COMPILATION: Motion detectors (sonic rangers) & their problems

Date: Thu, 20 Sep 2001
From: "Park, Nicholas" <ParkN@CFBISD.EDU>
Subject: Sonic Rangers

I'm trying to use sonic rangers with the cart-down-incline lab, and experiencing great frustration (as is usual with sonic rangers...). With a cart that is visibly speeding up, the sonic ranger at some lab stations consistently produces a nearly-straight position vs. time graph. With one group, I finally had them go back and do a rough timing run with stopwatch and meter stick. This produced (albeit with alot of measurement error) a clear parabola, so something is obviously wrong with the use of the sonic rangers. Does anybody have any helpful experience or suggestions about this?

Date: Thu, 20 Sep 2001
From: Fran Poodry <FPoodry@AOL.COM>

First check and see if it is some object near the side of the track, or the track itself. If you have the kind of sonic rangers that are hinged, angle the speaker/microphone upward slightly. If not, place a sheet of cardboard under it to make it tilt somewhat. Or, a student may be leaning over the track during the run, or a support rod may be getting in the way of the reading.

Date: Thu, 20 Sep 2001
From: Vaughn Jones <VBJONES@AOL.COM>

I have found that a light, styrofoam cylinder or sphere mounted on top of the cart improves results as there is a curved surface which always reflects directly back to the ranger. I suppose a cardboard cylinder would work as well. (Better than a flat surface)

Date: Fri, 21 Sep 2001
From: Sean McKeever

Perhaps you're starting the cart too close to the motion sensor. Motion sensors all have some "personal space isssues". Vernier's model will not measure any object closer than 40 cm. PASCO's older model has the same limitation, but newer model will measure as close as 15 cm.

Date: Fri, 21 Sep 2001
From: Bob Baker <bob.baker@WORLDNET.ATT.NET>

Some of my students just ran the rail lab using the Pasco sonic ranger set on short range and a 2.0cm diameter marble rolling down the rail. The data showed a very nice parabolic curve with a COR of .999. The students did start the marble at least 20 cm from the ranger. The students adjusted the positions given by the computer so that the initial position of the marble was zero and the initial clock reading given by the computer was zero. The marble was held before release with a horizontal pencil to keep the hands as far away from the signal as possible.

Date: Fri, 21 Sep 2001
From: "Brewer, Hugh D" <hdb752f@SMSU.EDU>

WIth the sonic rangers (motion detector) when you have a straight line, this usually indicates the detector found one distance (like the floor or other large object--student) and never read the motion of the cart. Place a cardboard square about 6"x6" on the cart and try. This week we had similar results with student getting graphs like that. Once the cards were attached to the cart the data was very good. Remember to start about 40 cm from the detector.

Date: Sun, 23 Sep 2001
From: Ellis Noll <Ellis_Noll@WEBBSCHOOL.ORG>

I have experienced the same problem that Nicholas Park described with sonic rangers. With a cart that is visibly speeding up, the sonic ranger at some lab stations consistently produces a nearly-straight position vs. time graph."

My experience has been that the graph is actually a parabola but appears as a straight line since only a few data points are plotted in the downward path of the cart. A small segment of a parabola will appear to be a straight line. I approached this problem by having the cart start from rest. With this approach, the parabolic nature of the graph is quite clear.

Date: Mon, 24 Sep 2001
From: "Park, Nicholas" <ParkN@CFBISD.EDU>

A point of clarification: the graphs we were obtaining were not horizontal -- I understand what would cause that; rather, they were straight and diagonal, indicating that the cars were moving at a constant speed, which they obviously were not -- and neither was anything else around them... I'm still stumped, unless it is an artifact of the "personal space issues" which Sean mentioned. I've switched to spark timers, and am getting great results -- plus the added benefit of additional exposure to "real life" motion maps.

Date: Wed, 26 Sep 2001
From: Pat Westphal <westphap@DATAEX.COM>

I read some of the messages/replies to Nick regarding the sonic rangers and the inclined plane paradigm activity. I thought I would try my hand at confusing the issue.

Because the position-time graphs are parabolic, the greatest change in velocity occurs in the first few centimeters of movement. (Remember the velocity-position graphs? They show a decreasing positive slope so the speed changes less during a cm at the bottom of the ramp than during a cm at the top.) Look at the shape of the parabolic curve and it looks linear after several seconds of movement (or at positions near the bottom of the ramp). If the motion detector is missing the first part of the movement, the bottom of the parabola seems to disappear to inexperienced eyes. This is particularly likely with motion detectors since anything closer than about 0.5 m from them is not "seen". Spark or dot timers don't suffer this myopia.

I have my class in six groups for this activity: Half of the groups use stopwatches and rulers; the other half use photogates and rulers. Three different objects are used: a marble rolls down the crevice between two pvc pipes taped together; a Hot Wheels car rolls down its custom track; a dynamics cart rolls down a wooden plank. The photogate groups and the stopwatch groups get equally good data. Often they need to do the experiment twice. This is because I don't tell them to be sure to get plenty of data for short position-time pairs where the predicted position-time graph is "interesting". So we, too, get some straight line graphs.

During whiteboarding, we ask "If the car appears to be increasing speed, why does the graph look like constant speed?. I have never had to point out the problem to them. Someone in the class ultimately notices that the end part of the parabola looks straight and that "maybe we need to focus on short distances and times" to test our hypothesis more carefully. So the linear groups come in after school (or before) and spend the 15-20 minutes it takes to re-gather data.

Sometimes science doesn't get solved in one period. The beauty of modeling paradigm labs is that most are so short that they can be done in a few minutes even if discussion of them takes a few DAYS.

Date: Wed, 3 Oct 2001
From: Glenn Wagner <Glenn.Wagner@ugdsb.on.ca>
Subject: constant acceleration and Pasco carts

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>

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 Green <matt_green@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 (see Jane's suggestions from a few days ago). 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.
