NEWSLETTER

ONTARIO ASSOCIATION OF PHYSICS TEACHERS
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Physics and Cognition

Sequential Vectors in Grade 10

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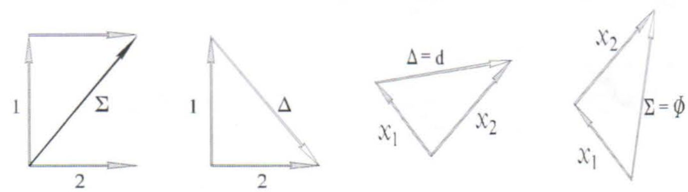
We want our students to be familiar with several concepts that are vector quantities. The current syllabus organizes the concepts in this order: *position*, *displacement*, *velocity*, *acceleration*, *force*, *momentum* and *impulse*.

Along the way, students must learn the *vector operations* needed to support textbook exercises in the *concepts*. We teachers plan for the students to arrive at an understanding of the *concepts* by repeated application of the *skills*. The two basic vector operation skills are sum Σ and difference Δ.

But there is a problem. Not all vectors behave in the same way. The *operations* and the *concepts* have a subtle set of inter-relationships that make systematic learning of them more difficult than it first appears. Some vector pairs are treated sequentially. Others are handled simultaneously. That makes four possibilities of vector operations, as indicated in the matrix below.

	Σ	Δ
Sequential		
Simultaneous		

Let's consider two sequential position vectors, $\mathbf{x}_1$ at one time, and $\mathbf{x}_2$ at a later time. The vector operations are $\Sigma(\mathbf{x}_1, \mathbf{x}_2)$ and $\Delta(\mathbf{x}_1, \mathbf{x}_2)$. The first thing we notice is that $\Delta(\mathbf{x}_1, \mathbf{x}_2)$ results in a physically meaningful vector, but $\Sigma(\mathbf{x}_1, \mathbf{x}_2)$ results in a physically meaningless vector.



In fact, if we look at the whole set of vector concepts in the curriculum, many of the sequential Σ's and Δ's are meaningless! (Meaningless Σ's and Δ's are indicated with a Φ).

In the current grade 10 syllabus, as our students proceed from position to acceleration, they are likely to get conceptually meaningless answers 5 attempts out of 8, even when they do the operations correctly. If we expect our students to learn the concepts by doing operations on various vector diagrams, then we have set them up for failure. Students typically begin with a low level of personal confidence in both their conceptual knowledge, and their operational skills. How will they know whether they have the concept wrong, the operations wrong, or both? (Or both right, in the case of the 0.07% who actually "get it.")

Let's leave this in an unresolved state for the time being. I'd love to hear responses from you. Perhaps we can set up a forum for discussion. Next issue: the case of the simultaneous vectors. And, a suggestion for a curriculum that is easier to learn.

	Position $\mathbf{x}$	**Displacement** $\Delta\mathbf{x} = \mathbf{d}$	Velocity $\mathbf{v} = \Delta\mathbf{x} / \Delta t$	Acceleration $\mathbf{a} = \Delta\mathbf{v} / \Delta t$	Force $\mathbf{F} = m\mathbf{a} = \mathbf{j} / \Delta t$	Momentum $\mathbf{p} = m\mathbf{v}$	Impulse $\mathbf{j} = \Delta\mathbf{p}$
Sum	$\Sigma\mathbf{x} = \phi$	$\Sigma\mathbf{d} = \mathbf{d}_T$ Total displacement, or total change of position	ϕ	ϕ	ϕ	ϕ	$\Sigma\mathbf{j} = \mathbf{j}_T$ Total impulse, or total change of momentum
Difference	$\Delta\mathbf{x} = \mathbf{d}$ Displacement, or change of position.	ϕ	$\Delta\mathbf{v}$ is related to a, E, j, and other changes of state	ϕ	ϕ	$\Delta\mathbf{p} = \mathbf{j}$ Impulse, or (ex)change of momentum	ϕ

Digital Physics

Exploring the Law of Conservation of Energy

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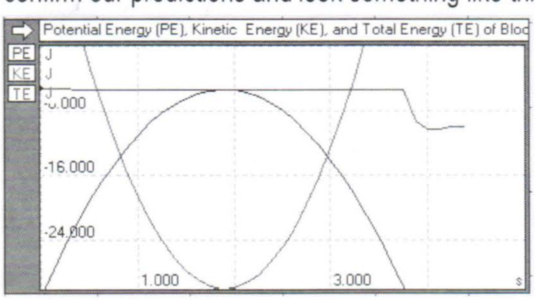
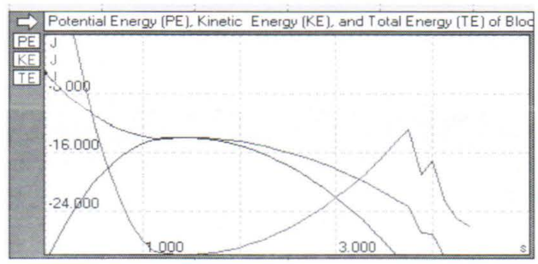
Hello all, and welcome to yet another opportunity to use computers in the classroom! In this session, we'll take a look at how we can use the program IP2000 (or something similar) to fortify an existing understanding of energy conservation and conversion. We'll do this by using an IP script I wrote that models a cart rolling up and then back down a ramp.

Because this analysis is fairly sophisticated, I reserve this discussion for my grade 12 students (and only after we have pretty much completed our discussion on energy). I begin by introducing them to the IP script and discuss with them what it is intended to model. After this, we talk about the type of energy the crate has as it moves up and down the ramp and what happens to this energy as the crate moves along this path. The kids are pretty much all over the fact the crate's energy (consisting of both E_k and E_g) will ideally remain constant and that there will be a transformation of energy from E_k to E_g and vise versa as the cart moves. I then ask the students to predict what the E_k, E_g, and E_T curves for the cart might look like as functions of time as it goes up and then down the ramp. This is, ostensibly, a trivial matter but most kids don't realize that both E_k and E_g (and thus E_T) are quadratic functions in time. After some discussion, this point should be clarified; however, some students may still struggle with it and it's important for them to realize that it's not so much the shape of the graph that is key but rather the trend illustrated by it (i.e.: as E_k decreases, E_g increases and vise versa). With this under our belts, we run the simulation and generate three beautiful graphs that confirm our predictions and look something like this:



I then up the ante of our discussion slightly by introducing the idea of friction. We begin by reviewing the effect that friction has on the energy of the crate (it decreases it), and how this energy is ultimately lost (as thermal energy).

With this in mind, I then ask the students to consider how the total energy curve for a real crate might differ from that of our idealized one above. They are quick to suggest that the total energy curve should decrease (as opposed to remaining horizontal). We then move to the next part of the simulation and generate graphs for a real crate that is experiencing friction. These graphs are illustrated below:



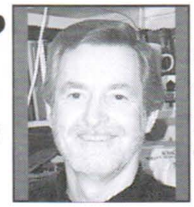
From these graphs it is clear that the energy of the crate is certainly decreasing. In fact, one can almost see the energy being drained from the crate just by examining the shape of each curve. As an interesting corollary, we can introduce at this stage the meaning of the slope of the E_T graph. Students with calculus will almost immediately interpret the slope as being the rate of change of total energy, and those without can be made to see this through an examination of the units obtained after finding the slope of this line. In either case, we see that the rate of change is negative, indicating that energy is being removed from the crate.

I do this activity with my students as a demonstration following a probeware lab involving an actual cart and ramp. In this way, I can augment what happens in reality by something that allows the variables to be more easily controlled and their affects, therefore, more readily seen.

Stay tuned next issue as we use the same simulation to have students explore the subtle, but important differences between the Law of Conservation of Energy and the Work – Energy Theorem. As always, anyone interested in having a closer look at how I address these topics with my students is more than welcome to contact me at paul.passafiume@sympatico.ca. Also, if you'd like to try the simulation (and avoid the drudgery of creating one yourself) let me know and I'll ship it off to you.

Until next time, happy teaching!

The Demonstration Corner



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Demonstration Cart, or "Happy Wagon"

By: Stuart Quick, Department of Physical & Environmental Sciences
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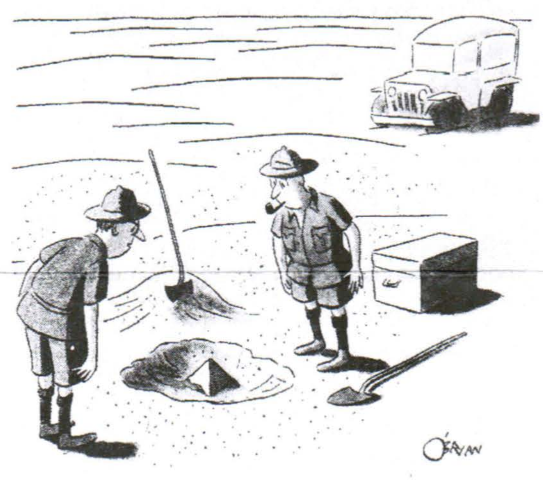
Some teachers might find it awkward and inconvenient to set up demonstrations on lab stands and take them down again in the time at their disposal. Lab stands tend to be weak affairs that wobble with even small loads. Or teachers may find setting up more than one demonstration at a time impractical.

I have used a demonstration cart which I call my "happy wagon" for some years. The body of the cart is one of the larger lab trolleys fitted with good-sized wheels. I have a square piece of plywood about three-quarters of an inch thick and some four feet square mounted in an upright position so one side of it faces the class. It is attached in such a way that it can be removed quickly. The side facing the class is mostly covered by a thin sheet of galvanized steel. Dead centre in the steel and board is a hole with a reinforcement on the reverse side so I can slip the axle of a bicycle wheel through it, holding the wheel perpendicular and enabling it to spin with little friction.

The use of the steel enables me to attach all manner of stuff on the board with magnetic fasteners – thin magnetic indicators (arrows) of different colours, holders for masses on springs, simple pendulum, etc, etc. For one of my opening lectures on the "unity" of physics I have the wheel spinning, the mass on the spring bouncing up and down and the pendulum swinging back and forth all at the same time.

The board is also useful as a backdrop to show the spot of your laser pointer, and to provide a contrast for other demonstrations, such as the waves on a string apparatus. I can even imagine for this coming term talking about buoyancy with balloons I have attached to the thing. Of course, the trolley gives you the space for transporting the stuff and for storing it too. Our Science Outreach kids like the wheel. I have the wagon parked outside my office door in the summer and I often see the wheel spinning after a bunch of them have passed by.



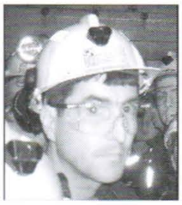
"This could be the discovery of the century. Depending, of course, on how far down it goes."

OAPT CONFERENCE 2006 ANNOUNCEMENT!

The OAPT is proud to announce that this year's conference will be hosted by the **Perimeter Institute** in Waterloo. Stay tuned for details, or visit us on the web!

Highschool Teaching Strategies

Police Officers in Your Physics Classroom



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Many high schools in Ontario have community police officers that spend some time each week in the school building. One of their goals is to build positive relations with our students. Most of these officers have had training in the use of both radar and laser speed guns. In addition, they are often more than happy to come in to our classes and give our students both a lesson and an actual demonstration on their operation. Students get a real thrill pointing the radar gun at passing vehicles (though they are occasionally disappointed that they can't hand out a ticket).

Besides the obvious physics behind the Doppler radar and laser (often called Lidar) the officers can provide insight into the actual operation. Students particularly like the details about when a radar gun is not effective and why laser is much more accurate in high traffic areas. Our officer also talked about the calibration process and why you never try and hide the radar gun behind the dashboard. It turns out that the rotating metal engine fan produces an excellent signal! Our officer also showed the class how the radar was calibrated using a simple tuning fork.

Students can also learn the about how momentum and Newton's laws apply to automobile collisions. Most large departments (for cities over 100 000 people) have specialist officers who analyze accident scenes. Bringing these officers into the classroom often only takes a simple phone call. These officers bring with them real world applications of physics principles that can often be the "hook" that really grabs our students' interest.

Below is a list of where these "officers in the classroom" can fit into the Ontario curriculum.

Curriculum links:

Grade 10 Applied and Academic Science: Motion unit

Grade 11 University physics: Motion and Forces unit, Sound unit, Light units

Grade 12 University physics: Energy and Momentum units

Grade 12 College physics: Mechanical Systems, Communication units

What's New at OAPT?

The New Physics Funding Formula

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Announcing OAPT discussion group: Listserv!
The main function of the group is to promote dialog among teachers of physics at all levels, from junior science to graduate school. You can post questions, news that would be of interest to the group, or any other suitable messages. Current hot topic: 'teaching physics with new curriculum'. Subscribe now!
To subscribe, send an email to oapt-subscribe@yahoogroups.ca

Grade 12 Physics Photo Contest:
In SPH4U category there are maximum 10 entries per school, in SPH4C category max 15 entries per school. Although the deadline to mail in your entries is between April 3 and May 1, students ending their semester one in January may want to prepare their photos now! See OAPT web-site for the last year's winning entries.

OAPT Physics Contest:
In semestered schools it is a good idea to register semester one grade 11 physics students, for the contest written on May 2, 2006, before the semester ends. With a collected fee of three dollars, students are more committed to show up on the contest day.

OAPT at AAPT:
American Association of Physics Teachers' 2006 Winter Meeting will take place in Anchorage, ALASKA, January 21-25 with the theme: "Celebrating AAPT's 75th Anniversary". To see the program and the beautiful views of Mount McKinley (6194) go to www.aapt.org/Events/WM2006/index.cfm.