Medical Physics Outreach at Ryerson University

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Medical physics is a relatively young but fast-growing sub-field of physics applied in modern healthcare, most notably in cancer diagnosis and treatment. Founded in 2006, Ryerson University's Department of Physics recognized an opportunity to provide specialized programs focused on this important field. Today Ryerson provides a Bachelor of Science degree program in Medical Physics, as well as Master of Science and PhD degree programs in Biomedical Physics.

Not long ago astrophysicist and popular educator Neil deGrasse Tyson made an astute observation that "if you take a tour through a hospital and look at every machine with an on and off switch that is brought into the service of diagnosing the human condition, that machine is based on principles of physics discovered by a physicist, in a machine designed by an engineer" [1]. There are indeed ample examples of physics practiced in healthcare, from the introduction of the stethoscope 200 years ago [2], to the diagnostic applications of X-rays, ultrasound, and MRI, to therapeutic nuclear medicine. In tandem, healthcare's dependence on medical physics creates diverse employment opportunities. Medical Physicists' roles range from running oncology clinics, to critical support provided by radiation therapists and technologists. At the same time research, development, and manufacturing of medical devices continue to grow and employ many more medical physics experts.

Tyson makes the case that society needs to prioritize ongoing investment in sciences in order to continue to advance healthcare, and that we need to foster greater public awareness of the role of basic science, such as physics, in healthcare to build more support for this important goal. However, while the significance of medical physics in healthcare is clear, it does remain relatively unknown to the general public, making it difficult to attract talented students into the field.

Summary

Ryerson University's Department of Physics offers a Medical Physics degree program. An outreach program has been developed to build greater awareness of the field among regional secondary school students.

Consequently, promoting Ryerson's Medical Physics program offers challenges and opportunities that we've aimed to address in part by developing an immersive outreach program that gives the Greater Toronto Area high school students a taste of university physics with emphasis on medical applications.

BACKGROUND: BUILDING AN OUTREACH PROGRAM

In 2012, Ryerson's Faculty of Science established the Office of Science Outreach and Enrichment (OSOE)†, whose mission is to make science engaging, comprehensible, and accessible to the general public, and to better coordinate promotional activities previously fragmented across individual University departments. Regional high schools – there are over 140 in the Toronto area – are invited to visit and participate in campus tours led by undergraduate students. Following the tour students visit a teaching laboratory to participate in a 2-hour hands-on lab-based activity in a particular subject of interest. There are presently offerings in Chemistry, Biology, Computer Science, Mathematics, and Physics.

THE PHYSICS WORKSHOP: ELECTRONICS FOR SCIENCE, LIGHT, NOISE, AND ART

The reality of recruiting to a Physics or Medical Physics program from a class of high school physics students seems to be that fewer than 1 in 20 students is seriously considering pursuing physics at a post-secondary level‡. Our Electronics for Science, Light, Noise, and Art workshop was developed with this in mind, placing heavy emphasis on keeping the activities informative but entertaining. The "light, noise, and art" components help engage even those participants who have no ambitions to pursue physics at all beyond the secondary level. By keeping technical activities entertaining, we aim to convey that even an informal interest in physics and electronics increases technical literacy and can be very worthwhile and creative.

† OSOE program information is available at www.ryerson.ca/scixchange.
‡ Based on informal polling of student participants.

The two-hour workshop allows 15 or 20 minutes to welcome students and provide orientation describing the first year university science experience. It also allows enough time to introduce the field of medical physics, and to point out the unique aspects of Ryerson's Medical Physics program. We touch briefly on the specializations of the Department's faculty members, like high intensity focused ultrasound (HIFU), a non-invasive method of tumour tissue ablation, or photoacoustic microscopy, where cell health can be characterized based on the thermal-acoustic shockwave signature generated from a laser pulse. We also highlight opportunities for students to collaborate with our faculty and adjunct faculty from local hospitals, particularly during their fourth year thesis course studies.

After the introduction we jump straight to circuits and have the students work in pairs to build a very simple current-limited LED circuit. The students are provided a small kit[§] containing an electronics prototyping board, resistors, capacitors, jumper wires, plus an LED and 9V battery. Web-based "connect-the-dots" style instructions guide the students in assembling the LED, resistor, and battery components into specific holes on the prototyping board to create a simple circuit loop. When powered on inevitably only half the circuits operate correctly until the LED orientation is corrected to allow forward-biased diode conduction, which initiates a quick discussion about semiconductors, current, Ohm's law, and conservation of energy.

The second circuit has the students assemble an amplifier-based "relaxation oscillator," which raises the excitement level when their LED begins to blink. The students are asked to swap certain components and to note the effect on the blink rate. The LED is soon swapped for a piezoelectric speaker to generate entertaining buzzing noises. During a quick recap we reflect on how changing certain components dramatically alters the circuit's frequency, reintroducing ideas like ultrasound touched on in the introduction, and making connection to electromagnetic radio waves and their role in common technology like radios and telecommunications.

By this point their comfort level with the kits is usually increasing so the third activity foregoes "connect-the-dots" instructions in favour of a schematic diagram as the students independently assemble a "light theremin." In this circuit a photodetector actively modulates an oscillator's frequency, creating a rough-sounding but very entertaining musical instrument as students experiment by waving their hands rhythmically over the detector to cause squealing noises. The recap for this activity makes the connection that we have moved from "static" to "dynamic" circuits, with active sensing components that could be used for practical scientific measurements or engineering. With each activity the students have acquired increasingly complex skills and tools.

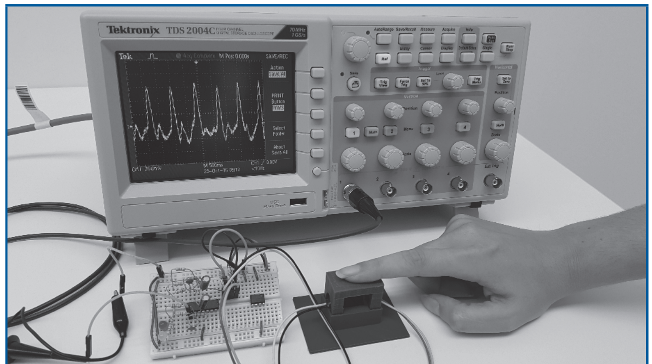

Fig. 1 Heartbeat sensor in operation.

For the final half hour of the workshop, students are given a schematic for a slightly more complex "mystery circuit," and begin a friendly competition to see which group can successfully complete the assembly first. When connected to an oscilloscope the circuit's secret is revealed as the students realize that the rhythm they observe on the scope is their own heartbeat (Fig. 1). The circuit acts as an optical pulse sensor, non-invasively tracking heart rate as each pulse of blood to the capillary vessels of the finger modulates the amount of infrared light reflected to a small phototransistor.

Overall, based on teacher evaluation and student feedback, the workshop is consistently well received. We hope the experience serves to entice more science-oriented students to seriously consider careers in STEM and, particularly, medical physics-related fields. To go from little or no experience in building electronics to assembling a functioning heart monitor in only a few hours gives a great sense of accomplishment. Most importantly, the workshop clearly conveys to all the outreach program participants the significant role physics plays in modern healthcare.

To view the web-based support pages for the electronics activities offered, see www.physics.ryerson.ca/electronics-workshop.

§ Additional kit components include LM324 op-amp, 555 timer, CdS photoresistor, piezoelectric crystal, and matched IR LED and phototransistor. One-time cost of kit components is about $10.

REFERENCES

For more information on arranging visits, see www.ryerson.ca/scixchange.

1. https://www.youtube.com/watch?v=VjY0vqgDMnE, October 26, 2016.
2. http://www.cbc.ca/news/health/health-medicine-stethoscope-laennec-heart-1.3818520, October 26, 2016.