OAPT Newsletter

Summer 2012

The Prez Sez

by Roberta Tevlin
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Record attendance at this year's conference at Perimeter Institute!

The conference was a huge success thanks to the effort and enthusiasm of all of those involved. We had to close off registration for the first time in the history of the OAPT. The 200 delegates at the conference represented nearly 80% of our membership, which is amazing.

The success of the conference is due to many people. We would like to recognize the contributions of:

- **The Perimeter Institute**: Try to imagine the conference without the building, the food, the technical support, the organizers (especially Marie), the northern travel subsidy, and of course, the speed dating of the researchers! PI was once again an incredibly generous host.
- **U of T Department of Electrical and Computing Engineering**: Once again they subsidized accommodation costs, allowing delegates to stay for just $19.99/night. This contributed to this year's record attendance and made more time for the important interactions that happen outside of the formal sessions.

Inside

Photo: Robert Prior

The Prez Sez (continued)

- **The Presenters**: We were very fortunate to have our two keynote speakers, Dr. Neil Turok and Dr. Cliff Burgess, and a remarkable lineup of workshop presenters. All of these people volunteered to share their expertise. The biggest complaint I heard from delegates was that they couldn't clone themselves and attend more than one session at a time. We will do our best to bring back the most popular presenters next year.
- **The OAPT Volunteer Team**: A small but dedicated team of volunteers handled registration, name tags, and other logistics. They introduced and thanked speakers, conducted and analyzed feedback surveys, and organized the extracurricular events..
- **The Delegates**: You are teachers who see value in equipping yourselves with the best ideas, principles and techniques to take back to your classrooms.

Volunteers welcome!

Your enthusiasm was infectious, your patience when things did not go smoothly was appreciated, and your feedback makes it all worthwhile.

Next year's conference will be at the University of Ontario Institute of Technology (OUIT) in Oshawa. Lisa Lim-Cole and Shawn Bullock are our new vice-presidents and will be organizing the UOIT conference. They are looking for volunteers! If you would like to be involved in helping the OAPT support physics teachers just drop me a line. I can find a task that suits your interests, abilities and time.

Snapshots from the conference…

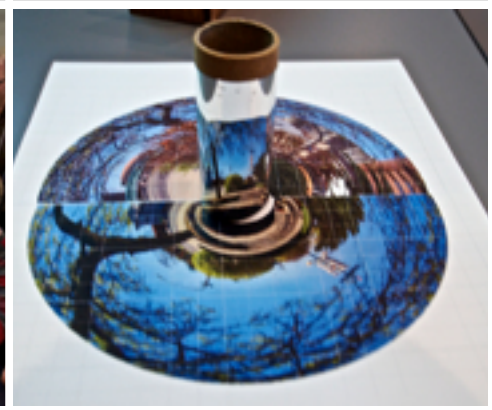
Tour of Perimeter Institute. These well-lit collaboration areas are liberally supplied with markers. Here, you're expected to write on the walls.

Dr. Cliff Burgess, showing us what CERN is really like. Hint: a certain famous author got it very wrong…

Dr. Lucien Hardy valiantly explaining wave-particle duality, Heisenberg, many worlds, and other conundrums of modern physics.

Greg Dick, in his best cheesy voice, introducing the participants in the Physics Speed Dating event.

Physics Speed Dating. Fast, furious, and way more fun than the other speed dating.



The Kitchener Anamorph, a sculpture designed by Dr. Jim Hunt, and a really cool example of the intersection between art and science.

More photos…

You can find more pictures of the conference at these websites.

OAPT

Robert Prior

Photo: Robert Prior

Waves & Sound with Dave Doucette

by Tim Langford

Officially this session was called “Getting the HOTS* for Brain-Based Learning”. Dave, coming off two years of administrative purgatory as OAPT president, was looking relaxed and happy to be back in the saddle as a teacher of teachers.

Memories that stand out from being in Dave’s presence on this day:

Entry cards. This is Dave’s reversal of the strategy of “exit cards”, which he says never worked for him. His “entry cards” are sheets of four multiple choice questions.** (Perhaps he would have only two questions per card for the students: I found these questions a little tricky!) He says that he used to post the answers to them, but one day he didn’t have time and said to his class, “Just compare answers with someone nearby who is also finished.” A new strategy was born, one that creates more discussion and arguments, and thus more learning.

A lonnnnng pause by Dave. “Don’t talk while the students are talking,” advises Dave. This is perhaps a reversal of what most of us would say to our students. (“Don’t talk while the teacher is talking.”) Dave says he will just wait, sometimes for ten minutes at a time, until the students are quiet. (I have been skeptical when I’ve heard master teachers say this before). Somehow when Dave says this I believe it.

Hands on, minds on. Dave has four student stations set up, each with a “cool” self-guided demonstration of sound. Three of them use a technology that students can readily identify: a stereo speaker. One uses a laptop and software. All four have simple instructions and two questions that require the students to think about what is happening. It is a true marriage of theory and practice and a true test of understanding.

Textbook treatment of air columns. Dave laments how poorly most high school textbooks explain resonance inside a tube. “For one thing,” he says, “they lead you to believe that the tube is resonating, when it is actually the air inside it that is.” His second complaint is that many textbooks have the positions and effects of nodes and antinodes reversed when it comes to air. “The node is the point of highest air pressure,” he says. Dave went on to explain why exactly the open end of a column causes reflection. This is rather counter-intuitive. WHAT IS YOUR EXPLANATION?

* Higher Order Thinking Skills

** Dave’s multiple choice questions came from PhysicsLab Online: http://dev.physicslab.org

After two years of administrative purgatory as OAPT president, Dave was looking relaxed and happy to be back in the saddle as a teacher of teachers.

Download materials from the workshops

Revolutions in Science with Dr. Richard Epp

by Sandy Evans

How much time do we spend with our students discussing the force of gravity? Do we ever suggest to them that it is not really a force? Many of us have had the experience of attempting to model the fabric of space-time to our students with a stretchy piece of fabric. We spread out the fabric, indent the middle to simulate a large mass warping it, and roll balls around it to model the effect of gravity on an orbiting object. It wasn't until attending Dr. Richard Epp's session at this year's conference that I thought of simulating the effects of gravity and space-time with a beach ball!

We teach our students about apparent weight and how accelerating upwards in an elevator will increase the normal force. Dr. Epp urges us to extend this concept to ponder that perhaps the "force of gravity" we feel is not really a force but instead is the ground accelerating us upward with magnitude a = g. This is Einstein's Equivalence Principle. Many students will ask, "If that is so, then why is the Earth not expanding outwards?"

Dr. Epp was able to clearly explain this through the use of a beach ball simulating space-time. We usually teach that projectiles will follow a parabolic trajectory due to the force of gravity. However, Dr. Epp showed that a projectile follows a straight path in curved space-time! He described how acceleration warps time and how gravity is really a warping of space-time. He discussed the concept of considering our motion through not only space but through time by considering velocity in four-dimensional space-time. Through Dr. Epp's workshop and a beach ball, we accelerated our knowledge and ability to teach the concepts of General Relativity.

Download materials from the workshops


Photo: Éole Wind

It is crucial that students learn that there are no new laws for circular motion.

Fixing Our Physics: Circular Motion

by Chris Meyer
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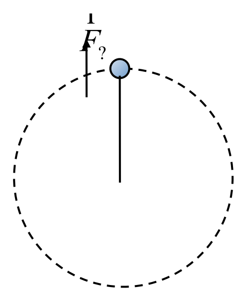
Ah, circular motion – I get dizzy just thinking about it. Everybody is doing it (even sometimes the LHC), but who understands it? This is a challenging topic for all of us. Fortunately, physics education research (PER) has many insights to offer us on matters topical as well as pedagogical. What does PER have to say about how to teach circular motion? Let's find out. For no extra charge I will throw in my own two cents' worth

A main goal of reformed physics teaching is the development of deep conceptual understanding within a robust interconnected framework. New ideas should not only "make sense"; they should be well connected to prior concepts and ideas. This is the antidote to rote algorithmic learning and disjointed knowledge. (I always say, "A little compartmentalized learning is a dangerous thing!") This goal can be realized through the careful exploration of the two aspects of circular motion: force and acceleration - cause and effect.

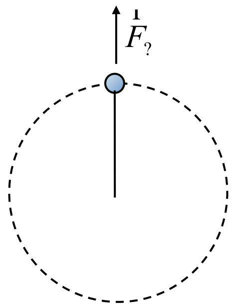
Curious Forces in Circular Motion

There are two persistent ideas that many students have regarding uniform circular motion: (1) that there must be a forward (tangential) force that keeps the object moving in a circle; and (2) there must be an outwards force keeping it from falling inwards. These ideas can very happily coexist in the fertile student mind along with the teacher-approved notion of a radially inward net force. For novice physics students all three possibilities may seem plausible and may not seem mutually exclusive. Only after repeated and explicit examination, followed up by careful reinforcement long after the circular motion unit is finished, will the misconceptions wither away.



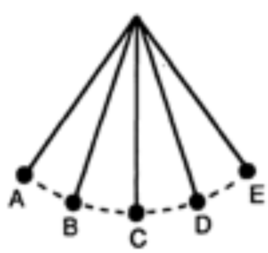
The appeal of a forwards force can stem from insecurity with Newton's 1st law in the context of two-dimensional motion. The idea that an external force is not required for an object to maintain a constant speed is strange enough. To compound things, physics suffers from very rich laws whose many consequences are not well unpacked for students. Mathematicians have theorems and their theorems' offspring: lemmas. We need these for physics! For example, Newton's 2nd Law should have a lemma, which I affectionately call the Orthogonality Principle, stating that "a net force in one direction does not affect the speed in a perpendicular direction." Obvious, right? Not for most students. This is a fundamental feature of the 2nd law that lies at the heart of understanding circular motion. Its earlier introduction when studying projectile motion can greatly help dispel the "forwards force" notion. Another useful lemma students should develop while exploring circular motion is "a force parallel to an object's direction of motion only changes its speed; a force perpendicular to its motion only changes its direction." Both lemmas are helpful ways of capturing the nuances of Newton's laws applied to two-dimensional motion.

The Outwards Force



The allure of an outwards force in circular motion is very great and surprisingly persistent (even amongst a number of teachers I have workshopped). We only have ourselves to blame for this, and by "ourselves" I mean our physical selves: when we travel in a circle we feel an outwards effect of some kind. It takes careful work to reinterpret this valuable observation. This work is a process that should begin long before the topic of circular motion is reached. The physical sensation of acceleration needs to be made sense of early on in the context of linear acceleration. The goal is the understanding that when accelerating due to any force other than gravity, our physical sensation is that of being pushed in a direction opposite to our acceleration. For example, we feel pressed into the seat of a car that is speeding up. This provides students with a familiar tool to help understand the sensation of being pushed outwards without having to conjure up an outwards force.

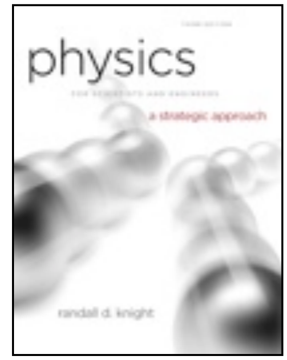
Especially in the case of an object being whirled on a string, another rationale students often invoke for the existence of an outwards force is the need to prevent the object from traveling directly inwards to the centre of the circular path. Another still is their attempt to explain why there is any tension in the string at all! These proposals need to be met with a careful kinematic exploration of circular motion. I find this is easiest in the context of orbits and the recognition of the need for orbital speed. Another valuable example is a rollercoaster loop with an unattached car upside-down at the top. The car could in fact fall straight down, but with a suitable tangential speed, it moves far enough forward while it "falls" that it remains in contact with the track.



A telling example of the challenges of understanding circular motion comes from a study by Sue Allen and Frederick Reif in which the researchers pose to a group of students and physics professors from UC Berkeley a simple question: What is the direction of the acceleration of a pendulum bob as it speeds up and reaches point C in the diagram to the right? Only 3 out of 5 of the veteran professors answered correctly, even when prompted to clarify their responses. Indeed, the matter of forces in circular motion can be very thorny. (What is the correct answer?)

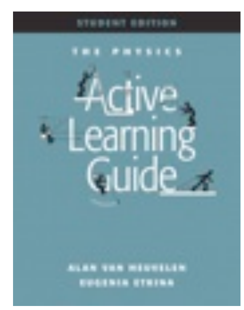
Unity and Diversity

One of the great things about physics is that a small number of ideas have the power to explain so many different things. Physicists toil to reduce the number of necessary ideas. It's kind of an obsession. Teachers do a bad, bad thing when we needlessly increase that number. This brings me to a dirty trick we pull on our students. By this point in their studies, students already have a name for the idea "the combined effect of all the forces in one direction" – known as the net force in, let's say, the radial direction. But then when circular motion comes along, we introduce this new thing "F_c" and our attempts at building a deep, robust understanding of circular motion lurches to a halt.



I am quite pleased to note that in Randall Knight's new textbook, which is deeply infused with physics education research, the mischievous Fc never appears. There are a number of very good reasons for never using this symbol or introducing an equation like $F_c = mv^2/r$. The main reason is that there is a perfectly good idea, $F_{net} = ma$, which really has this circular motion business well covered. Besides, you would never introduce a "handy" equation like $F_{net} = m(v_2 - v_1)/\Delta t$, owing to your confidence in your students' ability to find a strategy to determine the acceleration. So why sell them short with circular motion? If students don't begin their thinking about circular motion with $F_{net} = ma$ they are not making vital reinforcements between prior understanding and this challenging new topic. It is crucial that students learn that there are no new laws for circular motion. Even if you introduce the centripetal force equation as a convenient short cut, students will memorize it, and in doing so will cut short their thinking (which is bad).

"One of the great things about physics is that a small number of ideas have the power to explain so many different things.… Teachers do a bad, bad thing when we needlessly increase that number.

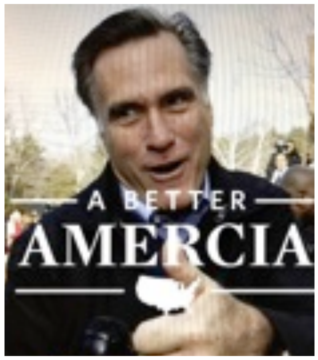


The Physics Union Mathematics program developed by Eugenia Etkina and Alan van Heuvelen at Rutgers University does a great job of emphasizing the deep connection between the kinematic and dynamic pictures of circular motion. If you email Professor Etkina you may receive a password to the website which has an astounding set of PER informed physics units. My own treatment of circular motion draws heavily upon their work. They take great pains to highlight how a velocity vector analysis of circular motion (acceleration points to the centre) agrees with a force diagram analysis (net force points to the centre) courtesy of, you guessed it, Newton's second law. These are not obvious results to be glossed over; they are pillars of a deeper understanding.

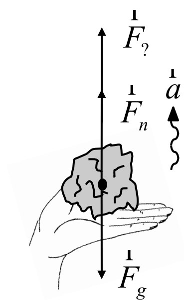
It is crucial that students learn that there are no new laws for circular motion.

The Many Problems with F_c

I have other concerns with the gormless F_c. Textbook authors don't really seem to use it and its namesake, the "centripetal force", honestly. The adjective "centripetal" is a valuable label when describing a familiar force that has a component responsible for keeping an object moving in a circle (my definition). For example: "When Mitt Romney makes a 180° turn in policy, political expediency is the centripetal force". Traditional texts define the centripetal force as $F_c \equiv F_{net}$, which is a problem for non-uniform circular motion. But even if we understand that they really mean the radial component of the net force, authors seldom use it this way in their descriptions; they tend to describe single, inward forces as the centripetal force. Furthermore, this term and its notation seem to be no more than an affectation of high school and introductory physics texts. In more advanced studies the term is abandoned and central forces are described or angular motion and moments are used.



Unfortunately, students are often quite relieved when you provide them with a new force, F_c. Perhaps it provides a convenient scapegoat on which to blame the mystery of circular motion. Just as novice physics students will often invent a mysterious new force to explain the upward acceleration of a held object (see the FBD to the right), they are happy to have a brand new force to explain the peculiarities of circular motion. Perhaps you have noticed how F_c tends to appear in free-body diagrams in curious locations or in the place of other, reasonable forces. They will stop thinking carefully about how friction might be keeping the car going around the corner. Why should they: it's the F_c that's responsible! Other times the F_c appearing in their FBDs corresponds to no known physical interaction. But what can we expect: neither does their physical experience of circular motion! (The outward force, that is.)



Multiple Representations

Learning to represent the physics of a situation in a wide variety of ways is another key to developing a robust, well-connected understanding. Those in the know call this "multiple representations". Depending on the topic, there are a variety of possible representations. Shown below is an example for circular motion. A great exercise is to provide one or two of these representations and have students devise the others. This often involves quite a bit of good old know-how and also some amusing creativity!

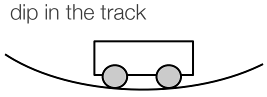
Chris's Razor: "If it's not necessary, don't teach it". Please, dispense with Fc.

Implementation and Invitation

All of the ideas discussed here can be used with any mode of classroom teaching: old-fashioned lecture or new-fangled group work (my modus operandi). But to be sure, your students will get more out of their experience the more they explain their own ideas to one another. I teach circular motion over five (yes, five!) classes using a variety of investigations and activities. Don't mess around: if you're going to do it, do it well. Follow this link to my website where you can explore my circular motion lessons and syllabus, amongst the other materials for my course. Finally, I re-issue my standing invitation: the door to my classroom is always open. Just email me if you would like to drop by and see a lecture-free, reformed physics class in action.

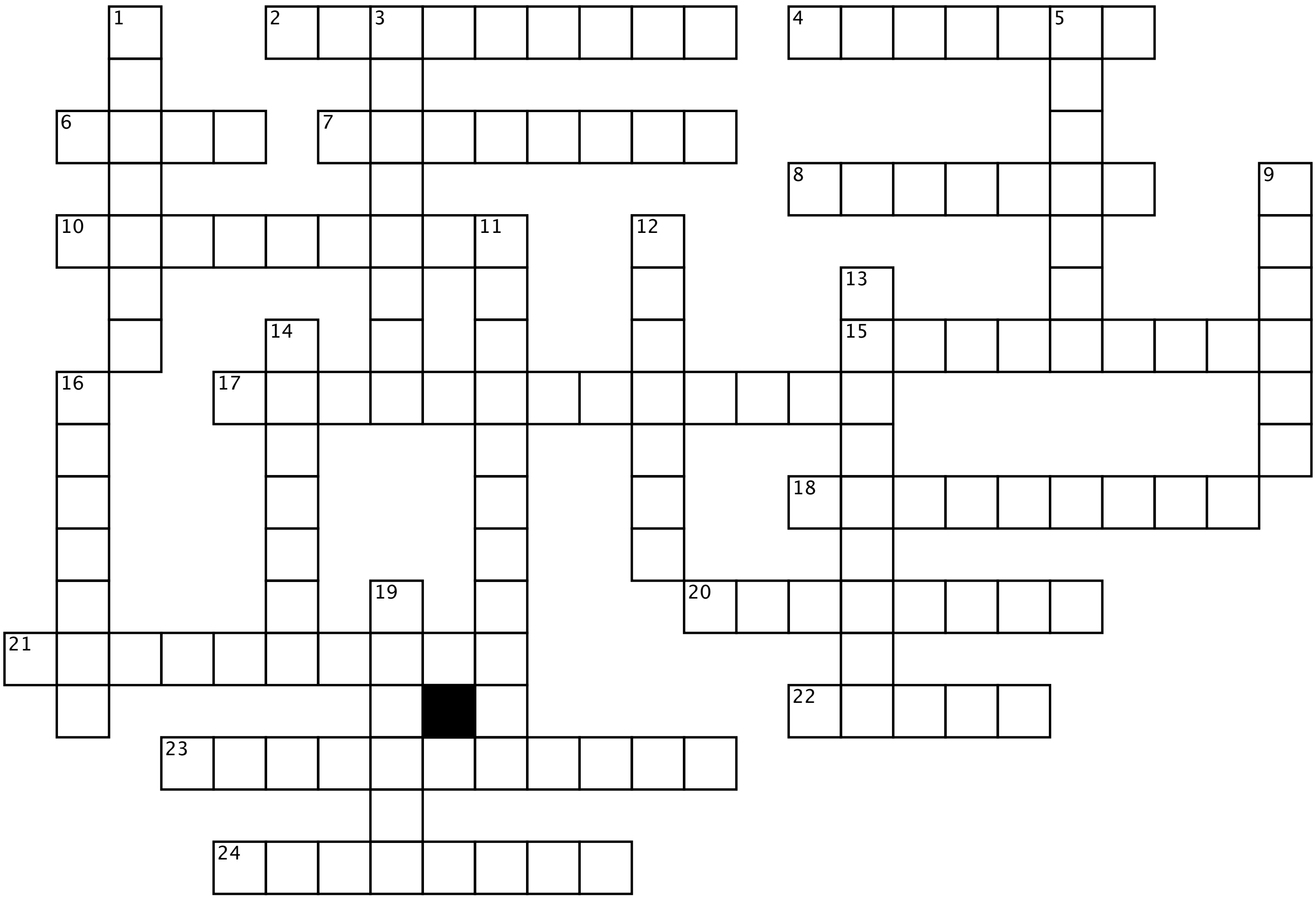
Executive Summary for Teaching Uniform Circular Motion:

- Use the terms radial and tangential whenever possible ($a_r = v^2/r$, $F_{net\,t} = 0$)
- Only use the term "centripetal" as an adjective for familiar inward forces
- Always start problems with $F_{net} = ma$; banish F_c
- Reinforce agreement between the kinematic picture and force picture
- Use multiple representations
- Provide activities that motivate the presence of an inward net force and that help refute the existence of forward or outward forces
- Help students explain why the object doesn't travel towards the centre of the circle and why we feel an outward force
- Create a lemma. Name it after yourself! "Parallel forces change speed. Perpendicular forces change direction."
- Make sure students' understanding will generalize easily to non-uniform circular motion

Words and Sketch	Velocity Vectors	Force Diagram	Newton's 2nd Law	Sample Solution
A roller coaster car moves along a frictionless circular dip in the track 			$F_{net} = ma_r$ $F_n - F_g = mv^2/r$	$F_n - F_g = mv^2/r$ $F_n - (350\text{ kg})(9.8\text{ N/kg}) = (350\text{ kg})(12\text{ m/s})^2/(7.8\text{ m})$

Phamous Physicists

Physics history. How well do you know it? Some of these physicists are famous, others are less well-known, but all have entries on Wikipedia.



Across

2. Has his own radiation
4. Bongo drummer
6. Also a high-quality speaker
7. Much bigger than his name
8. Excellent experimentalist, famous lecturer, but couldn't do trigonometry
10. Don't put before the horse
15. Limited stellar brightness
17. Stellar physicist
18. Threaded fasteners; male human
20. Scattering, but not bicycles
21. Knew where he was, or where he was going, but not both
22. Predicted the opposite of uncle-father
23. Heliocentric
24. "Of what use is a newborn baby?"

Down

1. Terracentric
3. The genetic physicist
5. On reflection, not as mad as he appeared...
9. Board
11. Not really a cat hater...
12. Famous contraction 13. Engineers' pub
14. Liked raisin buns
16. A big rock did it
19. The last alchemist

Ontario Association of Physics Teachers

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

New Materials on the Website

The OAPT website is fast becoming a must-go zone to get the best materials for your physics classes and physics-based units in intermediate science!

Due to be launched in September:

- A database of all the OAPT Contest questions since the contest's inception
- A database of all Demo Corner articles since the newsletter's inception

In development:

- A "DemoTube" database of short videos showing how to perform demonstrations and how to implement best practices in the physics or science classroom.

Stay posted. If you are interested in helping with this time-consuming project please email "The Prez": Roberta@tevlin.ca

Call for Articles

Have you or has a colleague of yours done something progressive or interesting with your physics teaching recently? Or perhaps you have the wisdom of many years of experience in teaching this difficult subject.Perhaps you teach Ontario's northland or in a rural area and have a different perspective or unique experiences to relate.

Share your experiences! Write a brief (~400 word) article for the Newsletter and send it to:

newsletter_editor_8@oapt.ca

Olga Michalopoulos honoured with the 2012 CAP Award

Olga Michalopoulos of Georgetown District High School in the Halton District School Board has been named by the Canadian Association of Physicists as the winner of the 2012 CAP Award for Excellence in Teaching High School/CEGEP Physics in Ontario. "I am humbled and deeply honoured," says Michalopoulos. "I have always been passionate about physics. I have also been fortunate and privileged to work with many outstanding colleagues who have continued to support me and help me grow as an educator. I thank them all. Most importantly, I want to thank my students for continuing to inspire me over the years and allowing me to touch the future."

The CAP Award for Excellence in Teaching High School/CEGEP Physics, which was introduced in 2010, is intended to recognize excellence in teaching physics in Canadian high schools or CEGEPs and to encourage and promote physics at the high school/CEGEP level in Canada. The award is sponsored at the national level by the CAP, TRIUMF, Merlan Scientific, Perimeter Institute, Institute of Particle Physics, Nelson Education, and Vernier, and at the regional level by the BC Innovation Council and the Association of Professional Engineers and Geoscientists of BC. The award honours physics teachers in Canadian high schools or CEGEPs who have a good understanding of their subject and who possess an exceptional ability to communicate their knowledge and understanding in such a way as to motivate their students to high academic achievement in physics.

See all the award winners on the Canadian Association of Physicists website:

- http://www.cap.ca/medal/publicity/recipients.php?year=2012&type=hs&lang=en

OAPT's 4th Annual Camp OTF

July 24 – 26 Carleton University, Ottawa

Looking for a phabulous professional development opportunity this summer? Don't miss this *justaboutfree* camp for physics teachers of grades 9 -12. For a paltry $100, you get:

- twelve hands-on workshops,
- two nights of accommodation,
- three full breakfasts, lunches and coffee breaks, and
- over $100 in teaching materials.

Our stellar lineup of presenters includes three past/present OAPT presidents: Glenn Wagner, Dave Doucette and Roberta Tevlin. Join their campfire while honing skills in building a research-based, conceptual physics program using differentiated instruction, inquiry-based learning, role playing, and dollar-store equipment to increase student understanding and physics enrolment. If you liked the conference, you'll simply love camping! It is easily the richest professional development program OAPT has offered.

Each year this camp has sold out, so **register now**! **Registration closes July 8th**.

For detailed information on the workshop sessions, go to our website at http://www.oapt.ca/ and click on 'The 4th Annual Physics Camp 2012'.