# Weaving Experimental Skills Throughout the Introductory Laboratory

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**Talk DE02**

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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:**

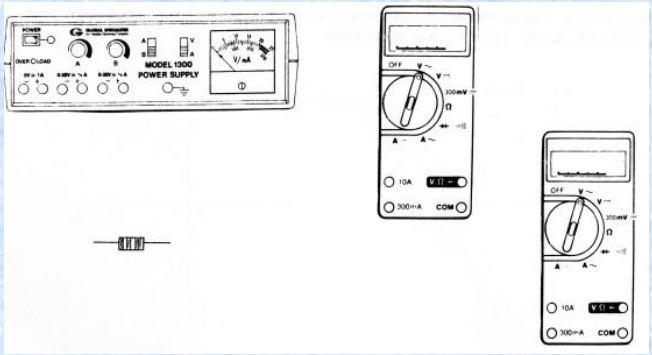
3 semester, calculus based sequence
3 hour lab period, ≤20 students/lab section

# 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:**

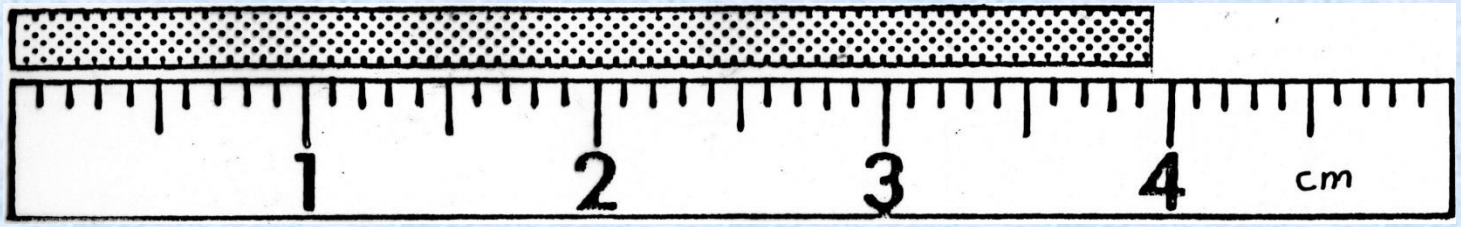
Semester 1: 2 abstracts

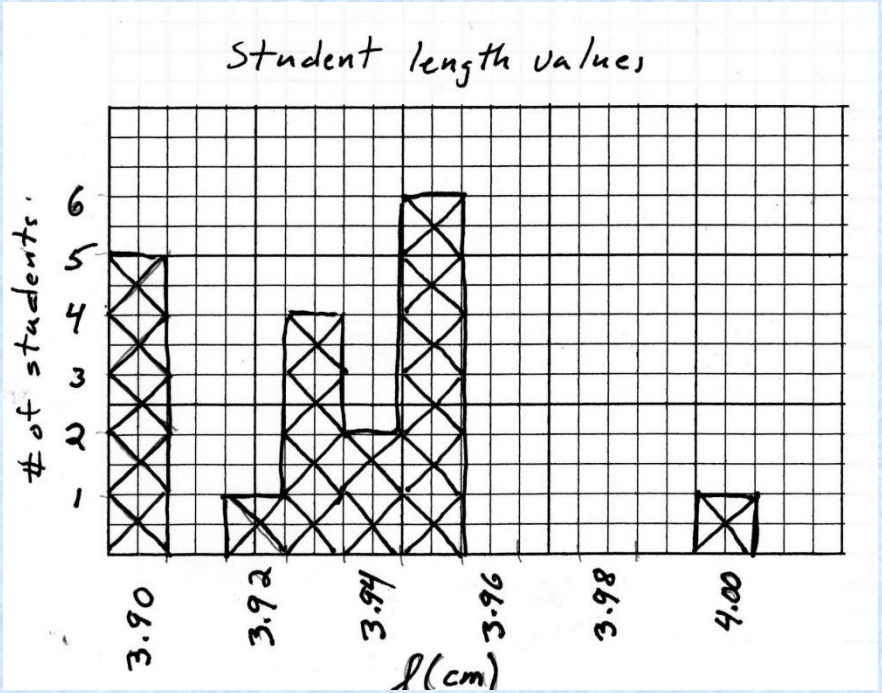
Semester 2: report (w/ partner) on self selected lab & ‘informal report’

Semester 3: Formal lab report with peer review

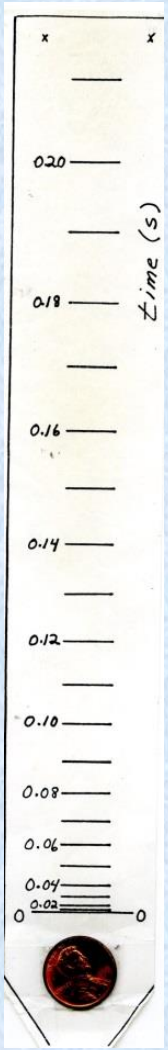
# Analysis Techniques: Measurement

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 horizonally fired dart? (R vs h)

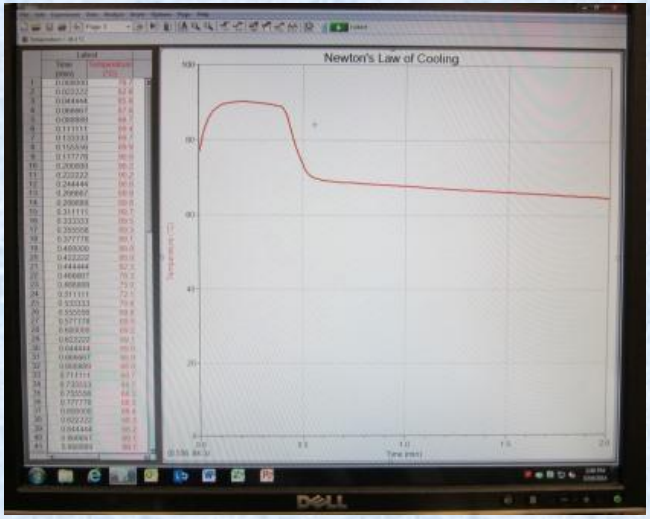
Does air resistance play a role?
(linearize 'no air resistance' theory and plot)

# Art of Design:

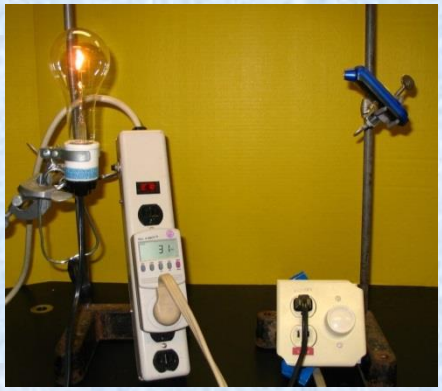
"How could this experiment be improved?

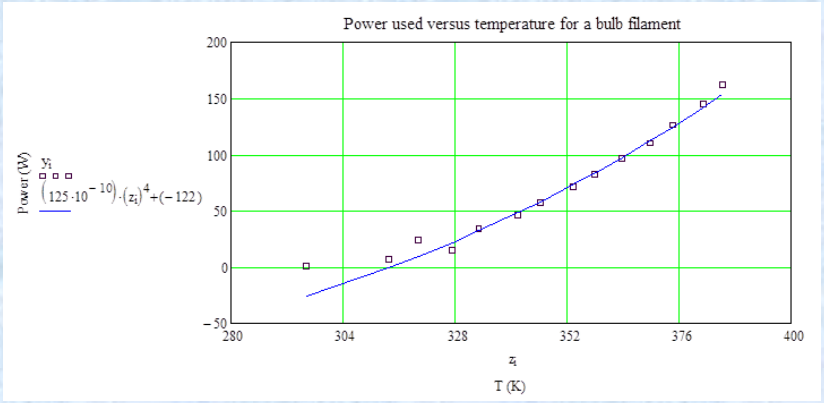
e.g. Coffee cup calorimetry – finding specific heat of known and unknown metals

- 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



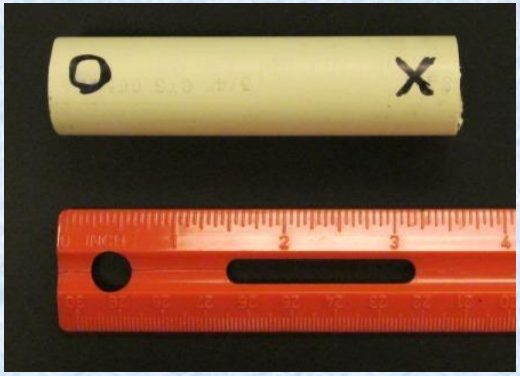


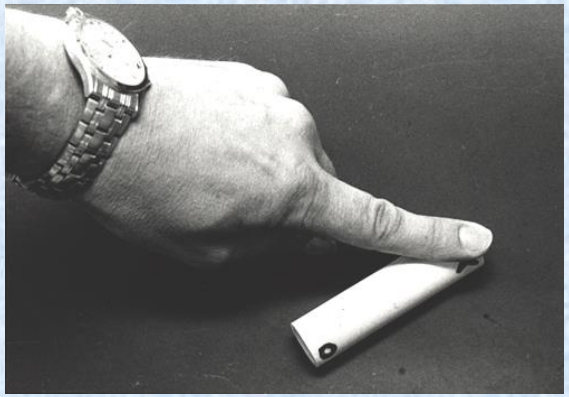

20 slide Powerpoint with discussion questions.

“Do your own experiment” – students select TPT or AJP experiment and make it work.

Writen 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 $B = \mu_o i/2\pi r$ (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

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# 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