OAPT Newsletter

Spring 2013

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The Prez Sez

by Roberta Tevlin
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The weather and labour conditions may be cold but the OAPT conference is HOT HOT HOT!

Our theme this year is Physics Education Research in Action

- Dave Doucette, Chris Meyer and Glenn Wagner have put together an intensive program outlining the research, general principles and specific techniques of PER. Find out what the fuss is all about or, if you already know, increase your expertise. They will kick things off with a tag-team keynote session on Friday morning. Then check out some of the eight different workshops focusing on PER presented by these three gents, Diana Hall and UOIT faculty.

- UOIT is the newest university in Ontario. This is your chance to get a close look at what they have to offer your students. Our generous hosts

Inside

The OAPT Newsletter is published by the Ontario Association of Physics Teachers.

President: *Roberta Tevlin*
Editor: *Tim Langford*
ePublishers: *Robert Prior and Derrick Sarwan*

Prez Sez (continued)

will be offering tours and five workshops featuring members of their faculty.

- This physics conference is not just about physics courses. Every time slot has a workshop that addresses the physics units in junior science courses. Let your principal know that you will be bringing back useful resources to support grade 9 and 10 science dealing with electricity, astronomy, climate change, optics The Process of Science – a new PI resource.
- For the third year running we are able to offer rooms with a continental breakfast at just $19.99 a night! Take the opportunity to stay in residence and explore projectile motion and conservation laws at a dart board or pool table! Check out resonance and dissonance with karaoke on Friday night! The special accommodation deal is available only to the first 80 registrants. Reserve your rooms now!
- The conference has a very generous early bird rate for those that register and pay by Friday April 5th. Doing so will make things easier on your pocket book and easier on the volunteers running the conference!

I and the rest of the OAPT steering committee look forward to seeing you at the conference!

Check out our new expanded website!

New features include:

- An Events page informing you of upcoming workshops, PTA meetings, conferences, etc.: http://www.oapt.ca/events/index.html
- A Resources page featuring concept questions for peer instruction, the archive of all Demo Corner articles, the archive of all OAPT Contest questions, and much more! http://www.oapt.ca/resources/index.html
- A new Google search feature to search the OAPT site
- The enhanced Newsletter page, featuring versions for your desktop, tablet, iPad, and iPhone: http://www.oapt.ca/newsletter/index.html

Rotman Comes Into the Grade 10 Classroom

Shawn Brooks
University of Toronto Schools

The Rotman School of Management at the University of Toronto is helping the University of Toronto Schools with our culminating task for the grade 10 Climate Change unit!

That's right, through their I-think Initiative[1] they are helping the grade 10 science teachers design a three-day activity that will be integrated through our Climate Change unit. The plan involves the use of a digital resource that allows students to calculate for themselves the mean surface temperature of the Earth with the simplest global climate.

If you are interested in this resource or want to find out more come to the workshop on Approaches and Ideas for Teaching Climate Change that Lisa Lim-Cole and I will be presenting at the OAPT Conference[2], May 2-4.

Links List

1. http://www.rotman.utoronto.ca/facultyandresearch/researchcentres/desautelscentre/programs/i-think.aspx
2. http://www.oapt.ca/conference/2013/program.html

Taylor's Pneumatic Toys

by Stanley R. Taylor
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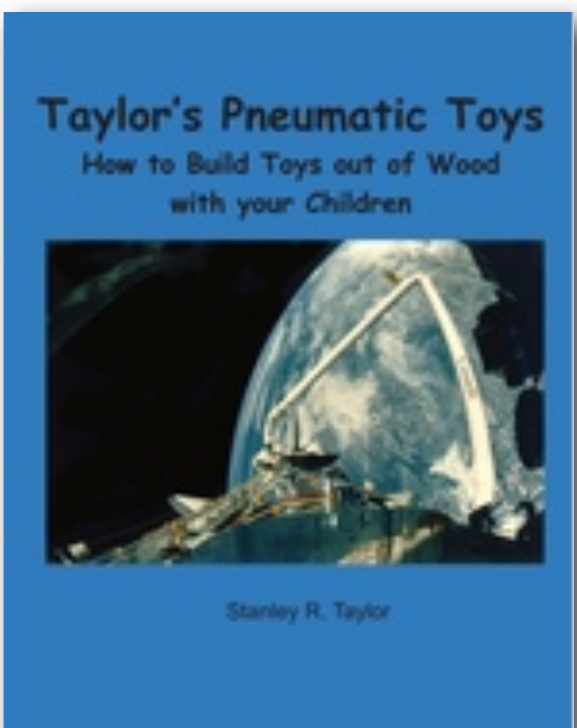

Stan Taylor has written a delightful little book that ought to be a standard classroom reference for every middle school Design & Tech. teacher. Taylor outlines eight pneumatics projects of escalating degrees of difficulty that can be built out of wood, plastic syringes, and everyday materials such as string, foam cups, shoeboxes, and even McDonald's fries containers. The only power tools that appear to be required are a drill and a jigsaw. Each project comes complete with a full parts list, step-by-step instructions, large labelled schematic diagrams, and black-and-white photos showing relevant details and the finished product. The binder-sized format of the book allows the diagrams and photos to be large enough that the details are visible. Each project is prefaced by a brief story that tells how the project idea arose and in some cases how sub-problems within that project were creatively solved. These stories invariably have a personal bent that makes the book endearing.

Taylor has given many workshops on the building of pneumatic toys. In February of this year he delivered a workshop on the construction of his Canadarm replica at the Johnson Space Center in Houston. He says, "Children and adults alike have learned through my workshops how to make many of the toys in this book. The sparkle in the eye of a child and the broad smile of an educator when they have made the toy and when they see it working is most gratifying.

Review by Tim Langford, newsletter editor

Physics Education Research at the University of Toronto

by Dr. David Harrison
introduced by Roberta Tevlin

Physics education researchers at the University of Toronto recently completed a study of how students perform in first year physics. One of the study's authors, Dr. David Harrison, has kindly agreed to make a pre-publication version of the resulting paper available for our readers. It is a fascinating paper about factors influencing student success. Attendees at the OAPT conference at U of T in 2010 heard Dr. Harrison's keynote address in which he described lab tutorials the faculty had recently instituted in order to foster more PER-based student-centered learning. This study compared the effectiveness of student learning in these tutorials with learning accruing from traditional lectures. Below is the abstract and a link to the full-text article. It will give you a sense of how PER research is conducted and is well worth reading. For an ego boost pay close attention to the discussion near the end: it appears that high school physics teachers in Ontario are doing a good job! Dr. Harrison will be giving a workshop entitled "Modelling the Scientific Method With A (Possibly) Stacked Deck"[1] at our 2013 conference Physics Education Research in Action[2]:

Abstract

We have studied the correlation of student performance in a large 1st year university physics course with motivation for taking the course and whether or not the student took a senior-level high-school physics course. Performance was measured both by the Force Concept Inventory and by the marks on the Final Examination. Students who took the course primarily for their own interest outperformed students who took the course primarily because it was required; students who took a senior-level high-school physics course outperformed students who did not. Students who took the course for their own interest and took high school physics outperformed students who took the course because it was required and did not take high school physics by a wide margin. However, the average normalized gain on the Force Concept Inventory was the same for all groups and sub-groups of students.

Full Text[3]

Hyperlinks Used:

1. http://www.oapt.ca/conference/2013/dave_harrison_2013.html
2. http://www.oapt.ca/conference/2013/index.html
3. http://www.upscale.utoronto.ca/PVB/Harrison/P131F12MotGr12/P131F12MotGr12.pdf

Nature: Judge, Jury and…

by Chris Meyer
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PER Corner

Who's The Boss? Nature.

I humbly propose a new model for education. We are all very familiar with the now somewhat unfashionable, yet prevalent, teacher-centred learning model: "All eyes to the front! Tim, pay attention — what I'm covering is important!" Here, the final word is always the teacher's. Next is the more au courant student-centred model, where the final word is often the students'. That's a big step in the right direction — getting those teachers to pipe down for a bit. But what we really need in science education is a nature-centred model, where the final word goes to Mother Nature. What better authority for knowledge and insight do we have?

For thirty years physicists have been researching how best to educate students. Through quantitative research great strides have been made to turn the study of education into a science. This science has identified teaching techniques that are substantial improvements over traditional practices.

Our Better, Nature

If there is one critical lesson about science for our students, it is our slavish devotion to nature's every word. Like doting suitors we ask her questions and take great pains to listen to her nuanced and subtle answers. Our quaint notions and fanciful ideas (like those involving me and Scarlett Johansson … sigh) only last so long before they are dispelled through empiricism and logic. What lesson could be of greater use? Are you listening, politicians? As educators, we need to transition away from being the figure of authority. Physics Education Research (PER) has shown that students learn best when they are talking about and explaining physics to one another. They have to wrestle with core concepts of physics themselves in order to build genuine understanding. Researchers have studied (empirically) the evolution of students' opinions about physics and about science in general as they progressed through reformed, student-centred, educational programs. Sure enough, the researchers' quaint notions concerning the goings-on of the student mind were dispelled.

Is Physics Real?

Who in their right mind would ask a question like that (aside from climate change deniers, creationists and Italian judges[1])? Pesky physics education researchers would. It has been hoped that the shift to student-centred learning would help students develop more expert thoughts and opinions about the operation and applicability of physics. To measure this great shift in thinking a few different surveys have been developed, the most recent being CLASS [2] (Colorado Learning Attitudes About Science Survey). Rather than ask students outright and get the answer we want, the researchers were a little coyer. In the CLASS survey a number of innocuous statements are presented for students' consideration, such as:

28. Learning physics changes my ideas about how the world works.

30. Reasoning skills used to understand physics can be helpful to me in my everyday life.

35. The subject of physics has little relation to what I experience in the real world.

37. To understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed.

In almost all cases, the proportion of students who agree with expert responses to these questions dropped after a semester of instruction, regardless of the format — traditional lecture or active engagement. Typical results [3] are a drop from 72% ±1% to 65% ± 2%. Even for courses [4] with high levels of group work and hands-on experimentation, the results are mixed at best. It seems that even with our best efforts, our teaching leads to fewer students believing in the reality of physics. What would Mother Nature say?

The psychology behind this disconcerting phenomenon is explored in Edward Redish's excellent book Teaching with the Physics Suite [5]. Redish notes that "students can attach new knowledge to their existing knowledge structures as something separate and only relevant for the context of solving problems in a physics class." As teachers we have all witnessed students' remarkable ability to compartmentalize knowledge. We've all watched them stitch unnatural ideas together into their misbegotten Franken-solutions. Redish proposes a few goals for our teaching to encourage a rapprochement between students and physical reality:

Our students need to understand how the physics they are learning is firmly rooted in the physical world.

Our students need to learn both how to use the physics they are learning and when to use it.

Our students need to connect the physics they are learning with their own experiences.

It is important that we upgrade our traditional problems and classroom examples to involve "real-world" situations. But that will not correct this problem. Students will always appeal to the teacher or the textbook for verification and validation of their results. The connection with nature is not secured. Cooperative group work allows students to work together to explore physical phenomena, find patterns and solve problems. This is another big step forward, but this may only be Aristotelian physics: while their ideas may be self-generated and even internally consistent, they have not been tested against nature. And to paraphrase the Tick [6], Mother Nature is a harsh mistress (just ask Bohr and Einstein).

A Modest Proposal

What should we do about this? I have a few suggestions, but first, full disclosure. I am accepting kickbacks from Mother Nature in the form of air, water and general foodstuffs, and I have not actually run the CLASS survey with my own students, so I have no empirical results. Nevertheless, my anecdotal results leave me hopeful (unlike with Scarlett Johansson – did you see her in The Avengers?). Here are my suggestions:

(1) Agree on "Close Enough"

Long before I changed my teaching practice my students had been "testing" predictions in "experiments". But what they were doing was bogus, in part because they did not understand how to decide whether a measurement agrees with a prediction. What process, after all, is more critical and unique to science than this? If my students happened to measure the exact same value as their prediction they would contentedly move on. If they didn't, they would show it to me and I (the voice of authority!) would say, "close enough," and the veil was again draped over Mother Nature. Looking back on it I think I could actually see the cloudiness forming in their eyes.

To peel back those veils students need a basic understanding of errors. We do a single lesson on measurement and error, but we do not do error propagation. My goal is to help them have a sense for errors arising from measurement tools and to help them crudely estimate errors in calculations. This can be as simple as "the calculation gave a result of 1.2 m which I wrote with two significant figures. So the result is reliable to within ± 0.1 m". I make it clear that this is only a very rough approximation of what they will later learn, but it sets the right conceptual framework. Once armed with errors for their predictions, it now makes sense to discuss what "close enough" means. "I measured a result of 1.1 m ± 0.1 m. They are within the error range of each other, so the result agrees with my prediction." Don't forget, physics is all about being close enough - we never actually get it "right". Great excitement comes from getting closer, getting that next digit for the electron magnetic moment [7], but we will never get them all.

(2) Test the Obvious.

Make regular tests of seemingly simple results. Here is an example: when my grade 12s learn how to analyze forces on an incline, we predict the size of the force required to hold a cart at rest and then test that prediction. A test such as this could easily be dismissed as trivial, obvious, or a waste of time — after all, it involves such simple math ($mg\sin\theta$). Try this with your students and watch what happens. It's really quite fascinating. I predict you will see surprise, amazement, excitement, a bit of relief, and it is true, some indifference (you can't win'em all). I observed largely the same results doing this with OISE teacher candidates as well. Something important happens when making this test. What exactly it is, I'm not sure, but I have a hunch that for most students, once you start doing math - any math — things become very unreal. Examples like this are quick, simple, and important — and occur throughout my gr. 11 and 12 courses [8].

(3) Talk About Your Feelings

The human body is an amazing apparatus complete with a wide array of sensory instrumentation. Students need to learn how to interpret their physical sensations in light of their emerging physics understanding. This is real kinesthetic learning. When their physical feelings remain at odds with the "rigorous" physical theories they learn, we leave them facing a choice — which is actually correct? Should we be surprised when they regularly choose in favour of their own physical intuition?

What does it feel like when you accelerate? As long as we're not talking about gravity, we feel a "push" in the direction opposite to our acceleration. Passenger vehicle examples like turning a corner or hitting the brakes are "real world" situations we routinely use with our students. They invoke their intuitions and describe mysterious forces away from the centre or throwing them forwards. Their sensations are not wrong, but we need to help them reason through what is happening and reinterpret what they feel.

Do we feel weight? Really? Place a heavy book on your hand. You are not feeling the book's weight, our unfortunate synonym for the force of gravity. The weight of the book does not act on your hand. The gravitational interaction between you and the book is outrageously small. You are experiencing another interaction involving the normal force (electromagnetism). Proof: have someone lift the book off your hand. Gravity doesn't just turn off like that. We, for the most part, "feel" normal forces, like the side door of the car pushing inwards against us as we turn the corner.

(4) If You're Right, Nature Nods

What about all those stock problems students "need" to practice their physics skills? They don't need nearly as many as we might think. I do on average two in-class problems with my grade 12s for each major unit. The students know these as the "physics challenges"[9]. They consist of a thought-provoking problem requiring about 70 minutes to solve. The crucial final step in each challenge is the testing of their solution. Put an object on a digital balance on an incline – predict the reading. Release a mass attached to a spring — predict how far down it will fall (video 1 [10], video 2 [11]). Fire an electron beam through an electric field — predict where it will deflect to. They know their work is correct not because the teacher says so, but because it works. My students get really pumped [12] up about these tests — watching the physics actually happen just as they have predicted is a great reinforcement of so many things. In other lessons we appeal to simulations, which may not be quite as good as the real thing, but it still helps to short-circuit the teacher/textbook authority loop.

(5) Bring Out the Toys

Technology may be the direct route into our students' lizard brains. They eat, sleep and breathe their gadgets and gizmos. They also get a real kick out of discovering that the physics principles they are learning in class, apply directly to their toys. To make this clear, and not just a teacher's promise, a test is required. My students place a piece of tinfoil between a charged ebonite rod and an electroscope and watch the leaves fall. Then they wrap the foil around their phone and watch the bars disappear. That's when a connection is made. They experiment with polarizing filters and happen to notice the filters turn off a laptop screen "accidentally" left open during class. Then the phones come out, soon followed by the excitement.

When You're Good To Mama … [13]

So it's time we give Mother Nature her due, her starring role in our physics production. I have found these suggestions to have made a substantial impact on my students, helping them to better understand that physics is real and not simply a torturous game invented by teachers. The side benefit of this approach, I believe, is that the work students do each day in class feels much more real to them. Engagement and motivation of my students are high, course attrition is low. According to a student who failed the first half of grade 12:

> *"My passion for physics sparked, and I realized it could actually be enjoyable! I like the fact that I can explain to people how the stuff in our daily life works (from storms, to magnetism, to putting coffee on a table)."*
>
> *Grade 12 student from York Mills C. I.*

So I predict when you're good to Mama, Mama's good to you … and your students. Test my predictions.

Links

1. http://www.guardian.co.uk/world/2013/jan/18/italian-scientists-jailed-laquila-quake
2. http://www.colorado.edu/sei/class/
3. http://www.colorado.edu/sei/class/CLASS%20I.pdf
4. http://prst-per.aps.org/pdf/PRSTPER/v5/i1/e013102
5. http://www2.physics.umd.edu/~redish/Book/
6. http://en.wikipedia.org/wiki/The_Tick_(1994_TV_series)
7. http://www.phi.kit.edu/quantum_optics/Lecture06_Additional_Material.pdf
8. http://meyercreations.com/physics/resources.html
9. http://meyercreations.com/physics/articles/Problem%20Solving%20-%20Feb%202011.pdf
10. http://www.meyercreations.com/physics/articles/Bungee%20-%20Good%20Test.wmv
11. http://www.meyercreations.com/physics/articles/Bungee%20-%20It%20died.wmv
12. http://www.meyercreations.com/physics/articles/Marble%20-%20Success.mpg
13. http://www.youtube.com/watch?v=kFp2ke920og

Upcoming Events

March

03.26
Perimeter Institute's "The Challenge of Quantum Reality"

April

04.08
Modern Physics for Grade 9 and 10 Science

04.10
Teaching Forces 'PERsuasively'

04.22
Modern Physics for Grade 9 Science

May

05.2 to 05.4
OAPT Conference: Physics Education Research in Action

05.22
Demonstrations: Entertainment or Education

For events happening in Ontario physics education be sure to check frequently the Events page on our website:
http://www.oapt.ca/events/index.html

Learning to Teach… Again?

by Lisa Lim-Cole
Vice-President, OAPT
Uxbridge Secondary School – Durham District School Board

Learning to teach started, for me, at the Faculty of Education. Recalling my experiences during my challenging practica that year I wonder how I managed to survive the steep learning curve. I've made my share of mistakes, apologized for them, and tried to correct them. I was in the principal's office far more as a first year teacher than I recall having been as a high school student. I remember my associate teacher telling me that learning to teach is really "on the job training" – figuring it out as you go. What I didn't realize at the time is that learning to teach continues no matter how long you've been teaching. Each new semester I re-evaluate how I do things. I credit my ability to teach to the many mistakes I've made. I know that setting up classroom structures by defining rules, procedures and expectations clearly for students is important, but often it is the last thing on a teacher's mind when faced with an enormous amount of curriculum to cover. However, without these structures in place a classroom quickly becomes an ineffective environment for student learning. What I have come to realize is that students need lots of opportunities to learn skills that we often assume they already have: group process skills, study skills, note-taking skills, writing skills. Where does all of this fit into our curriculum?

I suggest you attend the OAPT conference this year and focus on taking away one strategy or paradigm change.

Chris Meyer's approach to group problem solving has strongly influenced the way I have started to organize my classroom routines. However, what I have come to realize is that the recipe that Chris presents works well for him but does not always work for me. I agree that attention to the lessons PER is crucial. It is important to evaluate conceptual understanding and to provide students with an environment that allows them to confront their preconceptions and to work at reconstructing their understanding. I suspect, though, that some teachers may balk because they perceive that PER dictates that you need to do everything differently. We are all unique teachers with our own individual strengths, weaknesses, and style. It is important to reflect on how we instruct and to take steps to improve; however, a plethora of changes don't have to happen at once. Teaching is just as much a learning experience for the teacher as it is for the students. We must be careful not to overwhelm ourselves. I have adapted much of what Chris presents in a form that works for me. I challenge you to rediscover teaching… to reinvent yourself as a teacher… BUT one step at a time!

I suggest you attend the OAPT conference this year and focus on taking away one strategy or paradigm change. Find that one treasure that you can commit to trying out. Find that one connection that will become your sounding board as you rediscover the phun of being a Physics Teacher! It is amazing how one small step can lead to many new adventures! I credit much of what I do to the wonderful people I have met at past OAPT conferences! Join our collaborative team!

Quantum Minute Physics

By Roberta Tevlin

Minute Physics[1] is a fabulous collection of over seventy short videos made by Henry Reich that mostly look at modern physics. The videos are very brief, hip, and snappy and they make great use of animations and humour. I have combined three Minute Physics videos with The Perimeter Institute (PI) Challenge of Quantum Reality video and PhET's simulation of Quantum Wave Interference in a lesson to explore wave-particle duality. Below is an outline of the lesson with the links and questions for the students.

Exploring Wave-Particle Duality

Wave-particle duality is a key concept in quantum physics and the double-slit experiment is the best way to illustrate it. Textbooks tend to start with blackbody radiation or the photoelectric effect, but it is very difficult for students to understand how these show that light is behaving as a particle. Even the physicists a hundred years ago had trouble with this! However, if you show them videos of electrons, light and molecules forming interference patterns, dot by dot, and the implications are much clearer.

Part 1: Evidence Of Wave-Particle Duality

- What will happen if you send electrons toward a double slit, one at a time?
  PI video: *The Challenge of Quantum Reality* (9:24 - 13:00 minutes)

- What would it be like if water waves or sound waves showed particle-like behaviour?
  Minute Physics: *What is wave-particle duality? Part 1*[2] (1:09 minutes)

- What would it be like if light showed particle-like behaviour?
  PI Video: *The Challenge of Quantum Reality* (14:05 – 15:23 minutes)

- This same behaviour has been demonstrated with phythalocyanine ($C_{32}H_{18}N_8$).
  Minute Physics: *Single Molecules in a Quantum Movie*[3] (1:06 minutes)

Part 2: Interpretations Of Wave-Particle Duality

- What is happening between the slits and the screen? Describe the four interpretations.
  PI Video: *The Challenge of Quantum Reality* (19:13 – 22:13 minutes)

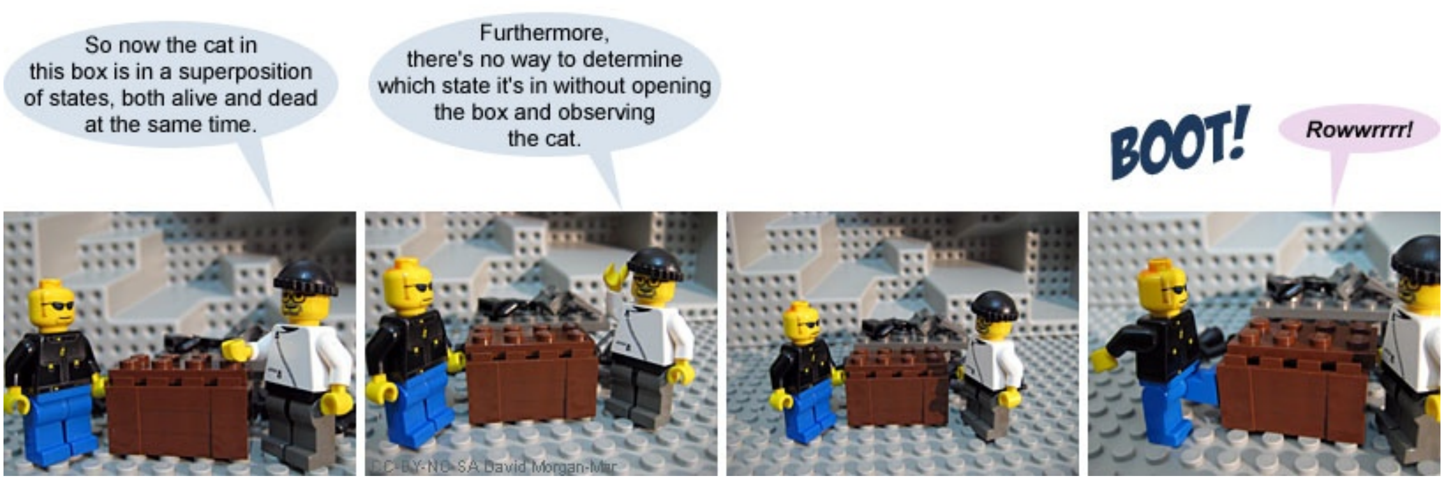
- Which interpretations are being used in each of these three resources?

  - ***Minute Physics:*** *What is wave-particle duality? Part 2*[4] (1:09 minutes)
  - ***Minute Physics***: *Schrodinger's Cat*[5] (1:48 minutes)
  - ***PhET Simulation***: *Quantum Wave Interference*[6]
  - (The first example uses the 'pilot wave' interpretation, the second uses 'many worlds' and 'collapse; and the simulation uses 'collapse'.)

There are more Minute Physics ideas on my website. There is a lesson on quantum tunneling and another on how lasers work. (These lessons include detailed answers to the questions posed.) You will also find a list of thirteen more videos[7] that I recommend for modern physics and ten for classical physics.

References

1. http://www.youtube.com/user/minutephysics
2. http://www.youtube.com/watch?v=Q_h4IoPJXZw&list=PLED25F943F8D6081C
3. http://www.youtube.com/watch?v=vCiOMQIRU7I&feature=player_embedded
4. http://www.youtube.com/watch?v=_rilY-v2Ym8&list=PLED25F943F8D6081C
5. http://www.youtube.com/watch?v=IOYyCHGWJq4&list=PLED25F943F8D6081C
6. http://phet.colorado.edu/en/simulation/quantum-wave-interference
7. http://roberta.tevlin.ca/common/minute%20physics.htm



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Submissions describing demonstrations will be gladly received by the column editor

Scaling Up

by Mike Massa
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In a first-year physics course that I've taught a number of times, one of the most challenging and widely enjoyed lectures deals with the development of scaling relationships. There are many appealing facets to this subject: there is minimal use of mathematics and formulae; many of the basic elements are accessible to students; and the principle of scaling can be readily applied with great effect to many "real world" questions. For example: Why do insects remain unharmed when falling from great heights? Why do parents always put cute little hats on newborn babies? Why are there no gigantic creatures like King Kong? And there's a great demonstration too!

Consider how the properties of a simple object change as it increases in size, while preserving its overall shape. A comparison of two cubes, with side lengths d and 2d, will show that the larger cube has 4 times greater surface area and 8 times greater volume than the small cube. Students may not think that the results of this example are particularly special at first. However, if we look next at a sphere which has doubled in radius, the volume V and surface area S will increase by:

$$\frac{V_{large}}{V_{small}} = \frac{\frac{4}{3}\pi\,(2r)^3}{\frac{4}{3}\pi r^3} = \frac{8r^3}{r^3} = 8$$

and

$$\frac{S_{large}}{S_{small}} = \frac{4\pi\,(2r)^2}{4\pi r^2} = \frac{4r^2}{r^2} = 4$$

As long as we compare two objects of the same shape (isometric), then the results are independent of the particular details of the shape itself. We arrive at two useful scaling relationships: the volume scales with the third power of a linear dimension (V ~ L3) while the surface area scales with the second power (S ~ L2) of a linear dimension.

What takes some convincing is that, for isometric objects, the choice of the particular linear dimension L used in the relationship does not matter. Since the shape is preserved, all linear dimensions can be related to each other by a multiplicative constant. So we can say, for example, that the volume of a human body depends on the third power of body height, or shoulder width, or finger length.

The scaling relationships become useful once we associate some physical significance with these geometrical properties. For cells, in order to maintain a stable existence a balance must exist between the intake and consumption of nutrients. The amount of nutrients consumed to fuel internal processes depends on the cell's volume. However, the acquisition of nutrients (and expulsion of by-products) depends on the amount of surface area – the window between the cell's interior and the surrounding environment. Comparing the rates of these processes:

Why are there no gigantic creatures like King Kong?

$$\frac{rate_{consumed}}{rate_{acquired}} \propto \frac{V}{S} \propto \frac{L^3}{L^2} \propto L$$

Thus, we find that as the cell increases in size, the consumption increases more rapidly than the ability to acquire nutrients. That is, beyond a certain size the cell will not function properly without alternative mechanisms to accommodate this disparity.

Large organisms encounter similar limitations. The rate of oxygen intake in the lungs, food intake through the stomach lining, and heat loss out through our skin all scale with the surface area. However, the rate of nutrient consumption and heat generation scales with the mass (i.e., volume) of the organism. These are all just a few of the biological processes which call into question the viability of a 15 m tall ape. However, perhaps the most stunning display of a scaling argument to discredit the plausibility of King Kong is a simple test of strength.

The demonstration uses a pair of wooden models of "moose." The "baby" has exactly the same shape as the mother, but every linear dimension is decreased to ⅕ the size. The demonstration begins with the mother lying on her back and the baby standing next to her on very spindly "newborn" legs. The typical expectation of the audience is that each moose should behave exactly the same, i.e., if the baby can stand up, so can the mother. (Admittedly, for the sake of engaging the students, I will play into this by emphasizing their similarities with a light-hearted discussion of "how much the new baby looks like her mother"… "how the newborn moose can already stand, when it took most of you a year to learn!")

When it comes time for the mother to stand up I ask a student to help turn her upright. (Her mass is approximately 30 kg). It becomes immediately obvious to the assistant that the mother will not be able to support her own weight. (At this point I quickly disengage and turn to discuss the mother-daughter bond with the audience, leaving the assistant hesitating before finally letting go of the moose). When the student lets go of the moose her legs dramatically give out, sending the mother to the ground with a huge crash. Many students let out a loud gasp, thinking there has been a terrible mistake!

The inability to stand is a result of the mismatch between the mother's weight and her leg strength. The weight of the moose (m_g) is proportional to volume (~ L^3); however, leg strength depends on the cross-sectional area of the leg (πr2). Thus, the mother's weight is $5^3 = 125$ times greater than the baby's, while the strength is only $5^2 = 25$ times greater. As with the balance of nutrient uptake/consumption in a cell, the ratio of load-to-strength scales as L, and the size limitation is demonstrated.

A second set of legs, with 125 times the cross-sectional area of the baby's legs (11.2 times larger radius), is then installed and the mother is able to stand next to the baby. While this fix works for the moose, when it comes to King Kong, the story is different. The 15 m tall ape was modelled after a gorilla, only 9 times taller. This would correspond to an increase in mass by a factor of 729, and would require legs with a diameter 27 times greater than a gorilla. A quick sketch (Figure 1) will quickly convince the audience that such a creature would not be viable.

To see the moose demonstration performed by former Demo Corner's editor Ernie McFarland and his colleague Tom Kehn go to: http://www.physics.uoguelph.ca/outreach/video/scaling_up.wmv

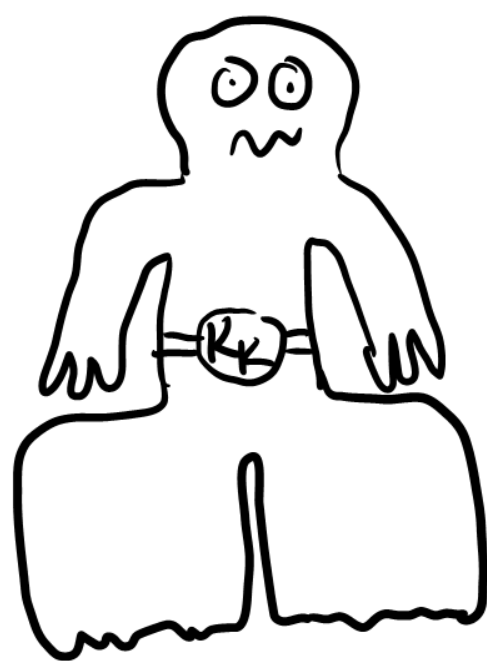

Figure 1: *King Kong — functional, but not fashionable*

Workshops

Free Workshops and Classroom Resources To register, email Roberta Tevlin: roberta@tevlin.ca

Modern Physics for Grade 9 and 10 Science

Duncan McArthur Hall - Queen's University - Faculty of Education - 511 Union Street, Kingston, ON K7M 5R7
Monday April 8, 2013, 8:30 am - 11:00 am
Room: TBA
Presenter: ***Lisa Lim-Cole****, PI Network Teacher, Head of Science — Uxbridge Secondary School (DDSB), OAPT Vice-President*

Physics is everywhere! As teachers it is our hope to entice young minds to observe the world around them, ask questions and seek answers. At this workshop three Perimeter Institute for Theoretical Physics (Waterloo, ON) resources will be explored, focusing on how the resources may be used for Grade 9 and 10 Science courses.

Everyday Einstein: GPS and Relativity

How does a GPS work? Scientific ideas form the foundation that support technological innovation. Let's explore the physics that's crucial to the GPS!

The Mystery of Dark Matter

Tired of students asking you what dark matter is? Come and explore the mysterious substance that makes up about 90% of the mass of every galaxy in the universe.

Beyond the Atom: Remodeling Particle Physics

What is everything made of? What is an atom? Let's explore!

Explore classroom-ready activities through discussion and play. All participating teachers will be provided a free copy of all three resources. See you there!

Teaching Forces 'PERsuasively'

Danforth CTI, 800 Greenwood Ave., Rm A76
Wednesday, April 10
Presenter: ***Chris Meyer***

Forces are our bread and butter, but is your bread getting a bit stale? Chris will help you teach forces using the latest techniques brought to you courtesy of Physics Education Research. A deep conceptual approach to learning forces through inquiry requires a rewriting of our traditional recipes to add in all sorts of new flavours. Come and enjoy the new education taste sensation! When you leave, you will be armed with all the resources you need to dramatically boost your students' appetite for forces.

Register in advance with Roberta, Roberta@tevlin.ca, so that there will be enough pizza!

Modern Physics for Grade 9 Science

Trent University, Room TBA
Monday, April 22
Presenter: ***Jim Pulikeel***

Join Jim (High School Physics teacher from Whitby) for some great hands on activities for teaching grade 9/10 science. All participants will receive great resources for the classroom. Topics covered will be:

Process of Science

Engage students in the creative, inquisitive and collaborative processes of scientific exploration through various cases studies, class activities, the "Alice and Bob" animated series, and MinutePhysics YouTube videos.

Mystery of Dark Matter

Our universe is moving too fast! According to Newton's laws of motion, stars on the outside of our galaxy are moving faster than they should. This resource helps has hands on activities to help demonstrate what gravity is and why dark matter is so important to the stability of our universe.

Particle Physics – Modeling the Bohr Rutherford Experiment

Have student learn about the Bohr-Rutherford experiment by modeling it through interpretive dance and hands on demonstrations!

GPS and Relativity

Teach students how GPS works and the importance of precision timing. Timing is so precise it must take into account the effects of Einstein's theory of relativity – both special and general relativity.

Demonstrations: Entertainment or Education

Danforth CTI, 800 Greenwood Ave., Rm A76
Wednesday, May 22
Presenters: ***Chris Meyer*** *and* ***Roberta Tevlin***

How do we best use demos in the physics classroom? Do we want the whiz-bang or the hmmm....? Roberta and Chris lead the demo show with a few of their favourites and provide some background on effective demonstrations.

Please bring your own demos along to share with everyone and we will have some great discussions. Let us know in advance what you will be bringing.

Register in advance with Roberta, Roberta@tevlin.ca, so that there will be enough pizza!

ONTARIO ASSOCIATION OF PHYSICS TEACHERS

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