Tracking through modern physics laboratory

Mark F. Masters
Timothy T. Grove
David P. Maloney

Indiana University – Purdue University Fort Wayne
Fort Wayne, IN 46805

Supported by DUE #0127078 from the National Science F

What is the purpose of laboratory?

Key Words

- To **Show …**
- To **Demonstrate …**
- To **Reinforce …**

What do we want the students to Learn?

- We want them to learn about how to collect data.
- We want them to learn about data analysis
- We want them to learn about uncertainty
- We want them to learn the physical concepts
- We want them to learn about the nature of scientific investigations
- We want them to become independent investigators

Unfortunately, we are often not explicit (to ourselves or to students) about all of these goals

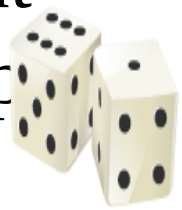
The end result is …

- The students are given many different labs on a variety of topics and concepts using different data analysis techniques and often variable experimental techniques.
- This is hard for the students… and therefore on the instructor
- This then causes the instructor to write detailed directions for the students to follow
- **Which means that the students learn to follow directions (and little else)!**

In the context of the traditional modern physics laboratory

One might see a series of unrelated investigations:

- Millikan Oil Drop Experiment
- X-ray diffraction
- Franck-Hertz Experiment
- Gamma Ray Spectroscop
- Hall Effect
- Doppler Shift of Light



Which are completed in random order

Problems

- Student learning is gauged throug reports …
  - Which are parroted from the detail instructions …
  - Or have sections copied from dubi sources
- Students concentrate on measuring values rather than understanding the physics
- Students compare with known values rather than using experimental uncertainties (anything closer than 5% of an accepted value is a good measurement no matter the precision of the equipment).
- When given freedom to investigate, students adopt a Random Systematic Method (RSM)

There has to be a better way!

Our attempt to remedy this situation

- Tracks: a series of closely rela investigations
- Early investigations are either concept building (mechanical analog) and/or developing understanding of apparatus.
- Directions, in general, consist of a series of questions that must be answered to set up the experiment or analyze the results.
- Knowledge from one investigation is useful in subsequent investigations.

Tracks

Nuclear Physics Track

- Mechanical Analog of ½ life
- Histograms of pulse heights
- Gamma ray spectroscopy
- Measurement of Cs ½ life

Molecular Spectroscopy

- Spectrometer
- Lensed Analog of a monochromator
- 1/2m monochromator
- Cs Dimer spectroscopy

Atomic Spectroscopy

- Fabry-Perot
- Externally locked diode laser
- Spectrometer
- Excitation of Rb vapor

Fourier Analysis

- Driven Oscillators
- Michelson Interferometer
- Doppler shift of light
- Fourier Spectroscopy

Resonance Physics

- Driven Oscillators
- LRC circuits
- Electron Spin Resonance
- Nuclear Magnetic Resonance

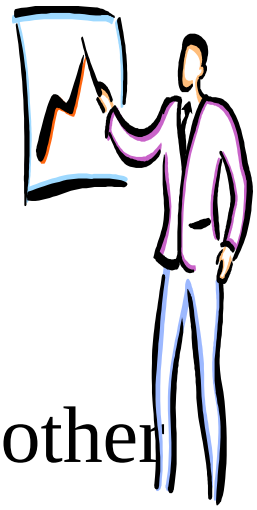
Laser Physics

- Spectrometer
- HeNe Laser
- Nitrogen pumped dye laser
- Spect. of Iodine molecules

Example Track: Resonance

- Mechanical Resonance
- Electronic Resonance (LRC)
- Electron Spin Resonance
- Nuclear Magnetic Resonance

Assessment of Student Learning: Poster Sessions



- Posters serve two purposes: Assessment of student understanding and to inform other students
- Professors and students read posters and query presenter (students first).
- Four Posters in a semester: First is faculty and a single student, second is student group (if there is one) and faculty. Third and fourth are the entire lab simultaneously
- Quiz at end of group poster sessions

Observations of student laboratory behavior

- Students are initially willing to accept explanation by definition and circular reasoning.
- Students first search the internet before considering books as a source of information.
- Entering students tend not to think about what data they should collect and why.
- Entering students tend to ignore the fundamental physics concepts and replace it with jargon.

Results so far …

- Many students (Physics Majors) have told us that they appreciate the freedom and have grown to dislike “cookbook” laboratories (Chemistry labs in particular).
- Students become more independent and confident in subsequent laboratories.
- Students’ ability with uncertainty is developing.
- Poster sessions are a valuable tool.

What remains to be done?

- A rigorous collection of data on student responses and reactions to the laboratory and poster sessions.
- Creation of new tracks: next up is Raman Scattering.