# NEWSLETTER

## ONTARIO ASSOCIATION OF PHYSICS TEACHERS

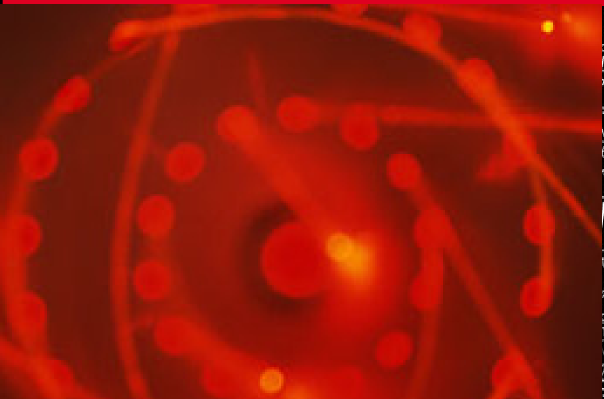
An Affiliate of the A.A.P.T, and a charitable organization

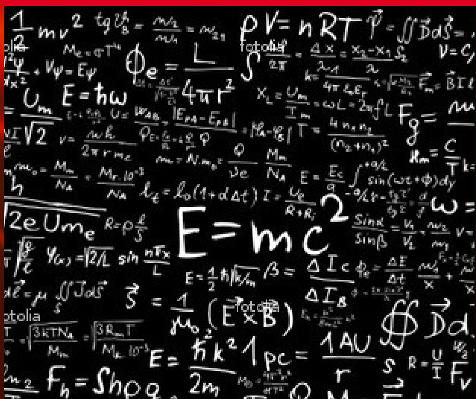
September 2011

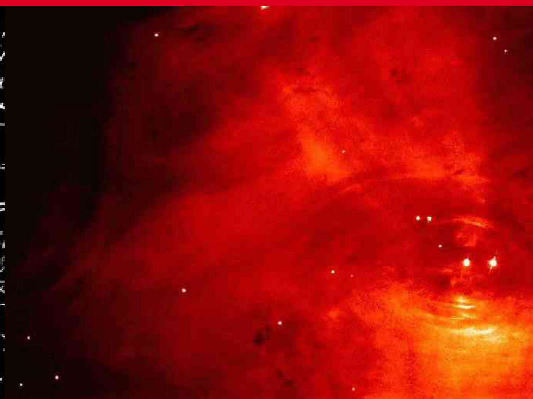
**Remembering the OAPT Conference at McMaster**

## A Summer of Physics Phun!

## Gearing Up for Another Exciting Year of Physics Education!







# Letter from the Newsletter Team

**We are excited to present this year's first newsletter in electronic form. As we move forward with this new initiative, we hope to provide OAPT members with a valuable resource. The Newsletter Team would like to extend an invitation to all its members to write articles this year to be included in this new newsletter format. It is our hope that this newsletter will provide physics teachers with a multitude of information which will help teachers enhance their own teaching practices. If you wish to contribute to the Newsletter, please contact us through the OAPT website.**

**Looking forward to an exciting year in physics education!**

**Lisa Lim-Cole**
**Tim Langford**
**Robert Prior**

# The Prez Sez

**Roberta Tevlin**
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**We have an exciting year planned at the OAPT, one filled with changes and opportunities.**

At the conference in April, which was fabulous, our volunteer base more than doubled! Check www.oapt.ca/contact.html. Email any volunteer by clicking on the job; click on the name to see a picture and brief bio. There are still many opportunities to be involved. Just drop me a line and let me know what your interest and availability is.

Plans for next year's conference are well underway. The Perimeter Institute will be hosting it, April 26-28. Mark these dates in your calendar now! We expect to have the program set by late September and to be able to once again offer accommodation at a rate of $19.99/night!

The newsletter and website are both being updated and the contest will be fully and smoothly online in the spring.

There will be many other opportunities for physics PD throughout the year:

- The Physics Teacher Association (PTA) in the GTA and the McMaster Community of Physics Teachers are two successful groups that have been meeting for a number of years.
- Two new PTA's are starting up - one in Durham and another in Guelph!
- The Perimeter Institute will be hosting after school workshops throughout Ontario, in the fall and spring.

**We'll keep you posted on these and other opportunities throughout the year.**

# YouTube Physics

**James Ball**
John F. Ross CV
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Based on his workshop presented at the 2011 OAPT Conference.

We all use videos in our classrooms. A long video provides passive learning; most students will tune in and out. YouTube videos are short (rarely more than 5 minutes) and can be used **to actively engage** our students. In the workshop session we explored a number of effective ways to use these short videos:

1. As **a hook** to capture student interest. The link below will take you to a video of wing suit base jumping. Most students will be awed by the beauty of the videography and the courage (or craziness) people flying at more than 160 km/h just metres from a cliff wall.
   http://www.YouTube.com/watch?v=ttz5oPpF1Js

2. To provide a source of **context rich problems**. The video linked below is of Dana Kunze completing a world record high dive (172 ft). Students can calculate this impact velocity. They can also measure the time his jump takes and determine how accurate their calculations were.
   http://www.YouTube.com/watch?v=paM5-nhr8Bc

3. As a means of introducing a concept. The photo above is from a commercial for Renault. The ad is intended to show how safe Renault cars are but it also clearly demonstrates conservation of momentum http://www.YouTube.com/watch?v=HbV98cnBbLg

4. YouTube videos can be used to **invite critical thinking**. Many of the videos on YouTube are "fakes". The link below is supposed to show Kobe Bryant jumping over a moving car. Students working is groups will usually determine both what is real and what is fake and if fake how it was done. http://www.YouTube.com/watch?v=TU2za57IOjw

5. YouTube videos can provide a **source of real world data** for video analysis. Students can import videos like the Kobe Bryant jump into programs like Logger Pro and analyse his motion.

6. YouTube has many clips from movies and TV shows. Below is a link to a clip from the TV show The Big Bang Theory. It has both excellent **physics and humour**.
   http://www.YouTube.com/watch?v=-PvwtS0htyk

It is important to **download the YouTube video before showing it** for several reasons. This prevents streaming issues and also means that students will not be able to see the comments associated with the videos. These comments usually have nothing to do with the video and are often filled with language that is not appropriate for the classroom.

There are many ways of downloading videos. At www.keepvid.com you simply paste in the URL of the YouTube video and click the download button. It will prompt you to select the format you wish and will then download the video for you. The free version of RealPlayer (www.real.com) comes with a feature that brings up a download button whenever you move your mouse over a video. Firefox comes with an add-on that displays a download button under the video.

# Senses Working Overtime: The Physics of the Nervous System

**Greg Macdonald**
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The world is a busy place and as the band XTC says, "I've got one, two, three, four, five senses working overtime trying to take this all in". At the May, 2011, OAPT Conference Dr. Deda Gillespie and Dr. Dan Goldreich of McMaster University showed us how three of those senses help us make some sense of the world. During their workshop, "Physics of the Nervous System," participants learned how the body receives signals and creates a mental picture for the senses of touch, hearing and vision. Our perception of the world depends both on basic physics and on some fascinating processing by our brain.

For example, the ear contains a lever system (the small bones called ossicles) to amplify incoming sound signals and uses mechanical resonance in the inner ear (cochlea) to stimulate specific nerves for each frequency of sound. Pretty straightforward physics... but when it comes to determining where the sound is coming from, our brain has a few tricks up its sleeve. For high frequency sound the brain is 'aware' that one ear is shadowed by the head from the incoming sound wave if the source is to the side, while low frequency sound waves diffract around the head and are heard in both ears. The brain notes the time difference between when sound is detected at one ear vs. the other ear and uses this to determine the source direction.

For vision we can use Snell's Law to understand how the cornea and lens focus light onto the retina and answer the question, "'Which part of the eye provides the most refractive power?". Straightforward physics. But our brain has a very complex processing task to make sense of the signals that light from two separate eyes provides.

## An Easy and Fun Experiment

The sense of touch offers an opportunity for a simple yet powerful experiment outlined by Dr. Goldreich, which can easily be done in the classroom: measuring the speed of a nerve signal. The only materials you need are a stopwatch and some students! Signals from touch receptors travel through the nervous system very quickly but it's still possible to measure their speed through a little gentle squeezing. The experiment has two parts:

In part one a group of at least ten students sits in a circle, eyes closed, one hand on the shoulder of the next student. The first student in the chain holds a stopwatch. Once everyone is ready, the first student squeezes the shoulder of the next student and starts the stopwatch. When the next student feels the squeeze s/he squeezes the next student's shoulder, and so on around the circle. When the first student feels the final squeeze, s/he yells "done" and stops the stopwatch. Repeat the experiment until the group's time is as fast as possible.

In part two the 'squeeze' is repeated, but this time each student squeezes the ankle of the next student. The signals will have further to travel: from the ankle to the brain instead of just from the shoulder. We can find the speed of the signal from $v = \Delta d / \Delta t$, where $\Delta d$ = the difference in distance and $\Delta t$ = the difference in the times recorded in part one and two. Finding $\Delta d$ means measuring the shoulder to ankle distance for each student in the group and summing them.

How good are the results? Our group of teachers at the OAPT Conference got a speed result of about 30 m/s. This is at the low end of the range for a touch nerve fibre (30-70 m/s) but still respectable. One neat thing about this method is that errors introduced by reaction time and signal time from the brain to the arm to perform the squeeze are theoretically identical in both part one and two, minimizing this source of error.

A full set of the slides used in the presentation can be found at the OAPT website http://www.oapt.ca/conference/2011/workshops/deda_gillespie_dan_goldreich.pdf and at http://psych.mcmaster.ca/neuroclassics/OAPT.html

Many thanks to Dr. Gillespie and Dr. Goldreich for a very interesting presentation. This article only scratches the surface of some ideas they presented about how our brain interprets the world.

# The Physics Education Research Column

## To Improve, We Must Measure

**Chris Meyer**
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**Editor's note:**
This is the fifth in a series of articles by Chris Meyer describing his experiences implementing a reformed physics program. Please e-mail him directly if you have any questions or feedback.

### Walk the Walk and Measure the Taught

Most of us feel that we know our students and their abilities. How often have you heard yourself or a colleague make a pronouncement that starts out something like, "My students like to …", or "My students would never …"? But what do we really know about our students?

Physics Education Research was founded on the principle that we can make useful measurements of our students' abilities and use those measurements to develop changed teaching practices. One standard measurement tool is the **Force Concept Inventory (FCI)[1]** , a math-free set of thirty multiple choice questions testing students' conceptual understanding of forces and motion, the core of introductory physics. Results from this test serve as a simple and widely agreed upon benchmark of teaching effectiveness

### The Force Concept Inventory

The FCI was designed to measure the extent to which a student is a coherent Newtonian thinker. A low score indicates strong Aristotelian conceptions or other "commonsense" views typical of students prior to (and too often after!) physics instruction. A score of at least 80% identifies a confident Newtonian thinker[2]. A large study[3] of over 6000 high school, college and university students revealed that:

1) Before any instruction, **high school students on average score about 28%** on the FCI (but closer to 45% for American honours and AP students);
2) The average student starting a first year university physics class scores around 44%;
3) Harvard's beginning calculus-based physics students score 70%.

The FCI is typically administered at the start of a course (the pre-test) and again at the end (the post-test). The **average fractional gain**, **<g>**[4] , states what fraction of potential improvement over the pre-test scores the students achieved and is useful in assessing the quality of instruction. Traditional methods of instruction yield a fractional gain of 0.23 with little variance across high school, college and university. For example, students scoring 13/30 (43%) on the pre-test would average about 17/30 (57%) after a complete course of physics instruction.

Reformed physics teaching programs of various kinds have a typical gain, <g>, of about **0.48**, roughly double the success of traditional methods. Some finely tuned reformed programs, such as Workshop Physics at Dickinson College in Carlisle, Pennsylvania, routinely score gains of **0.74**. These results suggest strongly that a long history of poor student achievement in physics is a direct result of traditional teaching methods having been inadequate or inappropriate.

## FCI Results at York Mills Collegiate

This past June I administered the FCI as a post-test in my reformed grade 12 physics course. Students were given no prior information about the test and it did not count for marks. Students completed the test in about thirty minutes with no aids or special instructions. 59 students wrote the FCI; 15 were away that day. The absentees were from across all mark ranges in the class[5]. The average score was **77%**. Three-fifths of the students achieved the level of Newtonian mastery (≥80%), while 93% scored at or above the level of an average incoming first year university physics student (44%). **Figure 1** shows a histogram of the results.

York Mills is an academic school with bright and highly motivated students, and I might reasonably assume an average pre-test score near the upper end of the high school range, 44%. (This school-year I will run the pre-test to find out how accurate this assumption is!) This gives an average fractional gain of **0.60** for the York Mills students. **Figure 2** compares the average gain for a number of teaching practises. These results help confirm the success of the reformed physics program at York Mills. Students showed a clear and sizeable improvement in their conceptual understanding of mechanics: almost triple the improvement generated by traditional teaching methods and better than a number of other reformed practices.

### To Improve, You Must Measure

Try it out! I encourage you to run the FCI with your own classes. The test is generally not available online (to discourage curious students). To get a copy you may contact the authors[6] of the FCI, or contact me and I will send you a copy. Please **don't let the questions out amongst the students**.

To learn more about reformed physics teaching check out the resources on my website: www.meyercreations.com/Physics.htm and past OAPT newsletters, http://www.oapt.ca/newsletter/, for my articles. Or come and see reformed physics teaching in action: the door to my classroom is open and I welcome any and all visitors; please just send me an e-mail. Good luck and may you collect the courage and data to improve!

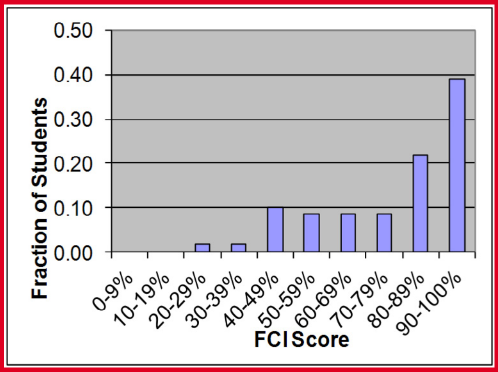


**Figure 1:** Histogram of FCI scores

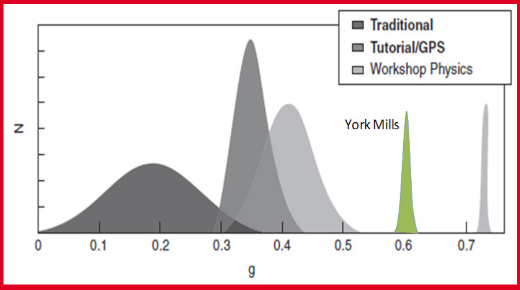


**Figure 2:** Average fractional gain values for different teaching practices including traditional instruction, the reformed Tutorials in Physics and Group Problem Solving programs, and Workshop Physics. (The distant spike is the Workshop Physics implementation at Dickinson College.) Source: Redish, Teaching with the Physics Suite. Wiley, 2003

[1]FCI "Home Page": http://modeling.asu.edu/R&E/Research.html

[2]FCI results and interpretation: http://modeling.asu.edu/r%26e/fci.pdf

[3]Large collection of FCI results: http://web.mit.edu/rsi/www/2005/misc/minipaper/papers/Hake.pdf

[4]$\langle g \rangle = (\langle S_f \rangle - \langle S_i \rangle)/(100 - \langle S_i \rangle)$, where $\langle S_i \rangle$ and $\langle S_f \rangle$ are the average class percentage scores on the initial and final tests.

[5]Please email me if you would like to see the raw data

[6]Using your school e-mail, please request the password from David Koch FCIMBT@verizon.net.

# The Demonstration Corner

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

## Mystery of a Pulled Spool

**Tetyana Antimirova**
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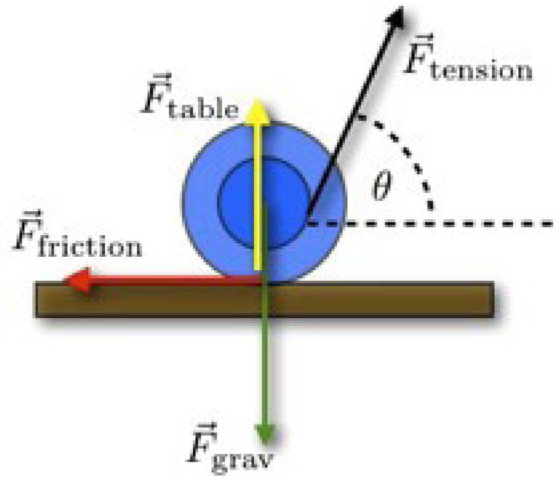
One of the ubiquitous simple physics demos that works equally well for all audiences from small children to the students in the introductory mechanics course is a plastic or wooden spool (or yo-yo) with a string wound around it. A virtually no-cost version of the "demo equipment" is a spool of common household sewing thread. Being curious, I did a Google search on yo-yo, and the search produced about 120,000,000 results!


There are many experiments that one can perform with such a spool, but perhaps the simplest one is the most striking. Set the spool on a table to that it is free to roll, with the free end of the string or thread being held at an angle to the horizontal (as shown). Ask your audience to predict in what direction and how the spool will move if you pull the string. If one pulls the string from below, the spool can be made to roll in either direction: forward or backward, depending on the angle of the string with respect to the horizontal surface. The real beauty of this experiment is that regardless of the majority of the audience's predictions, the spool can be made to roll in the direction that is opposite to the predicted one simply by pulling the string at the appropriate angle! Moreover, while most of the audience usually predicts that the spool will roll, not many see the possibility of it sliding. Yet if you adjust the angle accordingly, the spool may even slide on the surface instead of rolling. If you do this experiment, you will discover that the spool will roll away when you keep the angle between the pulling string and the horizontal surface large enough. The spool will roll toward the string if you decrease the angle beyond some critical value.

If you keep the angle close to the critical value while pulling the string, your audience will not even notice the small change in the angle you make and will be quite puzzled by the fact that the direction of motion of the spool can suddenly change. In order to explore this mysterious behaviour, you can give the spool to small groups of students and ask them to find out on their own how the spool responds to being pulled. Repeating the experiment with a spool of different mass or dragging the spool across a smoother or rougher surface will demonstrate that neither the spool's mass nor the friction coefficient affects the angle at which the direction of rolling changes. However, the critical angle will be different for the spools with different inner or outer radii. One can just stop here, but depending on the audience's knowledge background, one can also develop a free-body diagram and proceed with the detailed force and torque analysis to predict the critical angle at which the behavior of the spool changes. The free body diagram shown here is borrowed from the website of Rhett Allain (Southeastern Louisiana University) at http://scienceblogs.com/dotphysics/2010/01/yo-yo_rolling_sliding_pulling.php and corresponds to the scenario where the spool is pulled to the right. Here, $r_1$ and $r_2$ are the inner and the outer radii of the spool. Let's first find out the conditions at which the spool is just on the verge of slipping without rolling. One can identify four forces that act on the spool: weight of magnitude $\mathbf{F}_{grav}$= mg (down), the tension $\mathbf{F}_{tension}$ in the string due to the pulling, the normal force $\mathbf{F}_{table}$ that is exerted on the spool by the supporting table (directed upward), and, finally, the static friction Ffriction force. The tension force makes angle θ with respect to the horizontal direction.




Note that the friction is static (not kinetic), since the spool is not sliding just yet. Close to the threshold of sliding, the magnitude of the static friction force is reaching its maximum value: $\mathbf{F}_{friction}$=μ $\mathbf{F}_{table}$ where μ is the coefficient of static friction between the spool and table. If the spool is not yet moving, the net force in the horizontal direction must be zero. Therefore, Ftension cosθ = $\mathbf{F}_{friction}$ =μ $\mathbf{F}_{table}$ . In addition to forces, the torques must be considered. Only two of the four forces (tension and friction) produce a torque about the centre of the spool. The spool does not rotate when these torques balance: $\mathbf{F}_{ension}$ $r_1$ = μ $\mathbf{F}_{table}$ $r_2$. Dividing the previous equation into the last equation results in the equation that relates the ratio of the inner and outer radii with the critical angle at which the string must be pulled so that it just slides: cosθ = $r_1/r_2$. At larger angles the spool rolls away from the direction of pull, while at a smaller angle the spool rolls towards the direction of pull! Note that this equation confirms that the critical angle does not depend indeed on mass or the coefficient of friction.

An alternative qualitative explanation is available if we consider the torques with respect to the point where the spool touches the supporting surface. Only the torque due to the pulling force is non-zero. Even this torque disappears when the string is pulled at such an angle that the line of application of the force goes through the point of contact between the spool and the surface. If one considers the geometry, it happens when cosθ = $r_1/r_2$.

This simple inexpensive demo gives the opportunity to discuss several important concepts in mechanics, such as kinetic versus static friction, rolling versus sliding friction, and to analyze how the interplay of various forces and torque lead to different types of motion and more. Enjoy the toy!

# Physics Camp in Sudbury: "Inquiry Based Physics"

**Olga Michalopoulos**
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This summer, about 30 of us attended Physics Camp in Sudbury, August 10-12. Our "Camp Leaders" Roberta Tevlin, Dave Doucette and James Ball provided 3 days of jam packed workshops and many hands-on activities with the focus on Inquiry Based Physics. There was plenty of collaboration, networking and even role playing with colleagues from across Ontario and even a few colleagues from other provinces. Some of us even stayed up to hopefully see some Perseids streaking across the night sky, since we were in Sudbury during the peak of the Perseid Meteor Shower and we weren't disappointed! We all arrived not knowing quite what to expect, but by the end we all agreed it was well worth the trip and that we would attend Physics Camp again if we had the chance.

Some of the highlights included:

- **James' refraction exercise** where we had to collaborate in teams and physically act out what happens to light when it passes from a less optically dense medium (e.g. air) to a more optically dense one (e.g. water) and also when it passes from a more optically dense medium to a less optically dense one. Your students will really get a feel for what's actually happening to the light as it moves from on to the other.
- **Roberta's polarized light activity** where we all donned our 3D glasses and played. Great hands on activity that will allow your students to investigate the polarization of light. Check out the article in the November 2009 issue of the OAPT Newsletter where Roberta highlights the activities and also includes information and useful links. Here's the link: http://www.oapt.ca/newsletter/2009_11_nl.pdf
- **Dave's Dollar Store Physics**, including a "Big Circuits Activity" that can be used both in the grade 9 and grade 11 electricity units using large pieces of cardboard, aluminum foil, wires, batteries, resistors, Christmas lights, etc.

Also please take a minute to check out the "imovie trailer" Robert Prior put together from our three days at Physics Camp. It is great! The link is: http://www.flickr.com/photos/etherflyer/6047758436/

All of us left Physics camp feeling revitalized, re-energized and excited to go back to our respective schools to not only implement the many inquiry based activities that were presented to us into our classrooms this fall, but also share them with colleagues in our departments/in our school board. On behalf of all the teachers registered this year, I would like to extend a BIG thank you to Roberta, Dave and James . . . we look forward to more workshops like this in the future!!

# How Do You Kick-Start a Physics Teacher?

**Christine Hudecki**
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What do you do if you've been teaching physics for a while and feel like you need an injection of enthusiasm, excitement and great teaching ideas? You apply to EinsteinPlus - that's what you do! EinsteinPlus is a week long physics 'bootcamp' hosted by Perimeter Institute (PI) in Waterloo, Ontario. The Perimeter Institute itself is a think tank for over 100 theoretical physicists. It's a place where graduate students, post-docs and established professors and scientists work to further our understanding of modern physics. However, in the summer, it opens its door to us - educators who wish to learn more about physics and current physics research.

This past summer, I had the opportunity to be one of 40 teachers attending EinsteinPlus 2011. What an amazing experience! The best part was that it was physics all week long! What a unique opportunity it was to be taken away from the daily demands of running a house and to be given the chance to focus on personal learning. Quite often professional development opportunities are an hour or two squeezed in after school after which one rushes home. This was a chance to immerse, explore, share, discuss and then contemplate without interruption.

Like a well run classroom, our days were planned with a mixture of experiences. Lectures, activities, discussions, make-and-take sessions, quizzes, field trips and movies were all part of the package. We had it all! I appreciated Dr. Cliff Burgess' lecture on the Large Hadron Collider (why it was built and what it could tell us) and several days later, Dr. Louis Leblond's (P.I. post-doc student) presentation of his research on the finer details of the Big Bang. We particpated in activities on dark matter, polarization, black holes, relativity and particle physics. And what course is complete without a field trip? EinsteinPlus was no exception! We were treated to a tour of the Institute for Quantum Computing (IQC) where researchers are currently applying knowledge of quantum mechanics to build even more powerful computers.
My EinsteinPlus colleagues and I came from a wide range of backgrounds. Although we all currently teach physics, some were trained or had experience in engineering, biology, chemistry and even drama. Some are teaching in public schools, private school and virtual classrooms. Teachers attending EinsteinPlus came from across Canada (PEI to BC) and even from abroad (Australia, South Africa, UK). On two separate evenings there was an opportunity for all to share their best practises with each other. I came away with a wealth of ideas!
Now that I am a fully re-energized physics teacher, one might wonder how my classroom will change this fall? I am certainly more confident in my ability to teach and discuss modern physics (dark matter, black holes, relativity, quantum ideas). Since our workshops were presented with PER (Physics Education Research) in mind, my classroom will become more student-focussed and even more activity-based. Some of the P.I. resources I received make links to the physics strands of intermediate science and I plan to infuse modern physics into grade 9 and 10 where appropriate and help other intermediate teachers to do so. Let's get students excited about modern physics!

I know we all came away wanting to make changes in our classrooms and I hope to stay connected to my EinsteinPlus colleagues and work cooperatively as we transform our teaching practises. Finally, and perhaps most importantly, I will bring with me this fall a new sense of wonder and excitement about physics.
So if you've been teaching physics for a while and feel like you need a kickstart, I highly encourage you to apply to EinsteinPlus 2012. All information is posted at www.perimeterinstitute.ca . While you are there, surf around the site. By choosing the 'outreach' tab, you will find extensive resources available free for students and teachers. While guest lecturers are frequent at P.I. and upcoming events are posted on the site, you can also enjoyed viewing previously recorded lectures by choosing the 'PIRSA' tab. So get re-energized and excited about physics – its all there at the Perimeter Institute!

# Two prominent OAPT Members Honoured

Past President of the OAPT **Glenn Wagner** has received the **2011 Canadian Association of Physicists` Award for Excellence in Teaching High School/CEGEP Physics - Ontario**. Teaching at Centre Wellington DHS, Glenn has developed skill in the use of peer instruction, collaborative group work, concept mapping and problem-based learning. A PhD candidate, Glenn is the author of several research papers on physics teaching.

Past Vice President of the OAPT **John Atherton** has received the **2011 Premier`s Award for Teaching Excellence in the category of Excellence in Leadership**. During his tenure as an Instructional Leader at the Toronto District School Board, John established the GTA Physics Teachers' Alliance. In 2007 John launched the TDSB Eureka Conference, attended by 600 science teachers and described by many as the most useful professional development they ever attended.

## OAPT

### Grade 11 Physics Contest

Register online at www.oapt.ca

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at

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