Lab (L-1): New Fun and Games with Kinematics

Background

The relationship between an object's position, velocity, constant acceleration, and time can all be described by the kinematic equations. A computer-based data collection system allows us to measure the position of a moving cart as a function of time and generate graphs of the car's motion. Before attempting this lab, you will need to make sure that the Tracker software is installed in your computer. You will also want to watch this video which shows you how to use the Tracker software to retrieve the data for this and future labs.

Objectives

The objectives of this lab are to a) learn to use the Tracker video analysis tool, b) perform graphical analysis of motion data, and c) verify the kinematic equations.

Equipment

Computer with Tracker software installed   Video of accelerating object (provided)

Data collection

1. Download the Cart video generated by the good Ms. Dunham. Put it on your desktop.
2. Open Tracker on your computer. With your video on your desktop, you can drag it onto the Tracker work space. (If it hadn't been, you could have used File → Open to find the video file on your computer, then opened it). (If a warning comes up telling you to ignore certain frames, just click "ok.")
3. Use the Tracker program to generate Position vs Time data. Copy this into a Google Sheet (or an Excel Spreadsheet, depending upon your preference). If you are unsure how to use the Tracker program, watch the video mentioned above or reference the cheat sheet provided here.
4. Change the Tracker data to Velocity vs Time (again, the video or cheat sheet explains how). Put that data into your Google Sheet.
5. Title your Google Sheet file LastFirstName - Lab DL1 (e.g. DunhamRachel - Lab DL1). Make sure you include a header identifying the type of data being listed, units included, above each row.
6. Once you have all the data needed, quit Tracker (it's a huge energy sink).

Analysis

1. Create two scatter plots: a *Position vs. Time* graph and a *Velocity vs. Time* graph. Label your axes and give each graph a clear title.
2. For both graphs, add a trendline. For the position graph, use a polynomial fit.. For the velocity graph, use a linear fit. Display the trendline equation on each graph. (If you don't know how to

do this in Sheets, check out this quick tutorial). For the questions below, “graph” refers to both the points and the trendline.

Questions and calculations

1. Based on your *velocity vs. time* graph, what was the acceleration of the cart? Explain how you got this.
2. Based on your *position vs. time* graph, what was the acceleration of the cart? Explain how you got this.
3. Do a % comparison between your answers to #1 and #2. Remember that comparing two values is done by using

   $$= \frac{|V_1 - V_2|}{\left[\frac{(V_1 + V_2)}{2}\right]} \times 100$$

   Comment briefly on your result, including which value you think is more accurate and why.
4. Pick a time close to the beginning of the run but other than t = 0 and call it t_1. State that time.
   a. Use the *Position vs Time* graph to identify and report the position of the cart at t_1. Call this x_1,
   b. Use the *Velocity vs Time* graph to identify and report the velocity of the cart at t_1. Call this v_1,
5. Pick a time toward the end of the run and call it t_2. State that time.
   a. Use the *Position vs Time* graph to identify and report the position of the cart at t_2. Call this x_2,
6. Use the kinematic equation $(v_2)^2=(v_1)^2+2a(x_2-x_1)$ to determine the velocity of the cart at the end of the interval. (Note that you determined the acceleration of the system in Questions 1 and 2.)
7. Use the *Velocity vs Time* graph to identify and report the velocity of the cart at t_2 (i.e., at the end of the interval). Call this $v_{2,graph}$,
8. Do a % comparison between the *end-of-interval velocity* values you determined in Parts 6 and 7. Comment.
9. There are two other kinematic equations you haven’t used in this lab. It would be interesting to see if they actually work over the time interval you have chosen. To see:
   a.) Write down $\Delta x = v_1 t + .5at^2$, then put in the numbers for the time interval you used. Briefly comment on whether the right-side of the equation really does equal the left-side of the equation, and as a consequence whether that kinematic equation is working for that interval. (BE AWARE: the “t” variable isn’t a specific time but, rather, the time interval you are looking at--that is, that variable is really a Δt.)
   b.) Write down $v_2 = v_1 + at$, then put in the numbers for the time interval you used. Comment on whether the right-side of the equation really does equal the left-side of the equation, and as a consequence whether that kinematic equation is working for that interval.

To turn in

1. Your Google Sheet containing your data and graphs
2. BLURB WELL the work and answers to the above questions.. You can write this up on the engineering pads and then scan it into a single PDF to submit, or type it up in a Google Doc and

insert photos of your handwritten calculations. In any case, it should be submitted to your Google Classroom account.