COMPILATION: Unit 7 - what is energy? (semantics)

Date: Mon, 26 Feb 2001
From: Nicholas Park

Beverly Cannon writes:
<< I do talk about the momentum of a body. I don't call momentum a “property”. I do calculate it. But what do we say it is, if not a property? Curious question now. >>

A similar question can be asked about energy. Feynman prefers to think of it as nothing more than a number which can be calculated, but which has no other significance. From a philosophical standpoint, I would agree (after all, the amount of energy an object "has" depends on the reference frame!). However, students are more receptive to energy if they can visualize it as something an object "has," the transfer of which is subject to certain rules. I would emphasize with them that this is just a useful model for describing changes in measurable quantities, but I would describe it as such nonetheless. This might be a good point to speak about the question the philosophers of science like to address: "are the models we use 'real' in an existential way?"

(The working scientist's answer to this is, of course, "who cares, as long as they work!")

Date: Tue, 27 Feb 2001
From: Colleen Kozumplik <CKOZUMPLIK@AOL.COM>
Subject: Re: momentum/inertia/energy semantics...

It's always seemed to me that a thing 'has' momentum (or inertia or energy) in the same way it 'has' a position or location in spacetime--it's not a property really--just a measurable/calculatable quantity that helps us describe the thing (with respect to other things in it's reference frame) at any given instant....am I missing something?

Date: Wed, 28 Feb 2001
From: John Barrere <forcejb@YAHOO.COM>

Some excellent postings lately. Ek and Eg clearly depend upon the reference frame, and thus are no more "real" than momentum. But what about Echem?? I don't see how there can be different reference frames for the energy stored in, say, C-H bonds. Similarly for Ethermal - isn't the "reference frame" absolute zero?

Eel seems to me to be somewhere in between. Maybe I'm just hanging on to my bias that energy is "real" while momentum isn't???

Date: Thu, 1 Mar 2001
From: Nicholas Park

And what *is* Echem really? Essentially, it is electromagnetic. And for that, the "natural reference frame" is to consider the "zero point" the state in which all charges are infinitely separated. And so there is not any arbitrariness here. Of course, the same goes for gravity on a large-scale--i.e. out of the limited context of objects near the surface of the earth.

BUT... what is the point of all these energies, without Ek? The fact is, most situations that are modeled by energy considerations involve situations where kinetic energy can change. And since Ek depends on the reference frame, so does the total energy.

Therefore, "energy" as an abstraction can have no frame-independent meaning; the only thing that has any physical effect is the *change in* energy.

It is interesting to note that in the relativistic treatment of mechanics (with 4-D space-time, etc.), Ek and momentum are just different components of the same "thing" (the "energy-momentum 4-vector.") Of course, it is also true that E-field and B-field both depend on the reference frame, and that in some strange sense, the seemingly more abstract electric and magnetic "potentials" are more "real" than the corresponding fields. Really, all this goes to show is that our models, and whatever conceptions help us to understand them, are only of value insomuch as they correctly predict experimental results. They do not, IMHO, have any existential meaning.

Date: Sun, 4 Mar 2001
From: John Barrere <forcejb@YAHOO.COM>

I guess since I can go to the local gas station and buy a hydrocarbon liquid that quite easily produces electrical, thermal, and mechanical "work", it's always seemed to me that energy is much more real than momentum. But if I'm wrong in this thinking, then the question for me is when and where are students to be informed that neither energy nor momentum is really "real", but just convenient mathematical ways of balancing the books? I think NOT in any high school course. I could see a LOT of damage being quite easily done by raising this issue in HS. As Larry D. has so eloquently put it, "Modeling is not about making better scientists and engineers, it's about making the majority of our students better thinkers and more science-literate".

At the college level, maybe only those who are going to be physics majors have any real need to travel this road?

Date: Sun, 4 Mar 2001
From: Tim Burgess <tburgess@JAGUAR1.USOUTHAL.EDU>

A good start would be a student reading of "Six Easy Pieces" that are a collection of lectures given by Richard Feynman. Discussion of the energy chapter (2 or 3, I think) would lead to the "what is energy" discussion.

Date: Mon, 5 Mar 2001

From: Don Yost <DoYost@AOL.COM>

Energy: I think there is a big difference between "does not exist" and "is relative". The energy of motion of a peanut in a jet is relative to the observer, but I wouldn't say it doesn't exist.

Was cleaning junk and ran into "energy forms or energy carriers" , Am. J. Phys, Vol 51, no 12, Dec 83. Was handed out at some of the institutes. Worth a re-read.

Date: Mon, 5 Mar 2001

From: "Dr. Brian Houser" <bhouser@MAIL.EWU.EDU>

Subject: Are Energy and Momentum Real?

It seems there are quite a few out there who would admonish students for holding the belief that an object has momentum, energy, or other well-defined but (as claimed) unpossessible quantities. What's the problem? Apparently to avoid classroom comments like this "Oooh! Thog believe in impetus! Thog pre-Newtonian!" So instead we are strongly encouraged to do what? Teach high-school students that momentum and kinetic energy are merely artifacts of the choice of reference frames?

That the only things an object can "have" are scalars (invariants) under the Lorentz transformation? Sheesh. You might as well go all the way and argue that there is no such thing as the gravitational force, but merely a mass-induced variation in the space-time metric. "Period." "End of story."

Have Feynman help us out? Apparently it still needs to be pointed out that Feynman's class was an unqualified disaster as an introduction to physics, a fact noted, among others, by Feynman himself in his preface to Six Easy Pieces. But if "elegance and beauty" are your bag, why not start with QED (anyone got the modeling units for quantum electrodynamics?) and derive everything from there. And how about this useful factoid: momentum conservation is not fundamental; it's merely a manifestation of the translational invariance of the Hamiltonian. (Modeling unit 7,449 - but maybe one of these years it will get bumped up to the second year.)

There is absolutely no harm whatsoever in having students think of objects "having" momentum or energy. [Egad! It's come to this! Physicists arguing over the definition that "has" has!] Yay for Colleen K. Is not the real difficulty in holding students to specific definitions of terms so that they may make qualitative and quantitative descriptions of the behavior of objects?

Why is impetus bad? Because it seems like "black magic," a mystic power of motion from the dark ages? Seems to me that the biggest trouble is in its vagueness, a term used by the ancients to encompass many concepts related to motion which we now know to be distinct. Disposing of the term "impetus" seems more akin to clearing up extremely poor vision by a good optical prescription than to debunking a superstition: Look! That blur on the desk is actually several

related but distinct objects! Hey, I'd even have the impetus to use "impetus" IFF it were sufficiently well-defined to be useful, but I see no need for it.

How about inertia? So some don't use the term? That leaves "some" with a problem when they speak of "the moment of mmmff" for circular motion. What's wrong with inertia? Probably the same thing wrong with impetus.

In speech outside of a physics class, inertia can mean mass, momentum, energy, and whatever else. It would make sense to avoid using the term in a physics class unless there were a specific definition of what it means. (The same can be said for impetus) We are all free in our classrooms to create useful provisional definitions of terms such as inertia. The term "inertial reference frame" DOES have a solid definition (one in which Newton's first law is valid), and it seems silly to avoid the this name because it contains the root "inertia." There are, after all, reference frames for which Newton's first law is NOT valid.

The first law can be taken to be a postulate of the existence of inertial frames, and the second law a statement of behavior in such frames when a net force is acting. An inertial frame is presupposed in order to even make the statement that "either an object experiences a net force or it doesn't;" presupposed in order to even suggest this be the "end of story."

Ultimately the case will be decided in the "Court of Classroom Opinion." I suspect those who try to advance the idea that something cannot "have" momentum or energy WHILE maintaining the idea that these quantities are useful will find it a losing battle. I agree wholeheartedly with Colleen, and hope she speaks for most folks out there. Be careful with your definitions and be reasonable, and your students should be fine.

Date: Mon, 5 Mar 2001
From: Tim Burgess <tburgess@JAGUAR1.USOUTHAL.EDU>

On Mon, 5 Mar 2001, Dr. Brian Houser wrote:
<< …. Apparently it still needs to be pointed out that Feynman's class was an unqualified disaster … But if "elegance and beauty" are your bag, why not start with QED …. >>

Wow! Did this hit a nerve? I think I will avoid QED in sprite of your recommendation. I think the Feynman read I suggested would come after the development of momentum and energy and work by friction. The result is a discussion where students may, or may not, recognize the implications.

Thanks for the common sense, Brian!