COMPILATION: unit 5 - Newton's 2nd Law lab variations

Date: Sat, 20 Oct 2001
From: John Barrere <forcejb@YAHOO.COM>
Subject: modified Atwood extension

I was fiddling with some equipment on a teacher workday (aren't they all???) and came up with what may be a decent 2nd law extension/practicum. It is done after establishing << a = F/m >> in the first lab. My objective (for the extension I think) is to get to << a = Fnet/m >> by discovery rather than assertion. In the interest of brevity, the description below eliminates most of the discussion questions that would accompany the activity.

Using a PASCO car with picket fence and photogate, set up the modified Atwood machine and add a second pulley and string pulling opposite to the first (hanging off the other end of a lab table). Hanging masses equal on both strings. Tap the car and it will fairly quickly come to a stop. Measure its (negative) acceleration. Do a force diagram for the car. "Why does it accelerate to a stop?"

Now add some extra mass to the hanger so the car will accelerate in the same direction as the motion of the previous tap. Measure this acceleration. "What would the acceleration be in the absence of friction?" Hopefully the kiddos will see that the acceleration would be the sum of the second and the magnitude of the first.

Do another force diagram. Using << a = F/m >>, given the system mass and the "friction-corrected" acceleration, calculate what the force should be. It is neither of the horizontal tension forces, but rather the difference of the two. I did this with an actual <<delta F>> of 0.98N; the calculated force (based on "friction-corrected" acceleration) was 0.95N.

Voila!!

This same arrangement should work well for a lab practicum. Have I reinvented the wheel??

Date: Mon, 29 Oct 2001
From: Warren <rkinney1@BELLSOUTH.NET>

If it hasn't been brought up before, we use a neat experiment for F=ma. It's a variation of the PSSC experiment, but takes less time than counting dots on timing tape, but students miss the visual spread of the timing tape. We use the PASCO 2.2 m track, a dynamics cart, the inexpensive fans that attach to the cart, the black masses that are supplied with each cart, and the motion detectors. The experiment is introduced, and the students measure acceleration with one, two, three, four, and five masses. (Teams must share masses.)

The students plot acceleration as a function of mass, and the hyperbolic curves that they obtain are quite impressive. Of course the curve produces a constant when aXm is computed. Students are led in the pre-lab discussion to the assumption that the four AA batteries, which drive the carts, provide equal power for each run.

I would like to go back the other way and use a constant mass with changed power; i.e., one, two, three, and four batteries, but can't seem to make a good connection; if anyone has any ideas, I would be most interested.

Date: Mon, 29 Oct 2001
From: Jean Oostens <oostens@CAMPBELLSVIL.EDU>

With constant voltage applied to the motor of the fan, the force is constant (as long as the speed of the cart is not too large). The Pasco Fan-cart has a switch allowing two fan speeds. Further changes can be brought by using a combination of NiCd batteries or Metal Hydride, which yield 1.25 V each instead of 1.50 Volt. Of course, using different batteries might change the mass of the cart somewhat.

Another trick is to replace some of the batteries by an aluminum cylinder of the same shape. Here again, the mass could be affected.

HOWEVER: you still have the problem of finding the relation between the voltage and the force produced by the fan. Here, placing the fan on a balance, with the blades in a horizontal plane can provide the answer. I used at one time a digital balance with a tare button, to zero out the weight of the cart.

Rather than using as a reference the voltage of the battery, one could measure the speed of rotation of the propeller vith a photogate.

So it looks like a good science fair project, but would make a rather complicated scheme for a 50 minute lab (:>.

Have fun with this, if you try it, and I hope you do.

Date: Tue, 30 Oct 2001
From: Marc Reif <mreif@FAYAR.NET>

Instead of using the fan attachment for the Pasco dynamics cart, you could use a Pasco fan cart. It's more expensive, but it lets you change the angle of the fan to get different forces.

Date: Tue, 30 Oct 2001
From: Paul Sedita <Seditap@CANANDAIGUASCHOOLS.ORG>

Warren wrote: << I would like to go back the other way and use a constant mass with changed power; i.e., one, two, three, and four batteries, but can't seem to make a good connection. >>

I'm not sure what you mean by "can't make a good connection," but I'll take a stab. The increase in voltage (from 2 to 4 batteries) is not directly proportional to the resulting force. In fact, a doubling of the voltage should lead to 4x the force ($F \sim P \sim V^2$). Experiments w/ the Pasco carts (w/ attachable fan accessory) have verified this relationship very nicely for fresh batteries. This may be why the connection isn't being made.

Date: Thu, 15 Nov 2001
From: Pat Westphal <westphap@DATAEX.COM>
Subject: Newton's Second Law Lab

We recently finished the two-part activity investigating the dependence of acceleration upon net force for constant mass systems and the dependence of acceleration upon mass for systems to which the same net force has been applied. But we completed the exercise in a different way than we have before. It worked wonderfully and more smoothly than I could have imagined.

After establishing that acceleration is proportional to the net force and that acceleration is inversely proportional to the mass, we hypothesized that the acceleration might be proportional to the ratio of the net force to the mass. With the six acceleration data pairs for the first lab (for which we knew six different forces and the system's constant mass) and six acceleration data pairs for the second lab (for which we knew six different masses and the constant net force), the graph of acceleration as a function of the ratio of Fnet/m yields a wonderful straight line with a class average slope of 0.94 m/s2 *kg/N. The slope was the same for all groups so it must be significant and the definition of the Newton fell out "miraculously". We also discovered that those who didn't compensate for friction (mostly in the first lab) got lower values for the slope.

This method eliminated my old "hand waving" and "definition" technique of uniting the two variables into the familiar form of Newton's second law. My students all write the law this way now: Fnet = K ma where K = 1N/ kgm/s2 and it makes perfect sense to them. I'm happy:-) and maybe it will be useful to you.
