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7-29-2014

Weaving Experimental Skills Throughout the Introductory Laboratory

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Recommended Citation

Zwart, John, "Weaving Experimental Skills Throughout the Introductory Laboratory" (2014). *Faculty Work: Comprehensive List*. Paper 156.

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Weaving Experimental Skills Throughout the Introductory Laboratory

Abstract

The laboratory portion of an introductory course sequence can be used to meet a wide variety of goals ranging from illustrating phenomena studied in class, to building intuition about how the physical world works, to confronting the unexpected. Helping students develop experimental skills is a crucial goal that needs to be addressed in lab, especially in light of the fact that most introductory textbooks do not specifically address this topic. Important skills that students should learn in lab include how to analyze data, how to communicate results and the art of designing an experiment. This presentation will discuss how we weave an experimental skills thread through our introductory lab sequence in order to help students develop these key skills. See <http://homepages.dordt.edu/zwart/> for implementation details.

Keywords

physics instruction, lab notebooks, analysis techniques, graphing techniques, experimental design

Disciplines

Higher Education | Physics | Science and Mathematics Education

Comments

Presentation from the "Developing Experimental Skills in the Introductory Lab" track at the Summer 2014 National Meeting of the American Association of Physics Teachers held on the campus of the University of Minnesota in Minneapolis, Minnesota, July 27- 30, 2014.



Weaving Experimental Skills Throughout the Introductory Laboratory

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AAPT Summer 2014

Tuesday 07/29/14

Talk DE02

Thanks to Kayt Frisch for helpful comments and to Dordt College for conference funding via a Faculty Development Grant.

See **<http://homepages.dordt.edu/zwart/>** for copies of materials (this link is in the abstract)

Outline:

Lab notebooks
communication
analysis techniques
the 'art' of experimental design

Context:

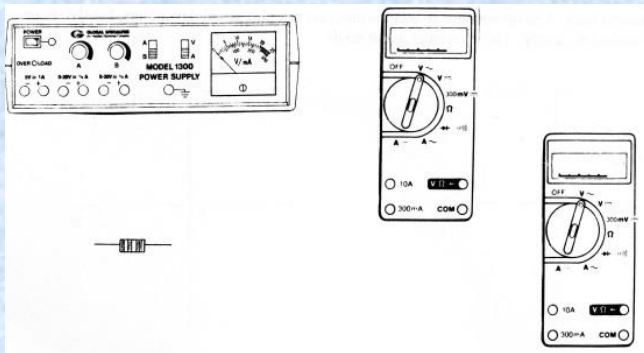
3 semester, calculus based sequence
3 hour lab period, ≤ 20 students/lab section

Lab Notebooks

To encourage students to keep a good lab notebook:

- Handouts only available during the lab period (except general info)
- Writing assignments given after the fact
- Open lab notebook lab quizzes (2-3/semester)

e.g. Sketch the apparatus you used in the ballistic pendulum experiment. Explain what you needed to measure and how you measured it.



Draw lines to represent wires that will send a current through the resistor and allow you to measure both the resistor's current and voltage. Be sure to connect to the correct jacks and circle where the DMM knobs need to be.

Communication / Writing assignments:

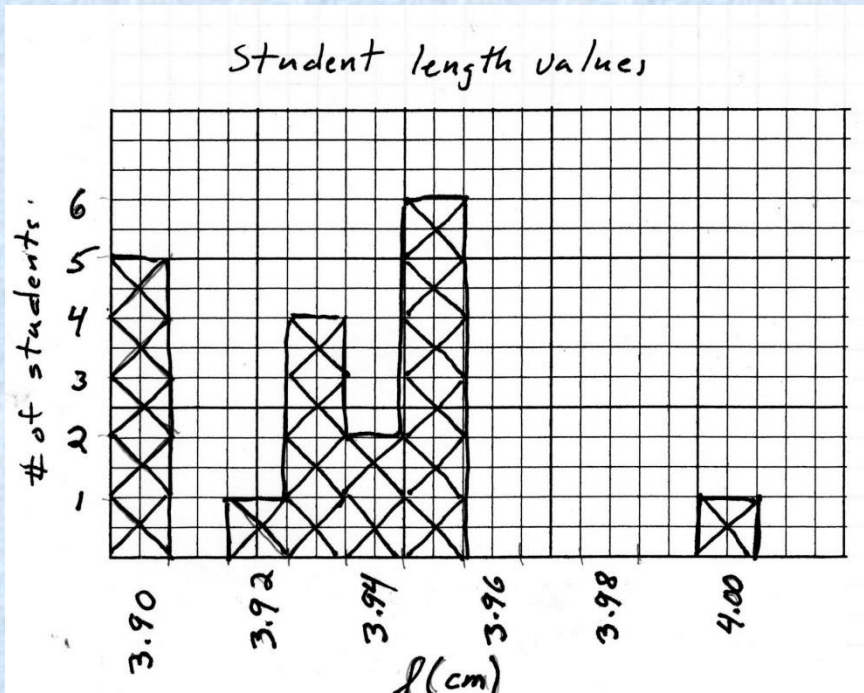
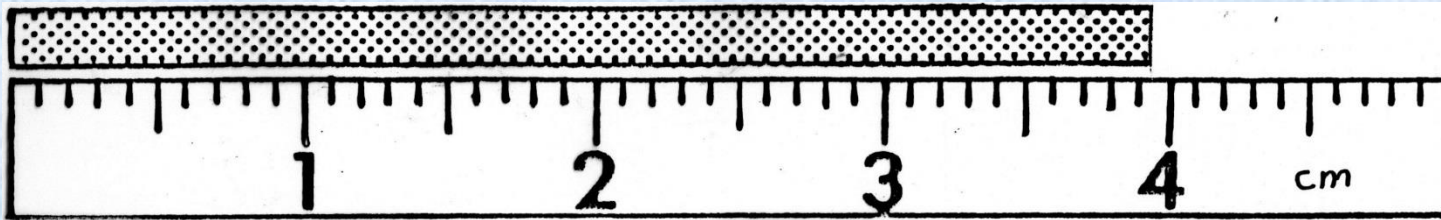
Semester 1: 2 abstracts

Semester 2: report (w/ partner) on self selected lab & 'informal report'

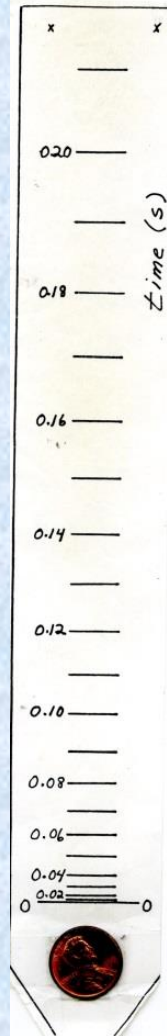
Semester 3: Formal lab report with peer review

Analysis Techniques: Measurement

Measurements and statistics – how long is the rod?



Analysis Techniques: Statistics of Repeated Measurements



Student measurement of reaction times –
Are you significantly faster/slower than your lab partner?

Analysis Techniques: Error Propagation

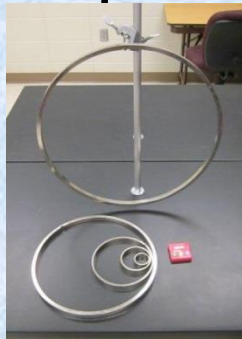


Find density and do error propagation with both low and high precision measurements.

Do aluminum first, then determine type of brass.

Graphing Techniques

- Linearizing data e.g. T vs \sqrt{L} for simple pendulum
- Empirical power law fits (ring pendulum, torque)



- Graphing to answer experimental Qs.

Is there a relation between range and launch height for a horizontally fired dart? (R vs h)

Does air resistance play a role?
(linearize 'no air resistance' theory and plot)

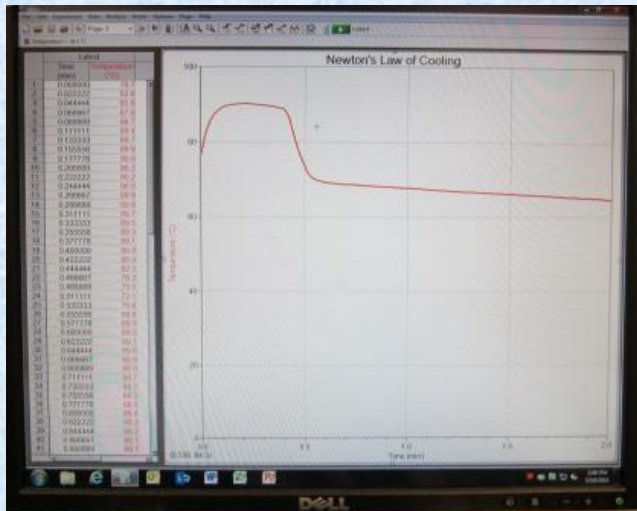


Art of Design:

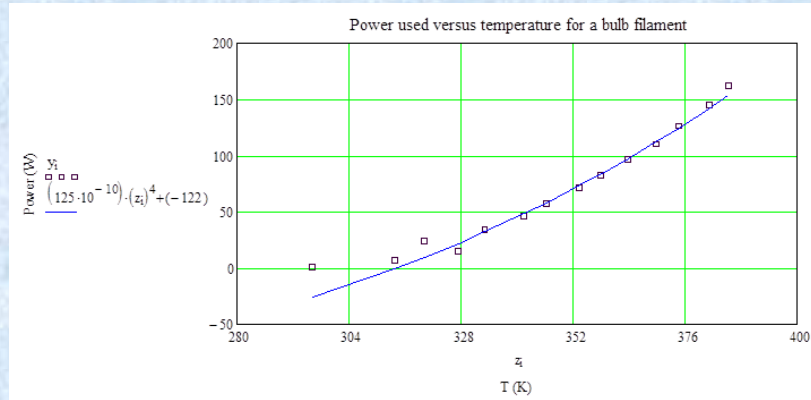
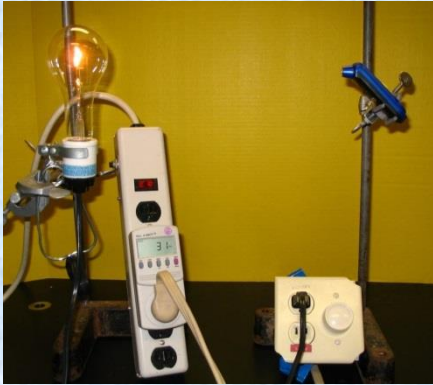
“How could this experiment be improved?”

e.g. Coffee cup calorimetry – finding specific heat of known and unknown metals

- Version 1: boil lump of metal, drop in cold water, measure temp with alcohol thermometer
- Version 4: drop room temp metal shot into hot water, monitor temp



What's wrong with this experiment?" exercise

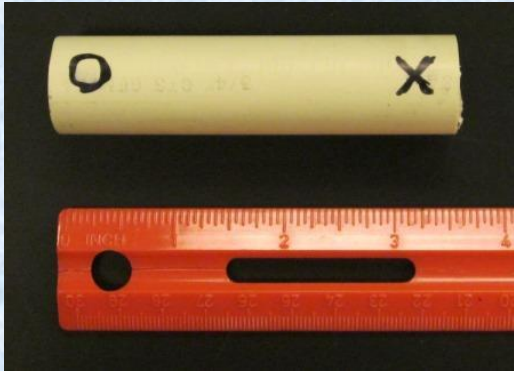


20 slide Powerpoint with discussion questions.

“Do your own experiment” – students select TPT or AJP experiment and make it work.
Written report score includes ‘difficulty’ portion.



“Spinning Tubes” – experimental design and role playing exercise



Students:

Form hypotheses and design experiments

Get equipment from ‘grants committee’

Present at ‘conferences’

See “Spinning Tubes: An Authentic Research Experience in a Three-Hour Laboratory” Arnold Sikkema, Steven Steenwyk, John Zwart, *American Journal of Physics* **78** (5), (May 2010) 467-470.

Instructor Led Small Group Design of Experiments in 3rd Semester:

e.g. suppose we wanted to test $B = \mu_0 i / 2\pi r$ (infinite straight wire Ampere's law result)

How long of a wire do we need?

How much current?

Where should the rest of the circuit be?

What range of r values?

.....

Questions?

See <http://homepages.dordt.edu/zwart/> for detailed information on the material presented (this link is in the published abstract).

Feel free to e-mail me with any questions
john.zwart@dordt.edu

Yet to come

Expand handout with analysis info to include design features, add regular items to weekly assignments

Student experimental project in 3rd semester

More clicker type questions, e.g.

Which of these is the best experimentally determined value for g ?

a) 9.9 m/s^2 b) 8.9 m/s^2 c) 9.8 m/s^2 d) not enough info