COMPILATION: Unit 3 - Acceleration lab (inclined rail lab, ball on ramp lab)

Date: Thu, 27 Sep 2001
From: mitchell johnson <mitchjohnson@EARTHLINK.NET>
I just had egg on my face during the acceleration lab.
When students let their Pasco carts run down the ramp, I forgot to catch the students so they could reset their time to zero instead of the time that the computer gave them. This may be the problem linearizing the graph but my parabola was very evident. This is a serious problem for me because I can't get the 1/2 for the at^2 because the 2 seconds ^2 is a lot smaller than 4^2. Unfortunately I didn't catch it until they were gone. I guess we will be re-whiteboarding that one!

Date: Fri, 28 Sep 2001
From: Stan Hutto <shutto@AHISD.NET>

I did the lab two different ways.

(1) AP class: Use PASCO track and carts, with an small Al pie pan attached to the cart. I got the best results by using a separate support to hold the motion detector away from the end of the track. Secondly we started the carts at the bottom and gave them a push up the track. That way it was only gravity doing the "release" at the top. Also we double checked that the detector was indeed detecting the cart by slowing moving the cart up pushing with a meter stick from behind and checking the correlating position on the screen graph.

Got great results. Did the lab at several angles and plotted acceleration vs. sin of angle and then extrapolated to 90 degrees and compared to accepted g for San Antonio g=9.793 and got great results - typically less than 1% error.

(2) Pre-AP: Did the lab using 1" steel ball-bearing and rail made from utility shelving support - about 4 feet length. We set the shelving rail on the PASCO tracks and then used photogate pair set at the pulse mode (Vernier experiment folder - Sensors - Pulse). I set the first photogate at the 2-cm mark thus allowing room to place the ball bearing on the rail close to the photogate, and then we placed the second gate at positions of 10-cm intervals (12-cm, 22, 32, etc.) Did at least five runs per position. Collected 10 data points. Got excellent results.

Using the PASCO track allowed the students to easily mark the photogate position by lining up the light opening with the tape rule on the track and then raising the gate until the light just blinks off. Then they are consistently measuring the same portion of the ball - which can be determined by moving the ball through the gate with a ruler and marking the points where the light goes on and off (enter length for velocity data).

Once again classes got great results. When we analyzed the P-T graph slopes for velocity and plotted vs. time we got very straight lines and then the V-squared vs. Position graphs were also good, with a nice correlation of the slopes. The ratio of slopes of the V^2-P, V-T, and the quadratic variable from P-T curve gave the expected ratios.

Date: Sat, 29 Sep 2001
From: John Barrere <forcejb@YAHOO.COM>
In my current low-tech environment, I've done the ball on the ramp quite successfully (ie, graph is a parabola) using a group of students who simply hand-time the ball's delta position. Eight foot ramp (0.5" aluminum channel) at a shallow angle works well.

Date: Wed, 3 Oct 2001
From: Glenn Wagner <GWAGNER@CWDHS.UGDSB.ON.CA>
I hope someone can help me with this experimental problem. Using sonic rangers we let a Pasco cart roll down the track collecting the d-t data. We get the parabolic nice curve. BUT when we go to linearize (squaring the time) the first 1/4 to 0.5 seconds has distinct non-linear part (almost a square root behavior in the time) followed by the linear part as expected. Does anyone else experience this problem and does someone have a solution?

Date: Thu, 4 Oct 2001
From: Jeff Steinert <jsteinert@AUBURNSCHL.EDU>

Glenn Wagner wrote: '... Does anyone else experience this problem and does someone have a solution? '

I believe this can arise in two possible ways:

1) If the car is moving initially (more than a few mm/s, check the velocity vs. time graph), then squaring the time will not linearize the graph due to the presence of the "initial velocity x time" term. In this case, squaring the time values gives a side-opening parabola, the later parts of which may appear to be straight.

2) A more common experience with motion detectors is that the time is not equal to zero at the same instant that the velocity is equal to zero. If this is true, it is possible to linearize the graph, but you first must adjust your graph so that v=0 at t=0. I'm not sure most students will understand why this is necessary, but I'd use the following procedure:

First, determine the time at which the velocity is equal to zero using the v vs. t graph (say, for example v=0 at t=1.3 s).
Second, create a new column of values (t') equal to your original times minus the 1.3 s (t'=t-1.3s). This will shift the v=0 point to t'=0.

Finally, square the values of t' and plot displacement vs. t'^2. This should nicely linearize the data, but may confuse the issue for most if not all students.

Another option is to use photogates and small picket fences to do this experiment. You will still encounter the difficulty of getting an initial velocity close to zero, but since timing does not begin until the gate is blocked, there is no need to shift the times to achieve a linear graph.

Date: Thu, 4 Oct 2001
From: Matt Greenwolfe <matt_greenwolfe@CARYACADEMY.ORG>
I have observed this with some of my lab groups, and not with others. My suspicion is that the start button is pushed before the cart is released so that there is a period of zero velocity at the beginning of the motion. It seems easier to time this correctly if the cart is pushed up the incline and start is pressed when it reaches the peak. However, this may introduce some complicated issues earlier than you might want.

Date: Thu, 4 Oct 2001
From: Sean McKeever <mckeever@PASCO.COM>

The problem with your motion sensor data could be related to data collection starting before or after the cart is moving. You could try using a photogate as a trigger to begin the data run, while using the motion sensor to collect the position-time data.

First, you would specify a start condition that will start timing when the photogate is blocked.
Put a picket fence on the cart and position the cart so the flag is just outside the gate.
Release the cart and the photogate will start the data collection.

The motion sensor will then begin capturing position-time data.

In addition, it would be useful to specify a stop condition to automatically stop data collection when the cart is 0.9 meters from the motion sensor.

Date: Fri, 5 Oct 2001
From: Andrew Schuetze <aschuetze@ACADEMICPLANET.COM>

Here's an idea that just came to mind when reading the suggestion to use photogates and a picket fence on the cart. The issue is to start the data run the instant the cart starts moving. How about a smart pulley. You can program a start condition and don't have to worry about the cart position relative to the sensor. Place the pulley on the uphill side of the ramp and use just the mass hanger. I wouldn't expect that the mass of the system is going to effect the results that you are looking for in this case.

Date: Fri, 5 Oct 2001
From: Jerel Welker <jwelker@LPS.ORG>
Subject: Linearizing parabolic data

From the math view:
Jeff Steinert's comment about linearizing parabolic or quadratic data when t=0 does not occur when v=0 is exactly correct. Linearization produces

y = (1/2)a*t^2 + c

where a is acceleration and c is the initial position. In mathematical terms this leaves out the "bx" from

y=ax^2 + bx + c.

The "bx" term is initial velocity in the physics model. If initial velocity is present, linearization adds it to "c".

The vertex form

y = (1/2)a(t - h)^2 + k

shows the vertex of the parabola which is where the velocity is zero. h is the time when the velocity is zero and k is the distance.

Note: If h is not zero and you multiply out the model, there is an initial velocity term.

If you'd like to see more with actual data, quadratic regressions, etc, visit the following site and follow the analysis of the data.

<http://lhs.lps.org/instruct/ballramp.htm>

Date: Sat, 6 Oct 2001
From: Mears Brian <Sidney313@AOL.COM>
Subject: How to model without money?

[My] school is well known for its ... financial problems. ... I need to come up with models without the use of standard equipment (including computers).

For the accelerated particle model, I had the students use long pieces of used molding, steel balls, and stop watches to observe, and measure the rate of the balls at specific positions on the molding (track).