Transferable-Skills Based University Physics Laboratory

Doug Harper and Doug Humphrey

Department of Physics and Astronomy
Western Kentucky University
Bowling Green, KY 42101

http://physics.wku.edu/
Abstract

We will report on the recently completed modernization of our university physics laboratories where an emphasis has been placed on teaching current skills that students can transfer to advanced laboratories in physics or their major area of study and apply later in their career. In these new laboratories, students collect data from a wide variety of transducers using computerized data acquisition and signal conditioning system.

The experiments use LabVIEW virtual instruments that we have purposefully designed to provide only the raw experimental data requiring the student to become adept at the fundamental skills of using spreadsheets for data reduction and analysis and using plotting and function fitting software to display results and extract critical information. In addition, throughout the three-semester sequence the concepts of data acquisition, signal conditioning, calibration of sensors, etc. are introduced. The students even learn how to write their own data acquisition programs for selected experiments using LabVIEW.
Scope of Project

This project impacted our three beginning calculus-based physics laboratories (PHYS 251, 261, and 271, each one semester hour).

Students in these courses have majors in physics, pre-engineering, engineering technology, computer science, chemistry, etc.
Emphasis on Skills

The primary goal of our revised university physics laboratories is to provide experimental evidence of some of the laws and principles of physics using current laboratory skills that students can transfer to advanced laboratories in physics or their major area of study and their career.
Objective 1

Design experiments that use modern instrumentation in conjunction with the microcomputer to provide students with the tools for making accurate and precise measurements.

The computers are fitted with a National Instruments data acquisition board with capabilities for analog-to-digital input, digital-to-analog output, digital I/O and timing/counting. The above interface boxes were built to provide appropriate signal conditioning (using the 5B signal conditioning modules shown below) and convenient hookup of commonly available transducers.
Sensors and Transducers

Commercially available sensors such as the Pasco Motion Detector and Force Probe shown below were used. Additional sensor types that were incorporated into experiments include strain gauges, photogate detectors, thermocouples, radiation detectors, etc.
Objective 2

Teach the students how to use the microcomputer for data reduction and analysis (spreadsheets) and data presentation (plotting and function fitting).

The LabVIEW virtual instruments that were written for these experiments provide the student with a convenient means for collecting data but typically only provide the data to the student in a raw form. The students are required to analyze the data using either a spreadsheet (Microsoft Excel) or a scientific graphing program (Igor Pro). The above graph is an example calibration curve of a Pasco Force Probe created by a student.
Objective 3

Use LabVIEW as the programming language for experiments while progressively teaching the students over the three semesters how to write their own data acquisition programs.

Shown is a typical LabVIEW virtual instrument for measuring position as a function of time.
Virtual Instrumentation

Throughout the semester students learn some of the fundamentals of computer assisted data acquisition using the LabVIEW programming language.

Above is an example LabVIEW block diagram that students write to perform a photogate timing measurement of the angular frequency of a rotating platform. The basic driver VIs for the photogate and timer are given to the student and they are required to write a routine that will …

- measure the time between successive blocked-to-clear transitions of the photogate and
- compute the angular velocity of the rotating platform.

The students then use this Virtual Instrument in a subsequent experiment where they verify the principle of conservation of angular momentum.
Feedback from students regarding the increased experience with computers for data acquisition and analysis has been positive. A few student comments from course evaluations are reproduced below.

“I came into this lab totally hating spreadsheets but now I use them in many classes whenever I can.”

“I like the way the lab has become more computerized. New technology is better than writing all the info out and calculating it by hand. The programs are very easy to use.”
Summary

We have modernized our three one-semester-hour University Physics laboratories with new experiments that emphasize transferable skills by

- designing experiments that incorporate computer-assisted data acquisition using a wide variety of sensors,
- using LabVIEW as the programming language while progressively teaching students how to write their own data acquisition programs in LabVIEW,
- using spreadsheets and scientific graphing software (Igor Pro) for data reduction, analysis, function fitting and presentation.

The shift from tedious data collection and laborious data reduction by hand has allowed more time for interpretation of results and critical thought about the physical principles.

The level of proficiency with computers shown by students increases markedly as a result of this laboratory. Students are able to use these improved computer skills in subsequent advanced laboratories in physics or their major area of study. Students often return to our laboratory to analyze their data from other labs in the college.
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