NEWSLETTER
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The Demonstration Corner

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Wire Fire !

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This demonstration is a nice way to illustrate the $P = I^2R$ relationship that is discussed in electric circuits. Figure 1 illustrates the equipment: a Variac transformer takes the wall output of 120 V and generates a variable voltage from 0 to 140 V. This is then sent through a Hammond Manufacturing transformer (167X5), converting down to 5 V output. We use this second transformer in order to increase the current through the wires. The output from the second transformer is connected to three wires in series: approximately 10 cm in length of each of ~18 gauge Nichrome, steel and copper. A piece of folded paper is placed on each wire.

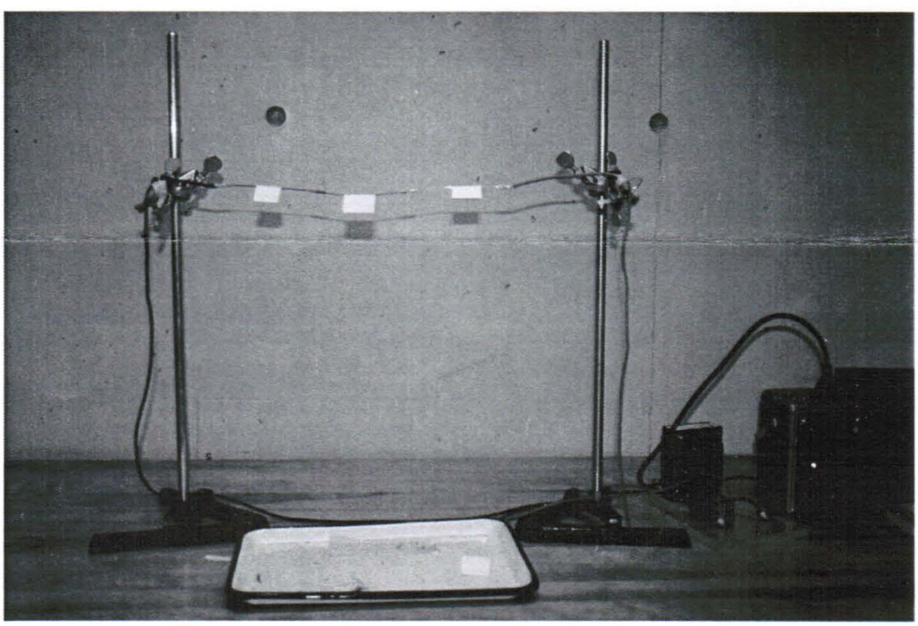

Figure 1: equipment setup for demonstration.

Because the wires are connected in series, the same current will flow through each one. This means that the relative power output of each wire depends on the relative resistance, which varies with the wire material. Table 1 gives the approximate resistivities (ρ) of the materials involved. (Recall that the resistance R of a wire of length L and cross-sectional area A is given by $R = \rho L/A$.)

Material	Resistivity ρ (Ω m)
Nichrome	100×10^{-8}
Steel	20×10^{-8}
Copper	1.7×10^{-8}

Table 1: resistivities of wire materials.

Before we turn on the Variac to conduct the demonstration in class, I provide the students with the values given in table 1 and I ask them to rank the power output of the three wires. The majority of students indicate that the Nichrome will have the greatest output while the copper has the smallest.

We then turn on the Variac and increase the output voltage to approximately 80 or 90 V. With a video camera zoomed in on the wires displayed on the lecture hall screen, it is clear that the paper on the Nichrome wire begins to smoke and eventually burns through and falls from the wire to the enamel plate below. The paper on the steel and copper wires is unchanged. See figure 2.

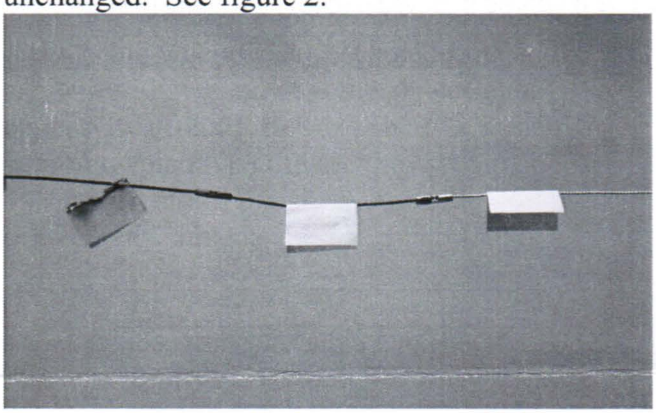

Figure 2: With the Variac output at ~90 V, the paper on the Nichrome wire (far left) burns and falls off. The paper on the steel wire (middle) and the copper wire (far right) are unchanged. (Note that the copper wire has a tin coating.)

I then ask the students what we need to do to get the other pieces of paper to ignite. They tell me to turn up the voltage on the Variac, so we increase the output to approximately 115 V. The paper on the steel wire now burns and falls off, while the paper on the copper wire remains intact (figure 3).

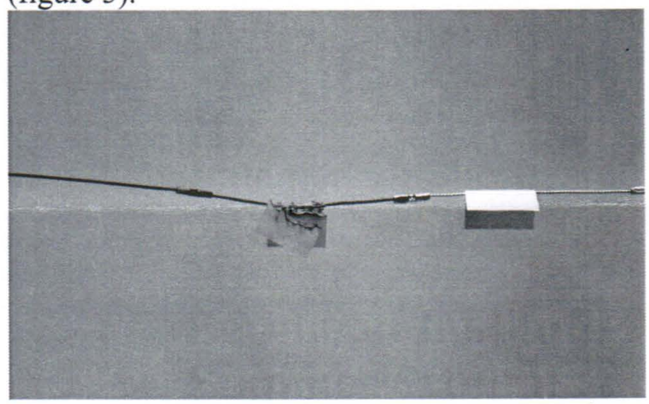

Figure 3: With the Variac output at ~115 V, the paper on the steel wire burns and falls off. The paper on the copper wire is unchanged.

They always want me to turn the Variac up all the way, and when we do, the Nichrome and steel wires glow nicely but the paper on the copper wire is unaffected. I usually ask them at this point which type of wire they would choose to send current through the walls of their house – not too many students opt for Nichrome!

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

!! CONFERENCE REMINDER !!!

This year's workshops and meeting will be hosted by **RMC** in **Kingston, May 28 to 30th** .

AS ALWAYS, GREAT PRACTICAL FUN CLASSROOM READY IDEAS FOR LESSONS, LABS AND IMPROVED LEARNING !

WORKSHOP by Randy Knight, author of **Five Easy Lessons: Strategies for Successful Physics Teaching**

Check out www.oapt.ca for details on all OAPT happenings!

Perimeter Institute for Theoretical Physics Offers Free Summer Programs for Teachers and Students

The 2009 International Summer School for Young Physicists (ISSYP) is an exciting and challenging two-week program for Canadian and international students, 17 to 18 years of age, with a keen interest in theoretical physics and who intend to pursue a degree in physics at the university level.

This summer school super-charges potential "Einsteins" with presentations by Perimeter Institute researchers on *cutting edge* theoretical physics – *hot topics* such as superstring theory, quantum computing and dark matter. Students will have opportunities to work with leading international theoretical physicists in small group *mentoring* sessions and participate in l*ab tours* and other activities with like-minded students from around the globe. Students are provided with insights into their own potential as possible *future researchers* in theoretical physics.

ISSYP 2009 will be held on-location at Perimeter Institute from August 8 to August 22, 2009. The deadline for applying to the program is Thursday, March 19, 2009.
Visit www.issyp.ca for details.

The 2009 EinsteinPlus International Workshop for Teachers is a one-week, intensive residential workshop for Canadian and international high school teachers that focuses on key areas of modern physics — including quantum physics, special and general relativity, and cosmology.

After the workshop, Perimeter Institute supports teachers participating in the program, to conduct follow-up activities with other teachers at home for the benefit of the wider education community.

EinsteinPlus 2009 will be held, on-location, at Perimeter Institute from Sunday, August 2nd – Saturday, August 8th, 2009. The deadline for applying to the workshop is March 31st, 2009.
Visit www.einsteinplus.ca for details.

For more information about these programs, please contact Julie Taylor, Outreach Coordinator, at 519-569-7600 ext. 5080.

MOdern PhYSiCS

Heisenberg Uncertainty Principle and Diffraction

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Here is a way to introduce HUP in a simple and concrete way through diffraction.[1] In high school physics we usually treat diffraction as an example of classical wave behaviour and for sound and water, that's exactly what it is. However, if electrons, photons or other quantum objects are showing diffraction, then there must be a quantum mechanical explanation. Why? Because when we turn the intensity of our source down until there is only one object at a time, we see that the diffraction remains. To explain the 'diffraction' of a single electron or photon you need HUP.

To give students a real tactile experience of diffraction, I recommend that you have them take two round pencils and join them with elastics as shown in Figure 1.[2] Direct a laser pointer at the wall and ask them to predict what the laser spot will look like when they look at the spot through the horizontal slit. Before looking, have them sketch what they expect and their reasons. Have them compare their answers with their nearest neighbours etc. Then let them look.

My students predicted many things, but none of them predicted that the spot would be stretched vertically. It's a great 'ahah!' moment. Next, have them predict what will happen if you squeeze the pencils closer together and then have them try it.

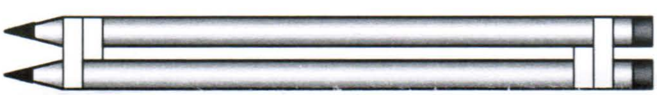

Figure 1

OK, so how does the HUP explain this?[3] HUP says that there is a limit to how precisely we can know the momentum and position of a photon. Specifically, $\Delta x \Delta p >= h/2\pi$. When a photon passes through a slit our uncertainty in its location, Δx, is just the width of the slit, w. However, this measurement of position results in an uncertainty in its momentum after the slit. Instead of hitting the screen at the same level as the original beam it has a probability of landing well above or below that spot. You can even make this quantitative and turn it into an experiment if you have a set of slits of known width like the Cornel plates.[4] Figure 2 shows the range of paths of the light after the slit. Let's call the length from the slit to the screen, L, and the spread of the central maximum, s. This diagram could also represent the photon's momentum. In that case the length is the momentum of the original photon, $p = h/\lambda$, and the spread is the uncertainty in momentum, Δp. By similar triangles, $\Delta p/p = s/L$ and therefore $\Delta p = ps/L = hs/\lambda L$. Substituting this and $\Delta x = w$ into HUP we have $\Delta x \Delta p = (w\ h\ s)/(\lambda L)$. Use the given values of λ and w and the measured values of s and L. You'll find that $\Delta x \Delta p$ is definitely more than $h/2\pi$ and will be around 2h.

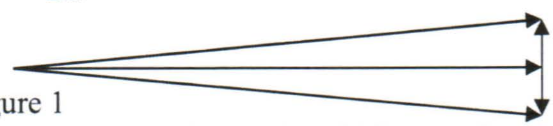

Figure 2

I have written a full lesson plan around this idea which you can find on my website http://roberta.tevlin.ca. Let me know if you have any suggestions to improve this. You can reach me at roberta@tevlin.ca.

[1] Dr. Damian Pope at the Perimeter Institute first introduced me to this approach.

[2] I found this demo in the "Diffraction of Light" resource from Cornell's Center for Nanoscale Systems Institute for Physics Teachers at http://www.cns.cornell.edu/cipt/labs/DiffractionofLight.html.)

[3] Prof. Walter Lewin of MIT explains this from minute 32 to 42 at http://ocw.mit.edu/OcwWeb/Physics/8-01Physics-IFall1999/VideoLectures/detail/embed34.htm

[4] Boreal has a set of two slides with many different slit patterns for $63. One of the two slides is the classic Cornell set of gratings which has single slits with 4 different widths. http://sciencekit.com/diffractionandndash%3Binterference-resolution-kit/p/IG0023801/.