NEWSLETTER

ONTARIO ASSOCIATION OF PHYSICS TEACHERS (An Affiliate of the A.A.P.T., and a charitable organization) February 2008

Editor's note: As physics educators we must take some action to help reverse a dangerous trend. Our students are steering away from taking high school physics in particular grade 12 university physics as they feel it will lower their averages. Please pass the open letter below onto your principals and guidance counsellors. Your students will thank you for it!

Letter from the Canadian Association of Physicists to high-school principals and guidance counsellors re physics courses

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Research we have carried out at Trent University over the last year (to be published in the Canadian Journal of Physics) has shown that students who have not taken the 4U physics course (or equivalent), but then must take a physics course at university, are failing or dropping out at a rate up to four times as great as for those who have taken high-school physics.

To draw this problem to the attention of the high schools, Professor Louis Marchildon, President of the Canadian Association of Physicists, has sent the letter below to all provincial ministers of education (except for Québec, which is different due to the cégep system), asking them to forward it to high school principals and guidance counsellors.

Open letter to high-school principals and guidance counsellors concerning physics courses

It has come to our attention recently that a number of high schools are recommending that their students not take upper-year physics because of concerns it may bring down their averages, hurting their chances for entry into university. In some cases, this has so reduced the number of students taking those courses that schools have even cancelled them, reducing even further the number of students who take physics.

However, physics is required for many university professional programs as well as for science programs, which means that such students in these programs will be taking their first formal physics course at university. Recent evidence shows that these students are largely unprepared for the subject and are failing or dropping out at a rate up to four times as great as for those who have taken high-school physics. Even when a university does provide a make-up course for students without previous physics training, this can prolong by a year the student's university career, at great expense. **Our strong recommendation is to advise a student who is likely to take a university physics course, for whatever reason, to take the high-school physics courses.**

Programs requiring a physics background

A physics background is required by many disciplines and professional programs, because it provides knowledge essential for the discipline while developing strong numerical and analytical skills. Such programs include the following:

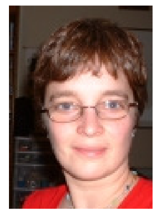
1. Medicine, where knowledge of basic electricity, mechanics and optics is required to understand the functioning of the human body. Reflecting this, the MCAT (Medical College Admission Test), required for entrance to most medical schools in Canada, has a high physics content.
2. Optometry, for the same reasons as for medicine.
3. Architecture, for which a good understanding of physics of structures is clearly crucial.
4. Engineering of all types.
5. Chemistry. Accreditation by the Canadian Society for Chemistry requires a university physics course.
6. Forensic Science. Accreditation by the American Association of Forensic Scientists requires a full-year university physics course.
7. Other sciences, in addition to physics.

Evidence that high-school physics is essential

Many university programs, including some in the life sciences, require high-school physics (SPH4U in Ontario) as one of the entrance requirements. However, a number of programs which require a physics course at the university level do not require high-school physics as an entrance requirement, as the high-school material is repeated at university although at a much accelerated pace. Our statistics, derived from a range of universities of different sizes, indicate that the group without high-school physics is severely disadvantaged at the university level. **The drop-out and failure rate of these students from their university physics course is typically in the range of 20%, compared to about 5% for those students in a similar course that does require high-school physics.** Dropping out or failing a course is a major setback for a university student, as it means an extra year of study or retaking the course over a summer which is a major commitment in time and cost. Moreover, students who have high-school physics perform substantially better than their peers in the same course who have not had high-school physics. Of course, some capable and highly motivated students without high-school physics perform well in university physics courses, but these are the exception to the rule.

Louis Marchildon, P.Phys.
President Canadian Association of Physicists
10 January 2008

High School Physics



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10 Things Physics Teachers Can Do to Help Their Students Succeed at University Physics

This article is a brief summary of the workshop presented at the Toronto School Board Science Conference "A Celebration of Discovery" on November 30, 2008. The idea of the workshop came out of the discussion with one of the first year students in an introductory physics course for science majors I taught last fall. The student was doing particularly well in my class and it was not hard to notice him. Once we had a chance to walk to class together, and I asked the student, what helped him excel in this class? His response was clear – he had an amazing high school physics teacher. This teacher not only helped the student to gain excellent physics problem solving skills, but also sparked his interest in physics as a future career. So what can high school teachers do to help their students succeed at university physics? The list presented below is neither an exhaustive compendium of successful high school physics activities or concepts, nor it should be treated as a recipe for success at university physics. I hope rather that it will focus our attention at some things that can be treated a little more extensively in high school to help the students succeed at their first university physics courses.

1. Try to emphasize that **physics is not about memorizing meaningless formulae**, rather physics is a science that studies how the world around us works and how physics concepts (that are often described using mathematical formulae) can explain it. So if your students are stuck on formulae memorization, ask them to explain these formulae in their own words **without** using math. This might help them think differently about physics. **Being able to plug numbers into the math formulae isn't physics**. Students' expectations of what physics is significantly affect their study strategies and as a result s success in the course. In the words of one of the first year undergraduate students: "*I feel that Physics is a lot harder to understand than I had expected. Going into this course I expected it to be a lot of math because that's what I was told by my older sister but in Dr. M's class it was mostly concepts which threw me off a lot*".

2. **Help the students learn how to organize their knowledge**. One of the most important findings of physics education research is that novices and experts organize knowledge very differently (Bransford, Brown et al. 2002). While experts operate with the concepts and ideas, the novices are often stuck with the unimportant (from the physics point of view) features of the problem. These findings emphasize the importance of concept maps or any other way of helping the students to identify important physics concepts and the relationships between them. Being able to see underlying concepts is a very powerful skill in a physics problem solving.

3. **Physics as any science is about asking the *why* question**. As the students become more sophisticated, their *why* questions will get more complicated and might be harder to answer. However, asking a good question in science is often more important than being able to answer it. This is how one of my students described how her opinion of physics changed during the course: "I feel that everyone is capable of learning physics as long as they change the way they think about the course. People need to realize that it is okay to ask the question "why?" and when they ask the question they need to be willing to spend the time to solve the problems associated with the question."

4. This brings me to the next point. **Spending the time to figure things out**. Somehow, students often think that if they cannot solve the problem during the first few seconds after they skimmed through it, they are not capable of solving it and doing physics in general. I believe that partially we are responsible for their attitude as we often solve problems which we have solved many times before. Rarely do our students see us stumbling or thinking aloud about a problem which is somewhat challenging to us. I think that "drive through" mentality is counterproductive in science learning. Problem solving requires time and not being able to figure things out right away is OK. There is no scarcity of examples from the history of physics showing that many ideas we are trying to teach our students took hundreds and thousands of years to develop, so it is alright if it takes the students time to understand how to apply them to problem solving.

5. This point brings us to helping the students **adopt a systematic approach to problem solving and use of multiple representations**: diagrams, graphs, pictures, equations, verbal or pictorial problem descriptions (Kohl and Finkelstein 2007). Novice problem solvers often stumble even before they have identified the given, drawn an appropriate picture or diagram, or thought of the concepts involved in the problem. I often remind my students that I am not going help them solve the problem unless I see a list of givens, a diagram and all the relevant information including the question asked in the problem. In addition I ask the student to write a list of possible concepts involved. Often these steps will help them get started, which will eventually boost their confidence and satisfaction of independent problem solving.

6. Another important point I try to make with my students is **"If you cannot explain what a concept means in your own words, using a scientific term to label it, will not get it any clearer"**. Very often the students use terms they don't understand and as it becomes part of a bad habit, it stops bothering them after a while and they stop asking questions. For instance, the terms such as acceleration, weight, energy, momentum, impulse, gravity, electricity, power, etc. are often used differently in everyday life and in a physics context. What is even more bothersome, that some everyday life terms, for instance, such as *weightlessness* are plainly misleading. Try to make sure the students really understand what they mean prior to using new terms.

7. **Help students examine their prior as well as newly acquired knowledge.** Make sure that the new knowledge they acquire in your class fits within their prior knowledge framework. One way of doing that is to keep asking "If-Then Questions". For example, Newton's first law often is counterintuitive to many of the novice learners. To help them think about it, you might ask the students to ponder about why it is so difficult for us to believe that there is no need for an unbalanced force in order for an object to keep moving at constant velocity. Sometimes, you might even play a devil's advocate and ask them, what if the opposite was true? How would the objects move then? How will the world around us change? The worst thing that you can do is to perpetuate the myth that physics laws and concepts learned in class are only useful to solving end of chapter problems and they do not apply to everyday world.

8. **Avoid overgeneralization and clearly identify when the things work and when they don't.** For instance, when talking about friction, try not to tell the students that friction always opposing motion (the force of friction opposing the relative motion). This might lead the students to think that friction is always going to be directed in the direction opposite to motion. Think about how you walk. What propels you forward is the force of friction between your feet and the floor, which is directed … forward! Another example, might be the claim that the normal force is always equal mg. This is true sometimes, but not always. Think of the inclined plane or of riding in an elevator or even of a "*weightless*" astronaut.

9. **Assess what you value.** If you believe that conceptual understanding is important, use conceptual questions in your quizzes and tests. There are lots of resources on the web with conceptual questions. One of them was created by David Harrison from the University of Toronto and is called Canadian In-Class Question Database (http://cinqdb.physics.utoronto.ca/). Give your students a chance to see that understanding concepts is important and is valued by you. We will continue doing it at the university and it will make student adjustment to college physics easier.The workshop sparked interesting discussion and provided a great opportunity to start building bridges between high school and university physics teaching. After all, many of the concepts and problems discussed in a first year introductory physics course are also discussed in a high school classroom. I would be very interested to hear what you think about this article. If you have comments or ideas, please e-mail me:

References:

Bransford, D., A. L. Brown, et al. (2002). How people learn. Washington, DC, National Academy Press.Kohl, P. B. and . D. Finkelstein (2007). Expert and Novice Use of Multiple Representations During Physics Problem Solving. 2007 Physics Education Research Conference, Greensboro, NC, American Institute of Physics American Association of Physics Teachers.

The Demonstration Corner

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Simple Centre of Mass Demonstrations

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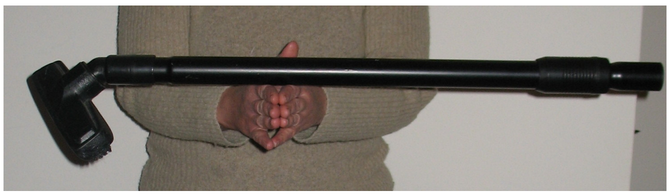
There are several very simple demonstrations on centre of mass that can be performed with everyday objects. In this article I describe a couple of demonstrations that I do with my students. The first one is balancing a long object. I ask



one of the students to hold a metre stick or any other object that is long enough on the top of her hands when the hands are far apart. Then I ask the students to predict what happens if the person tries to bring the hands together, moving the forefingers supporting the object from beneath towards one another very slowly. Many students will assume that it is very difficult to do because the stick will become unbalanced in the process of moving the fingers. Is this the right answer? Surprisingly for many, it is rather difficult to make the long stick lose its balance. If you ask the student to move her forefingers towards each other very slowly, the class will soon discover that it is possible to move one finger at a time along the stick, but not both! In the case of a standard metre stick the centre of mass is at the mid-point. It is even better to attempt to balance an elongated object other than a stick or rod, when it is not known beforehand where the centre of mass is located. If you are using a metre stick and want the centre of mass to be somewhere other than the 50-cm mark, just attach one or more clamps to the stick. Balancing the object on the fingers allows the students to find the location of the centre of mass. On the photo above, the vacuum cleaner brush and holder are balanced on the top of my forefingers. This is where the centre of mass of the brush-holder system is located.

The detailed explanation of what happens when we try bringing the fingers together while balancing the long object involves friction and normal force. In the case of a metre stick without any attachments, if the fingers are initially positioned even at slightly different distances from the centre of the stick, the normal forces that the fingers exert on the stick are not equal. As a consequence, the values of the maximum static friction force to overcome are slightly different for each of the fingers. The first finger to slide under the stick is the one that was farther away from the centre of mass initially, until it stops a bit closer to the centre of mass than the other finger. The next attempt to move the fingers will result in the motion of the other finger which initially remained at rest. The process will repeat itself until the stick is balanced, with both fingers located right underneath the centre of mass.

There are a number of interesting demonstrations that involve the centre of mass of an object being situated below the point at which the object is being supported. My favorite demo in this category is balancing two forks with a coin inserted between their teeth on the outer edge of a wine glass. The forks are balanced outside the glass, and it appears as if they defy gravity. Because the handles of the forks point downward and toward the glass, the centre of mass of the "object" consisting of the coin and forks is directly below the point of contact between the coin and glass, producing stable equilibrium. The demonstration is very easy to set up, and the photograph speaks for itself. This demo was shown to me by the Stanford University graduate student Guillaume Chabot-Couture.

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Submissions describing demonstrations will be gladly received by the column editor.

Please join us for OAPT's annual conference at Ryerson University May 22-24 2008

- Keynote Address by Dan MacIssac and Kathleen Falconer
- Tours of Ryerson Research facilities, Enwave Deep Water Cooling, The Rogers Centre and The Wind Turbine at the CNE
- Hands on Workshops

Welcome to the 47 preservice teachers who joined OAPT at TDSB PD session in November

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