# NEWSLETTER

**ONTARIO ASSOCIATION OF PHYSICS TEACHERS** (An Affiliate of the A.A.P.T., and a charitable organization) September, 2007

# The Demonstration Corner

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## Seeing and Photographing High Speed Events

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See the shards of a popping balloon, watch water drops suspended in the air or witness glass shattering — all of it seemingly frozen in time. Some of these events last less than one thousandth of a second but you can see them with your own eyes, thanks to the persistence of vision and a homemade sound trigger that releases a camera flash at exactly the right moment.

Figure 1 shows the setup. A high-speed event creates noise (A). When the sound reaches the microphone (B), the tape recorder (C) will send a current through the earphones wire (D). The current closes an electronic switch (E), which will trigger the flash (F).

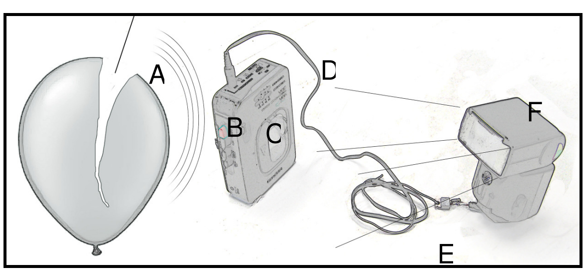


Figure 1

Figure 2 shows how to connect the wires to the electronic switch, which is a silicon controlled rectifier (SCR). Take a broken headset and cut off one ear bud. Strip the end of each lead, and then solder the leads to the anode and gate of the SCR. Then, solder the leads of a flash sync cord to the cathode and gate. If a flash has no sync connectors, connect the wires to the contacts on the hot shoe.

Let's say we would like to observe a popping balloon. Place the flash so that it will illuminate the balloon, but not blind yourself or your audience. Plug the headset jack into the voice recorder and turn on both the recorder and the flash. Snap your fingers to test the setup. After filling a balloon almost to the bursting point, turn off the lights (ensuring the room has no outside light) and then stab the balloon with scissors. The popping sound triggers the flash and you'll see a still image for a fraction of a second. By varying the distance between the balloon and the recorder, you can adjust the timing of the flash. Your students might be surprised at how close or far you have to place the microphone to capture the right moment, and they are left with a very tangible impression of the timing. They can also calculate the timing of high-speed events using the speed of sound.

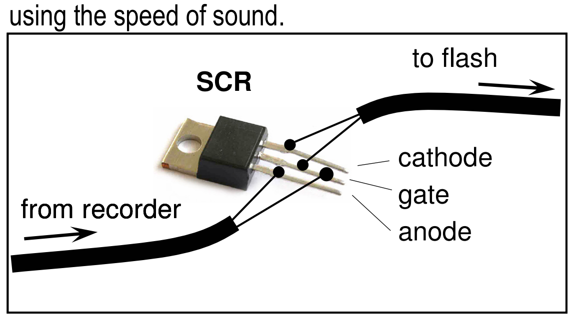


Figure 2

Sometimes you may get more than one flash in very short consecutive order. Most likely that is because the popping sound of the balloon reflects off the room's walls and triggers the flash again. We can solve this problem by adjusting the sensitivity of the recorder. If your recorder does not have that feature, wrap some foam around the microphone to dampen the loudness of the echo.

Most flash units can provide flashes as short as one 20-thousandths of a second. If they allow for manual setting, set it to the lowest power setting (e.g. 1/16). If they are fully automatic, put a reflective surface behind the object — the flash's circuit will stop the light more quickly.

Of course, even with persistence of vision, you only get a short-lived glimpse at the event. Taking a picture allows you and your students to see all the detail. Recording pictures with a camera is quite simple, especially if it is fully manual. We use the self-timer and an exposure time of ten seconds on our digital SLR camera. First, focus on the balloon. Then turn off the light, start the self-timer and when you hear the shutter of your camera, pop the balloon. Wait until you hear the shutter of the camera closing, and turn the light on again.

We were also able to get good pictures with consumer digital cameras, as long as they allow turning off of the built-in flash. To take a picture, turn off the room light, focus the camera by pressing the shutter release halfway and then press all the way.

Another person then pops the balloon. Wait maybe twenty seconds until you turn the room lights back on, because you want to record only the light from the triggered flash, but no other light. Many things can be photographed that way, as long as they make a sound. Ask students to come up with questions that could be answered with this setup. For example, does a tennis ball flatten when hit by the racket? Are falling drops of water spherical or tear-drop-shaped? Enjoy!

The Ontario Science Centre uses science as the lens to inspire and actively engage people in new ways of seeing, understanding, and thinking about themselves and the world.

Links:
http://www.hiviz.com/ Fantastic source of information on high speed photography. Sells cheap kits for sound triggers (including one with a variable delay).
http://www.diyphotography.net/ All kinds of tricks to create your own photography equipment without spending lots of money.

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

# OAPT Conference Report

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Last year's OAPT conference was held at the Ontario Science Centre (OSC). The conference began with a "bang" as Rolly Meisel showed us some of his favourite demos. Dave Fish then showed us how our Universe was much like an iceberg. Matter being the tip of the iceberg while dark matter being what makes up the majority of our universe and lies "beneath the surface". Bob McDonald, host CBC's popular radio program Quirks and Quarks finished the evening with an amusing and educational talk entitled "Sports in Space" Bob showed us that the ultimate swimming pool would be found on a cylindrical rotating space station. The water would form a layer on the inner surface of the cylinder allowing the swimmers to swim continuously without ever having to turn! The evening was rounded out with a wine and cheese in conjunction with the judging of the OAPT photo contest (the last year that this will run). Friday began with a presentation by Canadian astronaut Bjarni Tryggvason. Bjarni elicited a great deal of discussion about our definition of weight. Unlike most high school texts the conclusion was that we should define weight as the upwards response to the gravitational force (usually referred to as the normal force). The OSC then demonstrated its expertise providing us with some excellent demonstrations as well as a behind the scenes look at how exhibits are created. Friday afternoon was an opportunity for delegates to attend workshops. Dave Doucette gave a dynamic workshop on using martial arts as a way of having our students use their higher order thinking skills (HOTS). Martin Gabber presented a session highlighting the use of simulations in the physics classroom while Roberta Tevlin showed us how Spacetime diagrams allowed for student centred learning. The day finished off with Professor Ernie McFarland from the University of Guelph presenting a thought provoking talk on energy. Saturday morning began with a presentation by Professor Norbert Bartel from York University. He discussed his work associated with the Gravity Probe B mission. The goal of this mission is to precisely test Einstein's theory of general relativity. Stuart Bislan, an adjunct professor from Ryerson University, demonstrated how photodynamic therapy could be used in the treatment of cancer. The morning concluded with a presentation by Tetyana Antimirova about a unique outreach program between the Ryerson Physics department and the high school physics teachers from the greater Toronto area. After lunch Ben law engaged us and showed us how to engage our students with some explosive demonstrations. Anjuli Ahooja reminded us that everything is physics and that we don't have to look far to find its relevance in everyday life.

Gunter Ladewig, president of PRIMA performance introduced us to TRIZ a systematic approach to innovation and the design process. Jim Ross, past president OAPT, gave us an update on the new high school curriculum and as has been a tradition for the last four years, Professor Jim Hunt from the university of Guelph concluded this year's conference with a fascinating discussion of anamorphic art.

A dynamic demonstration of inertia: Photo by Rolly Meisel

# Dave Doucette's PER Corner

## 'Bridging Research into Practice'

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This is the 3rd in a series of articles using physics education research (P.E.R.) to modify instructional practice.This article considers a fundamental concept underlying both uniform motion and uniform acceleration – the 'time interval,Δt.

**Begin at the Beginning**

The time interval is often introduced cursorily as students measure distances or displacements to develop the ratio underlying the concept of *uniform motion*, Δd/Δt. It is an *a priori* assumption high school students easily handle such ratios. This assumption is not borne out by research. Arnold Arons cautions, "…one of the most severe and widely prevalent gaps…at secondary [school]...is the failure to have mastered reasoning involving ratios…This disability…is one of the most serious impediments to their study of science."[2]

How can we develop the concept of uniform motion,Δd/Δt, if ratio reasoning is so poorly discriminated? One suggestion is to have students develop the utility of this ratio through an active-learning paradigm.

*Constant motion vehicles* are available from many science suppliers and department stores at less than $10 an item. The next crucial item is a metronome, borrowed from the music department, or a freeware program downloaded from the net - to be played on a computer with speaker output. Simply tapping a stick on a table at one-second intervals will suffice.

Students mark the position of the vehicle with each one-second beat, for several seconds. They are asked to verify if their cars are 'constant speed vehicles' as advertised, using data to support their conclusion. Each group delivers an oral summary, with every member expected to contribute. This brings an element of group and individual accountability and provides a necessity for 'student discourse'. It is a method to gain cognitive engagement, an opportunity for students to verbalize with minimal risk, and according to Ed Redish is the 5th principle of cognitive instruction "For most individuals, learning is most effectively carried out via social interactions".[3]

Once complete the class is ready to operationalize a definition for uniform motion. Since you specified a one-second interval to locate vehicle positions, students naturally define uniform motion as relatively equal distances traveled in each one-second interval (*period*, *measure* or other student-suggested terms are equally useful).

This is an opportunity for guided-questioning to lead to richer insights. Groups are assigned to re-examine how their data would appear if they were assigned a time interval of 2.0 s, or 5.0 s, ½ s or 1.0 min, etc…to record their vehicle positions. This provides an opportunity for students to recognize position values, Δd, will scale up or down in **direct proportion** to the time interval, Δt. (This incidentally prepares the way to expressing this proportionality as a straight line on a position-time graph)

Students are led to recognize a 1.0-s interval is a *convenient* choice for developing terms such as velocity, acceleration, and impulse, and not a requisite. A step towards scientific literacy by underscoring physics concepts as a matter of invention and convention rather than necessity! "This approach immediately confronts students with the fact that scientific concepts are not objects 'discovered' by an explorer but are abstractions deliberately created or invented by acts of human intelligence [Arons, p.24].

To consolidate and extend the learning a work sheet is needed. Permutations of uniform motion should be explored, moving from simple and concrete to more abstract and challenging applications. For example, position-time data for a faulty constant-motion vehicle could be provided, with students distinguishing from the data when the motor was operating efficiently and the motion uniform. Data for a vehicle traveling from a level surface to inclines could allow students to identify different intervals of uniform motion. It is crucial in these examples for students to identify the distinct time intervals,$\Delta t_1$,$\Delta t_2$ and the associated position changes,$\Delta d_1$, $\Delta d_2$, etc and to defend why it is inappropriate to use $\Delta t_{total}$ in such circumstances. Identifying the limits of a concept or algorithm also point towards improved science literacy.

Word problems should be appended to include consecutive time-interval descriptions such as, "An air puck with a small fan motor attached is started from rest. The puck requires 4.0 s to reach a speed of 20 cm/s at which point the fan motor stops. The puck continues forward at 24 cm/s on the frictionless surface until a small 'parachute' is deployed, slowing the puck steadily until it comes to rest at a time of 16 s."

i) Identify the different intervals of time involved in the motion described. Describe the type of motion ideally occurring in each interval.

ii) Create a chart of data for the entire trip, choosing a time interval which seems appropriate. Explain why you chose the time interval for your chart. Suggest one other time interval you might have used instead. How would that choice change your data?

iii) Can you calculate Δd/Δt for any or all of your intervals of motion? In which case would the ratio be most accurate and appropriate? Would it have any meaning whatsoever in the other intervals?

iv) Create a position-time graph for the motion of the vehicle. Label the different intervals of motion. Justify the shape of the graph in each interval by referring to the type of motion involved. Then sketch a second graph of the same motion, but containing al least one significant error. Explain why this must be in error and contradicts the data, and why, in your opinion, a student might make this type of error.

These questions are not prescriptive but to showcase the level of thinking – and literacy- expected of the student. Of course, the same scaffolding is applied when t occurs in acceleration and impulse, by providing successively richer contexts in which students are lead to discriminate appropriate Δt's and discard others. The habits of mind suggested by judicious development of Δt may move students to higher levels of scientific literacy and improved success as scientists – and citizens.

To provide feedback or share resources, particularly any developed with this article's theme, contact Dave Doucette at doucettefamily@sympatico.ca.

**References**


1. *America's Lab Report: Investigations in High School Science* The National Academies Press, 500 Fifth Street, N.W., Washington, D.C. 20001, ISBN: 0309096715
2. Arnold Arons, *A Guide to introductory Physics Teaching*, University of Washington. John Wiley and Sons, 1990. ISBN 0-471-51341-5, p.3.
3. Edward Redish, *Teaching Physics with the Physics Suite*, University of Maryland, John Wiley & Sons, 2003. ISBN 0-471-39378-9, p.39.


**Email Addresses**

We send timely information of interest to Physics Teachers by email to all members. If you have not received any messages from the OAPT in 2007, it means that we do not have your current email address on file. Please send an message to Patrick Whippey <pwhippey@uwo.ca> and we will update our records.

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Come and join us at Ryerson University May 22nd-24th for this year's conference focussing on medical physics and physics education research

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