Writing your Formal Lab Report:

A Conceptual and Strategic Guide for Arts and Science Students

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Your Challenge

- Writing a journal like formal lab report (*Physical Review*) for labs that cover mostly work that's already been done
- Finding a focus for your report to delve into in detail, rather than reporting all of your results
- Start by looking at the *genre* itself
- Huge amount of variation, but common characteristics reveal most important elements

Approaching this Challenge: Concepts and Strategies for Writing

1. **Introduction:** Finding Motivation and Purpose for your lab
2. **Staking a Claim:** Doing something with your results
3. **Form versus Content:** Creating Your Own Structure
4. **Using Lab Report Apparatus:** Tables, Figures, and Abstracts

Introduction: Why is science done?

- Natural curiosity?
- Practical application?
- In order to fill some sort of gap
  - In knowledge
  - In performance
  - In technology
- Move beyond lab as pedagogical exercise

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Exercise in scientific discovery

Introduction: Context-Gap-Niche

Introduces topic
Engages the reader

- The gap:
  - Specific technical problem paper confronts
    - Could be a real, practical problem
    - Or simply a lack of knowledge
- The context:
  - Background information required to understand the "gap"
  - Also involves problems, often on a more general level
- The niche:
  - Specific space carved out by the paper
  - Solution that addresses the gap in some specific way
    - Purpose statement
    - Projection

Identifies purpose
Gives overview

What problem? I'm just doing a 50 year old lab with old equipment

- Develop a focus for your lab report
  - Can't engage every little detail in the lab procedure, every result, etc.
  - Create an appropriate focus first
- If there isn't a "problem" or opportunity to fix
  - What hypothesis are you trying to prove?
  - What knowledge are you trying to uncover/ confirm? (Verification, for example)

Developing Motivation for Watching Knots Untie:

Topological constraints such as knots and entanglements affect the dynamics of filamentary objects including polymers and DNA. . . . Understanding the physical mechanisms governing the relaxation of such constraints **is crucial** to characterizing flow, deformation, etc. of materials . . .

Context → Establishes significance of work within greater scientific community

Developing Motivation fo[r Watching] Knots Untie:

Signals technical gap, precise problem

Scaling techniques provide a pow[...] modeling dynamics of topological constrain[...] These are successful when the precise details of the interparticle interactions are secondary relative to the geometric effects. However, topological constraints are difficult to control experimentally, and typically can be probed using only indirect methods. Here, we introduce a physical system where these difficulties are greatly reduced, thereby enabling a detailed quantitative comparison with theory: a system of knots in vibrated granular chains.

Identifies the niche

Examples of Gaps and Potential Solutions Niches

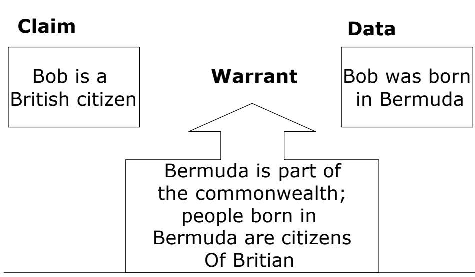
- Identification of Unknown Sample
  - Via identification of Hall Coefficients
- Verification of known characteristics / behavior of samples
  - Via identifying T_c for the sample
- Determining *(more efficient/quicker/ simpler etc.)* method for producing some sort of material
  - Making superconducting material

Real challenge is to develop an appropriate focus for your lab

Staking a Claim: Doing something with your results

- **Claim:** Statement you assert to be true
- **Data:** Scientific facts used to support
- **Warrant:** Logical explanation for why the data supports the claim

Staking a Claim: Doing something with your results



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- Results (data) don't speak for themselves
- Highlight the key results
- Develop a claim using these results
- Warrant these claims with logical explanation
- **Qualifier:** Qualify you claims based on strength of warrants

Staking a Claim: Doing something with your results

- Lab reports have one central claim
  - Often in discussion / conclusion
  - Responds to purpose statement and gap

Central Claim:

Warranting: Methodology, Discussion, even Background

Data: Results

Staking a Claim: Doing something with your results

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This is why we must:
1) Justify our methods
2) Highlight key results
3) Add logical explanation for how we interpret results

Staking a Claim: Doing something with your results

- Qualifying Claims:
  - Placing conditions or levels of uncertainty on your claims to reflect
  1. Quality of methods
  2. Quality of data

Significance of Error Analysis, Identifying Sources of Error!!

Staking a Claim: Example Arguments

- The sample was indium
  - **Data:** Hall Coefficient, Reference Value
  - **Warrant:** Reference value and Observed value were in range, within error

Staking a Claim: Example Arguments

- The sample was ***most likely*** indium
  - **Data:** Hall Coefficient, Reference Value
  - **Warrant:** Reference value and Observed value were in range, within error
  - **Qualifier:** But error ranges were way too high to actually say anything
    - Might suggest another claim: equipment or methodology flawed, need to provide warrant

Discussion needs to: engage issue posed in intro and, engage results in depth, exploring what can be said, with what certainty, and why . . .

Form versus Content: Creating Your Own Structure

- **I**ntroduction
- **M**ethods / Apparatus
- **R**esults / Observations
- **D**iscussion

Although it underlies all lab work, the IMRaD structure is very limited

Form versus Content: Creating Your Own Structure

Sophisticated writing bends form (rhetorical structure) to content

- Methods may be determined by initial results
- Results and discussion may take place together

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Making Structure Explicit and Maintaining Coherence

- Provide an overview of the paper
  - At the close of the introduction (be specific)
- Use informative and unique headings
  - See next slide
- Enumerate where possible
  - "The apparatus consists of five main components: . . . First . . ."
- Use transitions
  - Ensure that logical connections exist first; strengthen via . . .
  - Phrases such as "however," "in addition" that develop specific relationships between ideas in a paper

Form versus Content: Creating Your Own Structure

1. Introduction

Shows subordination/ coordination of ideas

5. Conclusion

Creates informative subtopics

1. Introduction
2. Superconductivity
   a) BCS Theory and Cooper Pairing
   b) Ginzburg Landau Theory
   c) Unconventional Superconductors
3. Fabricating YCBO
4. Discussion
   a) Critical temperature
   b) Hysteresis
   c) Sample Stability

Using Lab Report Apparatus: Tables, Figures, and Abstracts

- When reporting on results, sentences are not the most efficient method
- Tables and figures must be used to clearly show results (and even apparatus)
- Using them effectively:
  - Number, title, and caption tables and figures
  - Refer to tables and figures in text, highlighting significant data points or meaning
  - Adjust for context
  - Position them appropriately

Using Lab Report Apparatus: Tables, Figures, and Abstracts

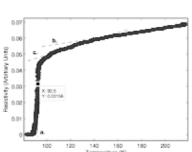

Figure 4: Temperature-resistivity profile for the sample under cooling; a) the critical temperature, b)normal state slope, c)fluctuation region slope.

Using the four-point measurement technique indicated above, and accounting for hysteresis, the critical temperature of the sample was determined to be 91.4K ±0.7K. In theory, the critical temperature is defined as the temperature at which a material exhibits the two main properties of superconductors. In reality however, the transition from the normal to the superconducting state is not immediate. This can be seen in the temperature/ resistivity profile of the sample provided in Fig. 4. . . .

Using Lab Report Apparatus: Abstracts

- Short stand alone summary
- Informative, not descriptive, meaning ...

Problem* / Purpose
Key Method(s)
Key Result(s)
Key Discussion Point

The g-factor, which relates atomic magnetic moment to angular momentum, was measured for elemental rubidium using optical pumping. Circularly polarized light from the rubidium emission spectrum was used to align a sample of rubidium atoms with a weak external magnetic field. A subsequent magnetic resonance investigation allowed us to determine the resonant frequency corresponding to the field strength and hence the energy difference between Zeeman sublevels in the split hyperfine structure. The values of gF determined using this method were 0.42 ± 0.02 for rubidium-85 and 0.65 ± 0.04 for rubidium-87. These values do not entirely agree with the theoretical predictions and indicate some areas of the experiment that require improvement.

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In summary,

- Develop a focus for your report that comes out of some sort of problem or gap in knowledge
- Identify your main claims and properly ***warrant*** and ***qualify*** them in your prose
- Develop a structure that fits your work, not labs in general
- Use lab report apparatus effectively

What I haven't discussed, but needs mentioning . . .

- Referencing:
  - Various different formats based on journal preference
  - Citation in body + List of works cited at end
- Academic tone and conventions:
  - Review journal articles to identify, mimic
  - **Warning:** not all published articles are well written
- Audience:
  - Write for your reader, not simply to get your ideas on paper
- Grammar, diction, (sentence design):
  - Too individual and complex to discuss, but . . .

Writing Support Around Campus

- Centralized site: http://www.utoronto.ca/writing
- College specific Writing Centres: http://www.utoronto.ca/writing/centres.html

  (New, St. Mike's, Woodsworth, Vic, Univ. College, etc.)
- Free 30 minute - 1 hour session with tutors