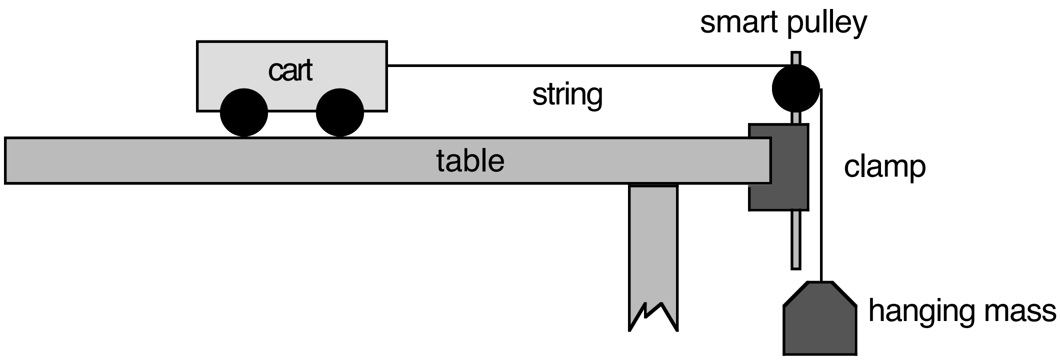
Lab: Kinematics AP Physics

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 position of a moving cart as a function of time and generate graphs of the car's motion.

Objectives
The objectives of this lab are to a) learn to operate the Lab Pro and Logger Pro tools, b) perform graphical analysis of motion data, and c) verify the kinematic equations.

Equipment

Lab table	Computer	LabPro Unit
LoggerPro software	Mass (50.0g)	Smart Pulley
cart	string	table clamp



Procedure
1. Set up cart/pulley system as shown, with Smart Pulley plugged into LabPro.
2. Start up LoggerPro software on computer.
3. Configure Logger Pro so that it recognizes the Smart Pulley as a "photogate timer" with a 10-spoke, inner groove" pulley.
4. Use LoggerPro to collect position-time data for your cart as it accelerates across the table. Be sure to catch the cart before it hits the Smart Pulley. Logger Pro will be displaying position-time, velocity-time, and acceleration-time graphs as the data is collect.
5. Examine the position-time graph, and then the velocity-time graph for the cart's motion. If both graphs have the appropriate shape, use the LoggerPro software to determine the slope of the velocity-time line.
6. Print two copies (one for each lab partner) of the data table and graphs, with both lab partners' names printed in the footer.

Other Stuff
Please refer to the *Checklist of Items to Be Completed for Each Experiment* for what to include in your lab notebook before you start answering the questions below!

ALSO, please note that that your x_{initial} and v_{initial} are almost certainly *not* 0 at time $t = 0$. Your data should allow you to determine what those initial values are for x_{initial} and v_{initial}, so that you can use them in your calculations.

Questions
1. What is the velocity of the cart at time t=0.5 seconds? (You may choose a different time to analyze if your cart wasn't moving at t=0.5 s.)
   a. Determine $v_{0.5}$ using the velocity-time data or graph (with explanation).
   b. Determine $v_{0.5}$ using the distance-time data or graph (with explanation).

c. Determine $v_{0.5}$ using the equation $v_2 = v_1 + a\Delta t$, and any data from your data table or graphs. (Explain your method, and identify appropriate data points on graphs.)

d. Determine $v_{0.5}$ using the equation $v_2^{\ 2} = v_1^{\ 2} + 2a\Delta x$, and any data from your data table or graphs. (Explain your method, and identify appropriate data points on graphs).

2. How far did the hanging mass travel between t=0.25s and t=0.6 seconds? (You may choose a different time interval to analyze if your cart wasn't moving between 0.25 and 0.6 s.)
   a. Determine Δx using the distance-time data or graph (with explanation).
   b. Determine Δx using two data points from the velocity-time data or graph. (Explain your method, and identify appropriate data points on graphs.)
   c. Determine Δx using the equation $x_2 = x_1 + v_1 t + \frac{1}{2} a\Delta t^2$ and any data from your graphs. (Explain your method, and identify appropriate data points on graphs.)
3. Calculate percentage differences between your largest and smallest values in Question 1 and comment. Do the same thing for Question 2.

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Additional Notes

1. This lab handout has a specific description of a lab you have been assigned to perform: it provides you with a specific list of equipment that is to be used, a "cookbook"-style procedure (just follow the instructions), and a specific list of questions to be answered. Some of the labs we do in here will be of this format, but some will be a little more open-ended: you may not receive an equipment list, you may not be given a specific procedure, you may not be given a specific list of questions that must be answered. Nevertheless, in these open-ended labs, you'll be expected to describe the same things in your write-up:

- What are you trying to figure out?
- What equipment are you using?
- What data did you collect?
- How did you analyze the data?
- What conclusions did you come to?
- What sources of error were there in the lab?

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Teacher Notes:

First Lab--check all computers out beforehand, including monitor, tower, LabPro hardware, LoggerPro software, printing

Before lab, set up Logger Pro file that has correct graphs already on screen

In-lab introductions for this first meeting:

1. Orientation to room: where can they find stuff?
2. Work off right side of the table
3. Take entire set of masses with you (to avoid losing them)
4. Cart is like a turtle--flip it upside down so it can't wander off

In-lab instructions to Students:

1. Monitor on
2. Tower on
3. Login: physics/physics
4. Assemble equipment for lab, THEN...
5. Double-click Logger Pro
6. Set up sensor
    a. Select sensor, if necessary
    b. Select configuration (if required; 10-spoke grooved pulley for this lab)
    c. Zero sensor, if necessary
7. Click "Start" to collect data. Wait until button turns red before releasing cart. Then click "Stop."
8. Select data and Zoom to focus on it
9. Do data analysis:
    a. Linear fit on selected data (high correlation?)
    b. Quadratic fit on selected data (low Root Mean Square Error?)
10. Printing
    a. Can print entire page or just a selected graph/data table
    b. Use Print Setup to orient printout to your liking
    c. Include a footer with your name, and any salient comments (cart mass = 499.83g, etc.)

For this lab, specifically:

1. Students don't *have* to use t=0.5s, or 0.25s, or 0.6 s. Those are just examples.
2. Make sure data table shows selected data so that you can use it in your analysis
3. Is the string parallel to the table? That can cause a decreasing acceleration over time.

Answers to Questions

4. What is the velocity of the cart at time t=0.5 seconds? (You may choose a different time to analyze if your cart wasn't moving at t=0.5 s.)
    a. Determine $v_{0.5}$ using the velocity-time data or graph (with explanation).
    Read from velocity-time graph or data table directly. (Best value)
    b. Determine $v_{0.5}$ using the distance-time data or graph (with explanation).
    Determine from *slope* of distant-time graph, possibly using regression. (May be off a little)
    c. Determine $v_{0.5}$ using the equation $v_2 = v_1 + at$, and any data from your data table or graphs. (Explain your method, and identify appropriate data points on graphs.)
    Determine using regression from the velocity-time graph and the selected time value. (Should match a)
    d. Determine $v_{0.5}$ using the equation $v_2^2 = v_1^2 + 2a\Delta x$, and any data from your data table or graphs. (Explain your method, and identify appropriate data points on graphs).

Select position values and acceleration from regression. (Should match *a*)

5. How far did the hanging mass travel between t=0.25s and t=0.6 seconds? (You may choose a different time interval to analyze if your cart wasn't moving between 0.25 and 0.6 s.)
   a. Determine Δx using the distance-time data or graph (with explanation).
      Read directly from graph
   b. Determine Δx using two data points from the velocity-time data or graph. (Explain your method, and identify appropriate data points on graphs.)
      Area under the curve unlikely, but vf^2 = vi^2 + 2 a Δx would work.
   c. Determine Δx using the equation $x_2 = x_1 + v_1 t + \frac{1}{2}at^2$ and any data from your graphs. (Explain your method, and identify appropriate data points on graphs.)
6. Calculate percentage differences between your largest and smallest values in Question 1 and comment. Do the same thing for Question 2.