President's Commentary (September 2007)
September 17, 2007
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The Advanced Physics Laboratory, from A - Z

I just Googled *advanced physics lab* and got 50,100,000 hits! When I changed *lab* to *labs* (to rule out laboratory) I got 7,270,000 hits. And using *laboratory* instead of *labs* generated 34,000,000 hits. As with all such searches, not all hits are useful or relevant, and there is some duplication. So what's the point? Very simply, the number of hits that were right on target is impressive, and sufficient to conclude that advanced lab courses are being taught at many colleges and universities.

What is an advanced physics lab? Typically, it's a lab that's intended primarily for the junior or senior year. The possible set of experiments for such courses is vast, including, but by no means restricted to (from A to Z): **A**tomic force microscope, **B**lackbody radiation, **C**haos and non-linear dynamics, **D**iode characteristics, **E**lectron-spin resonance, **F**ourier-transform spectroscopy, **G**eiger-Müller tube, Holography, **I**nterferometry (Fabry-Perot, Michelson, Mach-Zender), **J**osephson junctions, **K**err effect, **L**ow-noise signal detection, **M**össbauer effect, **N**uclear magnetic resonance, **O**ptical pumping, Photoelectric effect, **Q**uantum Hall effect, **R**utherford scattering, **S**olar photosphere spectroscopy, **T**hermal noise, **U**ltrasonic imaging, **V**acuum techniques and thin films, **W**ave-particle duality, **X**-ray crystallography, **Y**oung's double-slit experiment with single photons, and **Z**eeman effect.

Some advanced lab courses are structured, while others are inquiry-based research projects. The goals of such labs vary among institutions, but there are some common threads. Typical goals include having students:

- become proficient using modern experimental equipment and techniques,
- engage in experimental design,
- interface equipment with computers,
- use LabVIEW and Excel,
- learn how to analyze data in statistically meaningful ways,
- keep a comprehensive lab notebook,
- prepare professional lab reports,
- prepare poster presentations,
- conduct literature searches,
- understand the value and importance of ethics in scientific research, and
- develop an appreciation of the connections between

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experimental and theoretical physics.

It is apparent from the comprehensive nature of the experiments and techniques being taught and typical course goals that advanced lab courses are critical components of a physics major's undergraduate education. Soon after I was elected to the AAPT presidential chain, the great importance of advanced labs was impressed upon me during a dinner with former colleague and long-time friend, Jonathan Reichert. He pointed out that advanced lab teachers often do not have many colleagues who teach advanced lab courses, that there are relatively few advanced lab sessions at meetings, and that interactions with others who share similar interests are minimal.

This is very different from physics research, where communities of people with overlapping interests often exist. Coupled with the many skills needed to design and upgrade comprehensive advanced physics lab courses, it is clear that there is a problem. Reichert's main point was that AAPT could, and should, do more to help teachers of advanced labs courses, thereby strengthening undergraduate physics programs. This is an area Reichert knows well, having started his own instrument company in 1992 on a part-time basis. In 1999, he retired from SUNY-Buffalo to run the company full time. He is passionate about making advanced labs courses the best they can be, and his passion and logic convinced me to begin encouraging AAPT in the direction of advanced labs.

In fall 2005, AAPT formed a seven-member AAPT Advanced Lab Task Force (ALTF), chaired by Jeff Dunham (Middlebury College). The ALTF was asked to: (a) Identify ways for AAPT to provide more extensive, ongoing help to upper division laboratory teachers in order to improve their courses and better prepare their students for subsequent graduate level research; and (b) specifically address the advisability and potential effectiveness of each item in a list of potential courses of action, along with other relevant thoughts for improving the teaching of advanced labs.

In summer 2006, ALTF presented its recommendations. As a result of that report (available at http://advlabs.aapt.org/), AAPT started a listserv to facilitate communication between advanced lab faculty, established an advanced physics laboratory website on which existing successful lab experiments and other relevant information could be posted, arranged invited and contributed sessions on advanced labs at the 2007 Summer Meeting in Greensboro, and began planning a topical conference on advanced labs at the 2009 Summer Meeting at the University of Michigan.

The listserv, which was started in fall 2006, has a diverse subscriber list of 733 people. This is a result of contacting every known physics department chair and requesting the names and contact information of all faculty engaged in the teaching of advanced labs. AAPT membership is not a requirement for subscribers and in fact, *anyone* can read messages sent to the listserv. To post messages, one must be a subscriber, and *anyone* can subscribe. Many subscribers are AAPT members, and among non-members are members of APS, OSA, and others. Activity on the listserv has been light to moderate, with an average of about one message per day, with the messages tending to come in bunches when a *hot* topic arises.
The listserv is available at
http://lists.aapt.org/cgi-bin/lyris.pl?enter=advlabs-l.

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The advanced labs website at http://advlabs.aapt.org/ is still in its development stage, but already contains interesting items. These include: the full report of the ALTF, Jonathan Reichert's guest editorial, "What Happened to the Advanced Lab?" in the November 2006 *American Journal of Physics*, and Richard Peterson's article, "Lighting the Fire," published in the March/April issue of AAPT's new magazine, *Interactions Across Physics Education*. Peterson's article provides an expert's view on the advanced lab. The advanced lab website's editor, Ramon Torres-Isea (University of Michigan) is being aided by an editorial board, which selects materials for the site. AAPT web designers have prepared the site for resources such as descriptions of specific experiments, information on equipment, copies of relevant articles on advanced labs, and the like for advanced labs teachers. Using the URL above, the website will be supported by the software infrastructure of AAPT's ComPADRE website, which is part of the National Science Digital Library. We anticipate that the site will be in full operation by the end of 2007.

In the Greensboro session, The Advanced Laboratory I, two excellent invited presentations, "Lighting Fires in Advanced Labs" (Richard Peterson) and "The University of Florida Advanced Physics Laboratory" (Robert DeSerio) were followed by five interesting poster presentations. Part II, the next day, consisted of eight diverse contributed papers. Together, these sessions provided a remarkably comprehensive view of what can and is being done in advanced lab courses. The plan is to make a tradition of having one or more advanced lab sessions at each AAPT Summer Meeting. And the planned 2009 topical conference on advanced labs mentioned above will provide another unique opportunity for teachers of advanced labs to share information.

The people involved in advanced labs include teaching faculty and instructional resource personnel (lab supervisors, equipment gurus, etc.) in colleges and universities. Many physics support personnel and faculty are already involved with PIRA, the Physics Instructional Resource Association, an AAPT affiliate. PIRA was inspired by an impromptu lunch with some physics support people, who realized that they shared many problems and that each often "reinvented the wheel" because of working in near isolation. In 1986, about two years after that lunch, PIRA was formed to help rectify this situation. It has succeeded in networking people who had little contact with colleagues beyond their local domains prior to PIRA. Notably, PIRA members have conducted Advanced and Intermediate Instructional Laboratories workshops, sponsored by the Apparatus Committee, at AAPT Summer Meetings for many years (including Greensboro). In addition to involvement with advanced labs, PIRA members focus on introductory and intermediate labs and lecture demonstrations.

Recently, using PIRA as a model, an Advanced Laboratory Physics Association (ALPhA), was formed. The brainstorm for ALPhA came from Krishna Chowdary (Evergreen State College) after reading Reichert's guest editorial in *AJP* mentioned earlier. Chowdary suggested an ALPhA inaugural reception at the March 2007 meeting of APS in Denver, and a second reception (held in a jam-packed room) at the Greensboro meeting. Reichert's company sponsored both receptions and agreed to provide administrative and financial support for ALPhA's first year. Given the many people at the Greensboro reception and advanced labs sessions, it is clear that there is a high interest level within AAPT for advanced labs.

I anticipate that ALPhA will become an AAPT affiliate and will have a similar relationship with APS and perhaps other physics societies. It would be good if ALPhA, PIRA, and AAPT's Apparatus and Labs committees collaborated to sponsor future sessions on advanced labs. ALPhA could arrange sessions at APS meetings through the APS Forum on Education. In this way, many more advanced lab teachers would likely become part of an interacting, productive community.

The bottom line is that advanced physics lab instructors have received a major shot in the arm during the past year. I am truly pleased that AAPT planted the seed that sprouted into all this activity, which is bound to affect the teaching of advanced labs positively. Of course more can, and hopefully will, be done in the future. The beneficiaries are advanced lab teachers and, ultimately, physics students. Amen.

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