COMPILATION: Unit 4 - normal force (with updates)

Date: Wed, 18 Nov 1998
From: Fran Poodry <FPoodry@AOL.COM>

Today several of my students in one class insisted that they do not believe that an inanimate object can "push back." This is after going through the whole Camp and Clement bridging lesson on normal forces: mattress spring, foam pad, whiteboard on two supports, laser-and-table.

My students: all of these objects are simply RESISTING the applied force, not pushing back. When objects deform, they tend to revert back to their natural configuration, but they don't push back. One student: a spring only works the way it does because of its shape. If you stretch it out completely straight, then push on the ends, it won't deform. So the "pushing back" you feel is just a transient property. Most materials are not like springs.

Me: But how can you explain the demos with the spring and foam and whiteboard and laser on the table?

My students: They all resist the downward force of the object.

Me: What would it take to make you believe the objects push back?

Another student: Well, I don't want to say "seeing it" because we saw it and I still don't believe it. I don't know.

So, fellow modelers, how can I convince my students that if you push on an object, it pushes back on you? (I have access to a single PASCO interface with a single PASCO student force probe (strain gauge), if the other physics teacher isn't using it).

Date: Thu, 19 Nov 1998
From: Jean Oostens <oostens@CAMPBELLSVIL.EDU>

Try the following:

Take two magnets, one suspended from your force probe, the other placed on a balance. Approach the first magnet to the second, and observe the changes in readings of the balance and of the force probe.

The changes should be identical when converted in the same units (e.g. the weight in Newtons from ounces). This is consequence of Newton's third law.

The same can be done by having a water-filled beaker on the balance and immersing a block of metal hung by a thread from the force probe. (Add Archimedes to the list of contributors.)

Caution: Digital balances are sensitive to stray magnetic fields. Place an inverted styrofoam cup on the tray to isolate the magnet.

Date: Thu, 19 Nov 1998
From: Joseph Vanderway <jvanderway@EMAIL.CSUN.EDU>

Try this definition of a force: A force is an *interaction* between two objects (or systems) that results in a push or a pull.

- Yes, the last phrase is not needed, but it prevents "interaction" being interpreted in a "person interacting with his peers" kind of sense. -

Anyway, this definition can lead to the idea that any and all objects can interact with each other when they come in contact. Put a mass on a table and ask what the mass is interacting with. Each one of these interactions results in a force acting on the mass.

It is a bit harder to get into gravity, because the interaction doesn't require contact, but in general students seem to get the idea that the force of gravity is an interaction between an object and the earth.

Newton's 3rd law simply falls out of the definition because if the table interacts with the mass, then the mass interacts on the table.

From the dialog quoted, you might ask the students to define what they mean by "resisting the applied force". I have a guess that eventually they will be forced to describe "resisting" as "pushing back".

Date: Thu, 19 Nov 1998

From: Betsy Barnard <bbarnard@FACSTAFF.WISC.EDU>

After much struggle with a particular student not believing that a chair could "push up" on him I asked him to notice what direction his flesh was compressed when he sat. He noticed it was compressed "upward". So we all have normal force meters built right into our behinds!

Date: Tue, 24 Nov 1998

From: Fran Poodry <FPoodry@AOL.COM>

... is there a better way of training kids to say "normal force" rather than "natural force" (which they make up out of thin air) or "neutral force" (same phenomenon) other than simply stopping them and questioning them every single time they use the incorrect name?

Date: Wed, 25 Nov 1998

From: John Barrere <forcejb@yahoo.com>

Every time I hear the term "normal force", I have a hard time not thinking about Abbie Normal's brain in Young Frankenstein. Our use of "normal" seems tortured (abnormal?) to me - always has. Even though it doesn't flow very well, why not simply "perpendicular surface force" - it incorporates direction and the agent together.

Date: Wed, 25 Nov 1998

From: "Gill, Scot" <sgill@FAYETTE.K12.KY.US>

Mathematically, "Normal" means "Perpendicular". Thus Normal Force is an appropriate name as it incorporates the direction of the force nicely -- normal to the surface. The word Normal is a bit more general than Perpendicular as it applies to vector spaces whereas perpendicular only applies to geometric figures.

Date: Wed, 25 Nov 1998

From: Laura Sloma <LSloma@LUCKEY.NET>

On Tue, 24 Nov 1998, Fran Poodry wrote:

> Is there a better way of training kids to say "normal force" rather than "natural force" (which they make up out of thin air) ...

Egad!!!! I thought my students were the only ones doing this. They always call the normal force the natural force ... I have no idea where it comes from. I think I will question them more about this to see why they use that term and what it means to them.

Date: Mon, 30 Nov 1998

From: Brenda Royce <BRRoyce@attbi.com>

I was amazed the first time I heard students call it "natural" force! I had heard another teacher mention this phenomenon just prior to hearing it in my class, and it really seems to appear out of nowhere. It does seem once it gets started in a particular class, it's hard to stop. I'd also be interested in ideas for circumventing it (though, I'll have to admit, the term is at least somewhat logical since it "naturally" occurs when an object rests on a surface). Explaining the meaning of normal isn't adequate since that is not already a familiar term to most students.

When it came to discussing whether the table "pushes back", I also found the interaction definition of force very helpful. In the context of the bridging analogies, my students came to accept the idea of a surface-object 'interaction' pretty easily (even if they misname it!).

In regard to earlier comments on Newton's third law force pairs, it seems 'seeing is believing'. I just met with my local modeling colleagues tonight, and this came up. The consensus seemed to be that the students who observed thorough bathroom scale or Newton scale demonstrations were pretty well convinced, while those that missed the demonstrations don't quite get it. I know with my students I needed to go through three different states of motion (v = 0, const. veloc, and constant accel.) with the demos to convince most. I also found it was particularly important to draw system schema and force diagrams in conjunction with the demos while carefully guiding them to identify which forces we were observing in the demo. It still took a bit to untangle third law force pairs between two objects from Fg and Fn "pairs" on a single object in subsequent problems.

Date: Wed, 2 Dec 1998

From: Tom Gordon

Perpendicular = line at right angles to a point on another in 2-dimensional space.

Normal = Line at right angles to a point on a plane in 3-dimensional space.

UPDATES, posted a year later:

Date: Mon, 1 Nov 1999

From: Betsy Barnard <bbarnard@FACSTAFF.WISC.EDU>

Inanimate objects "pushing up?"

First I have a student push on his or her arm (or other fleshy part) and feel that their flesh "goes in". Their own flesh is a now a "normal force meter" that detects which way something is pushing on them. Then I tell my students to sit on the table and note that their normal force meter (their behind) detects that the table is pushing them upward. This usually does the trick.

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Date: Mon, 1 Nov 1999

From: stan hutto <fizwiz2@YAHOO.COM>

I found the compilation on forces very interesting, having forgotten the dialogue about "normal force" vs. "natural force". Last year was also the first time I ever heard my students use the term "natural force" and it seems that this same phenomenon occurred universally. I wonder if this term is/has/was used on some science program a la "Bill Nye" or in some predominant Phy Sci text that our students had been exposed to.

One way to perhaps divert the "natural force" syndrome this year would be to use the perpendicular subscript of an "upside down T" (I can't figure out how to draw that in this format) instead of the common "capital N" But then a new problem I'm sure will arise from that.

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Date: Thu, 11 Nov 1999

From: Brenda Royce <BRRoyce@attbi.com>

I was cleaning up older email and reread the normal force discussion. After reading Joseph Vanderway's comments, I thought I'd jump in with my 2 cents worth. I have found it helpful to use a similar definition of force: 'an interaction between two objects capable of changing the motion of an object'. Resistance to another object is quite capable of changing its motion -- I ask my students to decide what the motion would have been if the surface wasn't there (usually, it would fall), so the surface must be changing the object's motion. I also have avoided the dreaded 'natural' force pretty well this year by calling normal force a 'surface support force' and then adding the term normal force later (with 'normal' defined). I started this in an attempt to avoid the use of Fn for tension in a cable holding an object up.

COMMENTS ON THE COMPILATION ABOVE:

Date: Sun, 5 Nov 2000

From: Cindy Hunt <VWCACTUS@AOL.COM>

I think Joseph's idea describing the concept of interaction is key. I have also had success with changing their focus to "pulling". Once I "win" their understanding with a spring scale demo and two students pulling, then I can return to the concept of "pushing". They are able to see pushing as "negative" pulling.

Date: Sun, 5 Nov 2000

From: Patrick Daisley <patrick@DAISLEY.NET>

Concerning whether inanimate objects can exert forces:

I use a similar definition for force: an interaction between two objects that can cause an acceleration. When they are stubborn about inanimate object exerting forces try this. Place a lab mass on a meter stick supported on each end. The meter stick bends. Then remove the meter stick and place it sideways on the floor with a table or chair leg contacting each end. Place an object, without too much mass, in the center of the meter stick and pull it back, so the meter stick bends as it did before. Let go of the mass and watch it shoot out, slingshot style. Now, we know the object accelerated because it had a change in velocity/. What object exerted the force that caused the acceleration? It had to be the meter stick. I then add to my definition for force: An interaction between two objects that results in an acceleration and/or a deformation. Witnessing either an acceleration or deformation is evidence for a force, although the deformation is sometimes very difficult to see, as in the laser/table demo.

Date: Sun, 5 Nov 2000

From: MERVIN KOEHLINGER <physteach@PRODIGY.NET>
Patrick Daisley,

Do your students then wonder why the middle of the meter stick also accelerates in the same direction as the mass in spite of the fact that the mass exerts a force on it in the opposite direction?

Date: Wed, 8 Nov 2000
From: wchiles <ChilesWen@aol.com>

I’ve found that if students are "forced" to write Fnormal rather than just Fn, the tendency to call the normal force a "natural force" disappears. Last year I was happy to have to make the correction only once.

Date: Thu, 9 Nov 2000
From: Pam Teimorzadeh <Matolive2@AOL.COM>

Just spell the word normaL on the board and add a small extension on the left side of the letter "L" so it looks like the perpendicular symbol used in math. Kids never forget what normal force is after this. Try it.

FURTHER THOUGHTS, IN 2001:
Date: Sat, 3 Nov 2001
From: Jon & Sara Fishwild <fishj@INXPRESS.NET>

There was a demonstration in one of the last issues of The Physics Teacher last spring (April or May of 2001) which used a laser and optical lever to show that when a brick or cinder block wall is pushed on by a person that the wall will deform. This is similar in concept to using the laser to show how a tabletop deforms when a weight is placed on it, but this demonstration is far more convincing.

This year I used Camp & Clement’s Preconceptions book to discuss forces with my adaptive science kids. They met the laser demonstration with mild diversion, but could not believe the result of the cinder block demo (which by the way can be shown with a force exerted by a single finger).

Date: Thu, 15 Nov 2001
From: George Woods <geowoods1@EARTHLINK.NET>

The perpendicular force is another alternative. Normal is defined as perpendicular in a math context, but high school math mentions normal as much as orthoganal. Perpendicular force relates to prior knowledge. Introduce the perpendicular force and slowly substitute the normal force and you will avoid the "natural" confusion.

Date: Fri, 16 Nov 2001
From: Andy Edington <aedington@MTSD.K12.WI.US>

Regarding student use of "natural force" instead of normal force. As Arnold Arons always emphasized, discussing what is not the case is just as important (and sometimes more "instructional") as discussing what is the case. Instead of trying to find ways to keep the "natural force" from coming up, simply address it when it happens. In the end, the students will come out ahead.
