length" in the upper ribbon matches your reference (1.000 m if you use a meter stick).
    c. Once you've set them, you can click the Axes icon again to hide the purple axes (but they will be saved).
11. **Picking data points:**
    a. Place the slide-cursor back at the beginning of your interval and click on the "Track" menu above the ribbon, then New → Point Mass. You should see graph axes pop up on the right side of the screen.
    b. Select a portion of the object you can easily identify throughout the motion -- for this lab, use the marker dot on the hood of the car that was even with the starting line. Holding down Shift, position your cursor on that position and Click. This will leave a mark and will advance the object however many frames you identified in Step 9c above. If you need to zoom in to 100% to get a better look at the object, do that.
    c. Continue to Shift-Click on the object in the place selected in Step 11 until the object gets to the end of its run.
    d. The table and graph generated (it will be to the right on your screen) will be for the object's Position vs Time in the x and y directions.
12. You need to find an equation that fits your position data using the built-in Tracker tools. To do this:
    a. Control-click on the position (x) vs. time graph in Tracker and select Analyze. A larger version of the graph should pop up in its own window.
    b. Click "Analyze" above the y-axis of the graph, then Curve Fitter and the appropriate shape (hopefully, your graph looks like a parabola!). This will produce a best-fit line with values at the bottom of the graph window. You may need to use the slider between the two columns to make sure you can see all the values for A B C on the right.
    c. If the best-fit line looks like it matches your data points, then print this window using the File → Print dialog (or, alternately, take a screenshot of the window to print later).

   d. Paste this window into your lab write-up. (hint, since this is your first lab: an appropriate "blurb" for the "Data" section would be "Position vs. time graph of data with a best-fit line using Tracker")

13. Save your work to your hard drive using the Save icon. You may need to give Tracker permission to access your Documents or other folders when prompted.

## Analysis:

1. Let's evaluate your best-fit line (note that each part here needs its own blurb!):
   a. Using the values given from Tracker, 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 look at the table of data next to your graph. Use the final value in the table to calculate the acceleration of your car using a kinematic equation. 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:

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

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?

*See the next page for information about the lab write up for THIS lab*

## 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!

**Header**
**Objective** (hint: sum up the introduction in a sentence or two)
**Data** (your graph printout with best fit line)
**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.