COMPILATION: Unit 9 - impulse-momentum paradigm lab

Date: Wed, 23 Feb 2000
From: Armand Amoranto

I have been working with my students on the Impulse lab in Unit 9 over the last two days. The data we are getting is horrible. The values for impulse are on average 10-25% the values we are getting for the change in momentum from the values from the motion sensor. Our problem is that the amount of data we are getting from the collision is at most 2 or 3 peaks on the force graph. At first we were getting only 1 or 2 points in the peak. This meant that there was a high probability that the values for the force that we were getting were not the actual force that the force sensor applied to the cart. Does anyone have any ideas how to improve the lab performance? This is the first time I am trying this lab.

Other things we have tried:
Increased the sampling rate to 200 Hz. Increased it to 2000 Hz. But neither produced better data.

Help me.

Date: Wed, 23 Feb 2000
From: "Richard J. McNamara"
Hi Armand,
Have you tried calibrating the force sensors? An even higher sampling rate might help too, because there is a small time delay between the force's sensor analog output and the motion sensors digital output. Other than that, I'm not sure what else to do.

Date: Wed, 23 Feb 2000
From: Joseph Vanderway <jvanderway@CSUN.EDU>
Try using a compressable spring on the sensor or the cart to extend the duration of the collision.

Date: Thu, 24 Feb 2000
From: John Barrere <forcejb@YAHOO.COM>

Regarding the problem Armand posed, I ran thru the impulse lab after school today. Stationary (calibrated) force probe with a 2N, 20 N/M spring attached to it. Other end of spring had about 40 cm length of string which attached to cart. This slack let me get the cart moving before loading the spring. Total cart mass was about 1.5-2.0 kg. Motion detector for velocity; got agreement of (m)(delta v) with integral of F vs. t within 2-3 %.

Date: Fri, 25 Feb 2000
From: Douglas Vallette <dvallet@UCF.K12.PA.US>

Summary: A different(?) way to impulse.
How a student and I figured out what was going wrong with the photogates.

I just finished the impulse-momentum lab, but I did it a different way. (I think I got the idea from an earlier post.) I had students start the cart from rest, and pull it with a string attached to a force probe. We considered the area under the curve, the average force, the time of the pull, and the velocity of the cart after we stopped pulling. We measured the velocity just after pulling by passing the flag end of the small picket fence cards through a photogate. (Some students chose to use the other end, and had to reflect on which velocity was best (average, initial, etc.)

Results: Some groups got within 2-3% on the results; others had 20% error. There were several problems:

Problem (1) The Pasco 500 interfaces default to 10 Hz data rate (don't ask me why.) They can't handle more than about 500 Hz. We got good force results between 200-500 Hz.

Problem (2) I actually have a couple of force probes that won't zero properly when we tare them. Calibration curves are way off, and need to be re-calibrated carefully.

Problem (3) When measuring the velocity after the pull, the cart would sometimes travel as long as a second before passing through the gate.

Problem (4) Photogates are not necessarily precise when dealing with high speeds. This leads me to story #2 (with a good ending.)

Summary: Clee, A hard-working student and I spent an hour last Friday after school figuring out why his momentum-conservation data was systematically low.

Here's how it happens. One photogate consistently read a velocity that was about 5% lower than the second, even if we pass the same cart through two gates side by side (~1 cm apart), in either direction. Changing data rates doesn't help because the data rate controls analog, not digital input. The quoted digital rate is 10 kHz. Despite this, the "time within the gate" measurement for a flag (2.5 cm) passing through each gate differed by 0.001-0.002 seconds consistently. Why? I'm guessing it is because the photodetector circuitry has a response time on the order of 1-2 ms. Perhaps the photogates have different response times. It seems that with speeds of 0.5 m/s or so, the error in time measurement is a significant fraction of the time in the gate (5%.)

Clee astutely said: "Oh, so if I use the 10 cm flag, I should have 1-2% error." He tried it, and he was right.

What do you think?

Date: Sat, 26 Feb 2000
From: Larry Dukerich <dukerich@ASU.EDU>
Armand Amoranto wrote the following:
>I have been working with my students on the Impulse lab in Unit 9 over the last two days. The data we are getting is horrible....

I, too, have had difficulty with this experiment. I now do it as a demo with the computer hooked to a larger monitor so I can display the graphs to the class. I find that if I do the following:

1. use a Vernier dual range force sensor that is securely attached to a ring stand that is clamped to the desk.
2. make sure that the plunger on the PASCO cart lines up with the tip of the sensor and strikes it dead on (not at an angle).
3. reduce averaging on MacMotion from 9 pts to 7.
4. leave the sampling rate at its default value (too large a sampling rate gives a noisy curve).
5. use relatively low velocities (0.25 - 0.4 m/s) when I push the cart toward the sensor,

then I can get impulses (by integrating the force vs time curve) that are often within 20% of the change in momentum. My students are not too troubled when we calculate m-delta-v to be 0.35 kgm/s and find that the impulse is 0.30 Ns. What really seems to be most instructive is to show that while the force sensor was reading 0, the velocity was nearly constant. The CHANGE in velocity occurred at the same time that the sensor showed a spike. The shaded area under the triangular spike matches (pretty well) the region where the velocity is changing. BTW, I use the velocities given at the outer edges of the shaded region as Vi and Vf.

I would appreciate it if anyone out there has a recipe for getting better results than the one I have provided.