COMPILATION: sequencing units - when to introduce energy?

Date: Tue, 25 Sep 2001
From: Chad Dorsey <dorseyc@LINK75.ORG>
Subject: Introducing Energy -- when/how?

I am beginning to ponder the "big picture," and thinking down the road to energy topics. I seem to remember some discussion that the road was made significantly smoother by introducing hints of energy almost from the beginning, by having the students identify stored energy and "energy of motion," etc. even with the buggy lab or soon afterward. If I do this, however, I'm not entirely clear how much of the topic to introduce when, and how much is *too* much.

I'd be interested in some feedback from those who do things one way or the other: have you found it better to hold off entirely until a certain point in the curriculum, "dribble" ideas as grist for the mill later, or go whole hog at the beginning? If you have introduced energy concepts earlier on than Unit 8, how have you done it, and when, for example, have you introduced things like bar graphs and pie charts?

I don't mean to knock the constant-acceleration/velocity thinking caps off of everyone, but I'd rather not regret my lack of action in a month or three.

--Chad Dorsey
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Date: Wed, 26 Sep 2001
From: Joseph Vanderway <jvanderway@CSUN.EDU>

I don't mention energy until after we develop an explanatory model for constant acceleration (Newton's Laws). Then when we deal with non-constant forces, we develop a model of energy. I take this opportunity to review where we've been by linking all the models so far to energy. I use it as a chance for review.

So far, so good...

Date: Wed, 26 Sep 2001
From: James Vesenka <jvesenka@UNE.EDU>
Re: Where to introduce energy.

Chad is a graduate of our past summer's modeling workshop at UNE. He has had an earful on how I deal with introducing energy, but I would like to share my approach with the larger modeling community in the hopes of finding others who are tackling the issue of effective model development. Should these models determine the order in which the mechanics units are examined by our students? Energy is an incredibly important topic, but where exactly does it fit into the big picture of basic mechanical models?

In Hestenes' fifth lecture on "What do we teach?" he presents five mechanical models, the free particle, constant force particle, linear binding force, central force and impulsive force. I save the linear binding force for the second semester when I deal with waves, sound and light. *I have reorganized the first semester mechanics units around the remaining four models.* The free particle model includes Unit 1 on graphing, Unit 2 on constant velocity, Unit 4 on vectors and net zero interactions, and parts of Unit 7 dealing with kinetic energy and stored energy of non-accelerating particles. I return to Unit 3 when I introduce the constant force particle, Unit 5, 6 and those parts of Unit 7 dealing with situations in which energy conservation reflects an accelerating particle. *I treat energy conservation as a tool providing an alternative, and sometimes singular, mechanism for addressing physics situations.*

This approach is not free of headaches. Motional energy has to be defined in the free particle model in the absence of commonly used definitions such as the work-energy theorem. However, this appears not to cause the students any distress. There are benefits as well - when I introduce Unit 9 on impulsive forces, we can use the failure of the conservation of mechanical energy during collisions to help develop a new conservation law based on momentum. Rotational energy naturally can be applied to the central force model. Lastly, introducing fluids to our many med-bio majors, conservation of energy is the most straightforward way of developing Bernoulli's Equation.

Clearly the typical "kinematics, dynamics, energy" sequence has been dismantled in my course. However, I cannot believe it is a new idea because it seems to be a natural outcome of developing representations around models, rather than a concept sequence that traces its roots back to Halliday and Resnick. Then again, I could be out of my gourd. I can say that the reorganized sequence enabled my students to achieve the highest gains yet on the FCI and TUG&K and highest scores on the Force and Motion and Mechanics Baseline Tests. I certainly would like to think that some of my students' success is based on better physics concept organization.

Kind regards, Jamie
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[UPDATES, 1 1/2 years later. I asked these 3 modelers how they're sequencing units this year, and when they're introducing energy (Unit 7). - Jane J]

Date: Tue, 04 Feb 2003
From: dorseyc@link75.org (Chad Dorsey)
Jane,
This year, I have been proceeding with the units as numbered, and haven't introduced energy concepts much at all. I plan to move fairly quickly through projectile motion and then introduce energy as the next unit. I may spend a day introducing pie charts a week or two before starting energy in depth as an excuse to review/summarize the previous units and preview energy concepts.

Date: Tue, 04 Feb 2003
From: Joseph Vanderway <hrggh003@csun.edu>
Hello Jane-
This is still what I do. "Works for me."

Date: Wed, 05 Feb 2003
From: James Vesenka <jvesenka@une.edu>
Jane:
Thanks for a chance to response to the sequence ordering process. If you could attach the following addendum I would be grateful.

I have continued to employ energy conservation as a tool that I start early (immediately following the free particle) and cycle back to with each core model. Sometimes the cycle ends with energy (e.g. constant force particle - CFP) and sometimes it helps to introduce a model (e.g. impulsive force). Though I do not introduce the name "restoring force model" until waves in the second

semester, I do develop Hooke's Law and the energy stored in a spring as a lab for energy conservation in the CFP (though it is not truly an example of CFP.)

The advantages of a story line based around core models, as opposed to the traditional kinematics and dynamics, energy, etc., has been a better comprehension of Newton's second law and grudging recognition of the importance of energy conservation. I cannot understate the latter. Given a choice between kinematics relationships and energy conservation, the students I have worked with will almost always choose the former because of a greater perceived comfort level with velocity and acceleration, as opposed to kinetic and potential energy. This is particularly unfortunate because we know the difficulties students have with truly understanding acceleration. *Treating energy as a "topic", to be recalled periodically when it is convenient, diminishes its power as a predictive tool.* On the other hand, **repeatedly returning to energy conservation breeds comfort.**

Alas, though my first two years using this approach were successful, this past year I noticed a small drop in the gains on a variety of assessments. Though I suspect the real cause of the lowered gains to be due to reduced levels of discourse, I present the slightly diminished returns as "truth in advertising".