COMPILATION: Unit 4 - Newton s 3rd law lab

Date: Tue, 15 Dec 1998
From: "Douglas A. Johnson" <djohnson44@ameritech.net>
Subject: Newton's third law lab

My colleagues Mike Lyman (U Akron site) and Betsy Barnard (ASU site) and I have hit upon a slight variation -- as far as we know -- in convincing students that the third law always holds. We made this our paradigm lab for the unit.

We used the "student" force probes, but any of them should work. We mounted a probe on each of two ringstands in such a way that the s-hooks would push on each other -- or pull. (One of them must be upside-down or a couple of screws meet first. It would have been a good idea to affix some flat surface to the s-hooks so they wouldn't keep sliding off each other. Next year.)

The bases of the ringstands can be loaded with mass (we used a brick) and one of the stands can be pushed or pulled. The students saw that this allowed us to model the worksheet with all the A/B interactions. (We showed them the worksheet before doing the lab, but didn't have them do the force diagrams until after the lab. When we assigned the worksheet, we had them do force diagrams for both A and B.)

In the pre-lab we guided them to see that there were three kinds of things that could be changed:

1) Mass (A=B, A<B, A>B)
2) Interaction (push, pull)
3) Motion (Acc. = 0, Acc. is +, Acc. is -)

I think that makes 18 different combinations.

We made a check list in which to record the resulting forces. There are only two qualities for force: magnitude and direction.

For magnitude, there were columns for A=B, A>B, A<B
For direction, there were columns for A and B both +, A and B both -, A and B in opposite directions.

The students made a grid that was reminiscent of the one we used for the Conservation of Momentum lab.

The only data gathered was to look at the graph of force vs. time and judge which force was greater and in which direction the forces were.

When all was finished, every student had checkmarks in only two columns! They simply have to accept that the forces in an interaction are always equal and opposite! If they ever slipped up, a quick reminder such as "What did you see on that checklist...." snapped them back to the world of physics.

Date: Thu, 17 Dec 1998
From: Fran Poodry <FPoodry@AOL.COM>

Yay Doug! (and Betsy and Mike)!
Now all I need are the force probes...we did it all with bathroom scales and spring scales, and the kids still aren't quite convinced. The bad thing about modeling is that you can no longer tell kids something is true and have them believe you. Back before modeling, kids always believed what I

said because I am a science teacher and therefore I must be right. Now they want to prove everything, and my mere word isn't good enough.

Date: Thu, 17 Dec 1998

From: gheri fouts <gfouts@pixi.com>

Paul Hewitt has an interesting set of labs for 3rd law that I use where the students pull on spring scales. It is a gradual step-by-step lab and they soon get the idea. But alas, some of them jump right back into their own mental set right afterwards, but only a very few. Check it out in his lab book.

Date: Mon, 21 Dec 1998

From: Eric Gardner <ktp@gate.net>

I've tried hooking a rubber band between two equal mass Pasco carts and stretching the rubber band. I ask "Is the rubber band pulling on each cart with the same force?" To which they all say yes . Then load up one cart with two or three 500g bars. Repeat. With a little probing they "seem" to be convinced that the rubber band still pulls on each the same. Now I bridge to the "rubber band" force of gravity being mutually attractive. I move the carts with a constant velocity while the band is stretched, and ask the same question. Then I try to accelerate the carts and maintain the constant tension in the band.

Then I turn the carts vertical and call the massive cart the earth and the less massive one the "ball". We discuss Newton's third again!

Date: Wed, 1 Apr 1998

From: Mark Campione <mcampion@BCIU.K12.PA.US>

I was hoping someone could help me. I was trying to set up the demonstration of Newton s 3rd law using 2 force probes and the ULI. I am not sure if I am to use MacMotion, Data Logger, or some other software and I am not 100 percent sure of the complete set-up.I was hoping for the outcome that I had seen at the workshop, equal and opposite forces displayed on 2 graphs.(If using Data Logger, is a Volts to Newtons conversion needed?) (Calibration of both force probes is also not clear.)

Date: Wed, 1 Apr 1998

From: Jean Oostens <oostens@CAMPBELLSVIL.EDU>

I assume you would want to use Data Logger. You need to calibrate each of the two probes in the very position in which you plan to use it. This is because the weight of the hook will change the reading if you turn one of the probe upside down after calibration. For calibration, use the same known mass and figure its weight in Newton. Use a pulley to change the direction of the force if needed.

The demo can be done by attaching the two probes with a string, or with a spring. The latter allows a smoother variation when two persons pull the probes apart.

A third way that I used in Akron is to mount magnets on the probes in such a way that they repel each other, and varying the distance. This shows that even "non-contact" forces obey Newton's third law.

Additional demonstrations:

(1) Make a coil (about 100 turns) wound on a light plastic bottle and place it on an electronic balance. Tare it to read zero. Just above the coil, suspend a magnet attached to a force sensor. Run a current (about 1 amp) through the coil, and observe the proportionality between the readings of the balance and the force probe (Both are proportional to the current, by the way).
(2) Suspend a copper tube from a force probe. Then drop a neodymium magnet through the tube. The magnet reaches a terminal velocity when the eddy currents just cancel its weight. Newton's third law requires that an upward force would appear somewhere else. Look at the force probe reading during the time the magnet falls through the tube.
To confirm, place the magnet on the edge of the top of the tube, so as to read the sum of the weights of the magnet and the tube.
(3) Place a beaker with water on a balance. Suspend an object denser than water from the force probe. Archimedes Principle tells us that the object will undergo an upward push. Where will the corresponding reaction be ?

Date: Fri, 10 Apr 1998
From: DoYost <DoYost@AOL.COM>
Third Law.
Connect two force probes. Reverse the reading on one of them. You can now push them together, or mount them on carts and bump them together. No matter what you do, you always get a positive and exact negative line on the graph.

COMMENTS ON THE COMPILATION ABOVE:
Date: Thu, 9 Nov 2000
From: Thomas J Gordon <tomgordon@JUNO.COM>
Force a 1-hole rubber stopper over each S-hook on your force probes when you want the two probes involved in a collision. Make a small slit in the small end of the stopper first.

MORE THOUGHTS IN 2001:
Date: Sun, 4 Nov 2001 10:31:34 -0800
From: mitchell johnson <mitchjohnson@EARTHLINK.NET>
Subject: Re: Worksheet 4 (Newton s Third)
I have my students do worksheet 4 with the two blocks pushing on each other. I have them put 1 kg on the pasco force sensor that the worksheet shows to have the greatest mass. I then have them graph f1 vs f2 and it is amazing how the slope always equals 1.