

## LabVIEW Helps Teach Physics Lab

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**The Challenge:** Empowering physics students to acquire experimental data in laboratory courses.

**The Solution:** Using Macintosh-based systems of DAQ boards controlled by LabVIEW.

At Purdue University, approximately 2,100 freshman students a year complete their physics laboratory curriculum using LabVIEW data acquisition and analysis software. These students perform six activities that include measurement and graphical analysis activities; an examination of the theory behind computerized data acquisition; the kinematic relations among position, velocity, and acceleration; Newton's second law, the work-energy relation; mechanical energy conservation; and simple harmonic motion.

Activities are carried out in a laboratory containing 15 Macintosh Quadra 800 stations running LabVIEW along with Lab-NB data acquisition (DAQ) boards, airtrack and torsion pendula apparatus, and a locally developed curriculum. A team of Purdue physics instructors, technicians, and students develop and construct all virtual instruments (VIs), apparatus, and signal preprocessing electronics.

The ability of LabVIEW to simultaneously analyze in detail and display ensembles of discrete motion data is often the first significant opportunity students have to

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examine calculus as a meaningful mathematical process rather than as a set of memorized recipes. Students have described these kind of activities as "[giving] some sense to the equations that I was working with," and "adding meaning to mathematical formulas."



*John Becker and Tanya Fields study the simple harmonic oscillation of a torsion pendulum in the Physics 152 Laboratory. Photo credit – CIS Photographic Services, Purdue University.*

The data collection and display power of LabVIEW permits students to meaningfully experiment with physical relationships in a readily interpretable, graphical format. Students can tinker with the apparatus and collect usable data in minutes. In traditional labs, students would need much more time to acquire analyzable data, let alone prepare and interpret graphs and reflect upon the relationships.

Students are aware of the pre-eminent role played by computers in real-world science and engineering research, and keenly appreciate the opportunity to use a research-grade package such as LabVIEW during their learning. Many of the instructors and some students use LabVIEW in their own research efforts as well as for instruction. For instance, one engineering major described the incorporation of LabVIEW into his freshman physics labs as "real-world engineering."

The LabVIEW programming environment is particularly appropriate for the

needs of a physics laboratory for two reasons – it facilitates close control of the computer interface for the instructional environment, and it is an extremely robust, feature-rich, research-grade programming environment. With LabVIEW the human factors (the controls and graphics layouts) inherent in the user interface are closely controlled to reinforce critical conceptual points throughout the laboratory activities.

Typical laboratory sessions in the physics laboratory start with an individual prelaboratory assignment. Students then follow the activity guide printed in the manual while the instructors assist with suggestions or answer questions. Students work in small groups, first calibrating their apparatus, then collecting their data from airtrack gliders or pendula constrained to move under many different forces and conditions. Laboratory reports are usually communal efforts, resulting in a group report modeled on academic journal arti-



Aaron Hexamer and Sarah Bekofske study the motion of a glider floating on an inclined air track with a sonar transducer in the Physics 152 Laboratory. Photo credit – CIS Photographic Services, Purdue University.

cles. Exercises in topics such as error estimation and propagation are also assigned.

Spreadsheet and scientific plotting application training will be included in future versions of these latter activities. Students have commented on the appropriateness of the curriculum – they recognize the value of these laboratory activities and computer skills to their education and their future careers as

scientists and engineers. We are grateful for the support and guidance of our students and instructors, of Purdue University, the Physics Department, the School of Science, the University Computing Center, the Physics Education community, and National Instruments.✶

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Printed versions of the laboratory curriculum are available at: Shibata, E.I. & MacIsaac, D.L. (1993). *Physics 152 Laboratory Manual (3rd ed.)*. Dubuque IA: Kendall-Hunt. ISBN 0-8403-9222-2. Electronic copies and VIs are also available from the authors.



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