Writing in Physics - Student Laboratory Reports

Vince Kuo
Department of Curriculum and Instruction
University of Minnesota

Ken Heller
School of Physics and Astronomy
University of Minnesota

Details at
http://www.spa.umn.edu/groups/physed/

Supported in part by NSF,
and the University of Minnesota

Task

- Write down 3 things that you want to get out of this discussion.
- Compare your list with your neighbors and decide on the one most important thing you want to get out of this discussion.

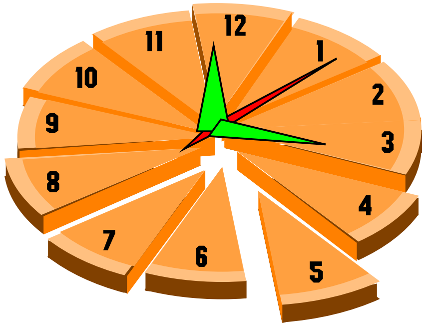
TIME ALLOTTED

2 minutes for individual list, 3 minutes for discussion.

PROCEDURES

Formulate a response individually.
Discuss your response with your neighbors.
Listen to your neighbors' responses.
Create a new response through discussion.

AGENDA: A Guide for Discussion

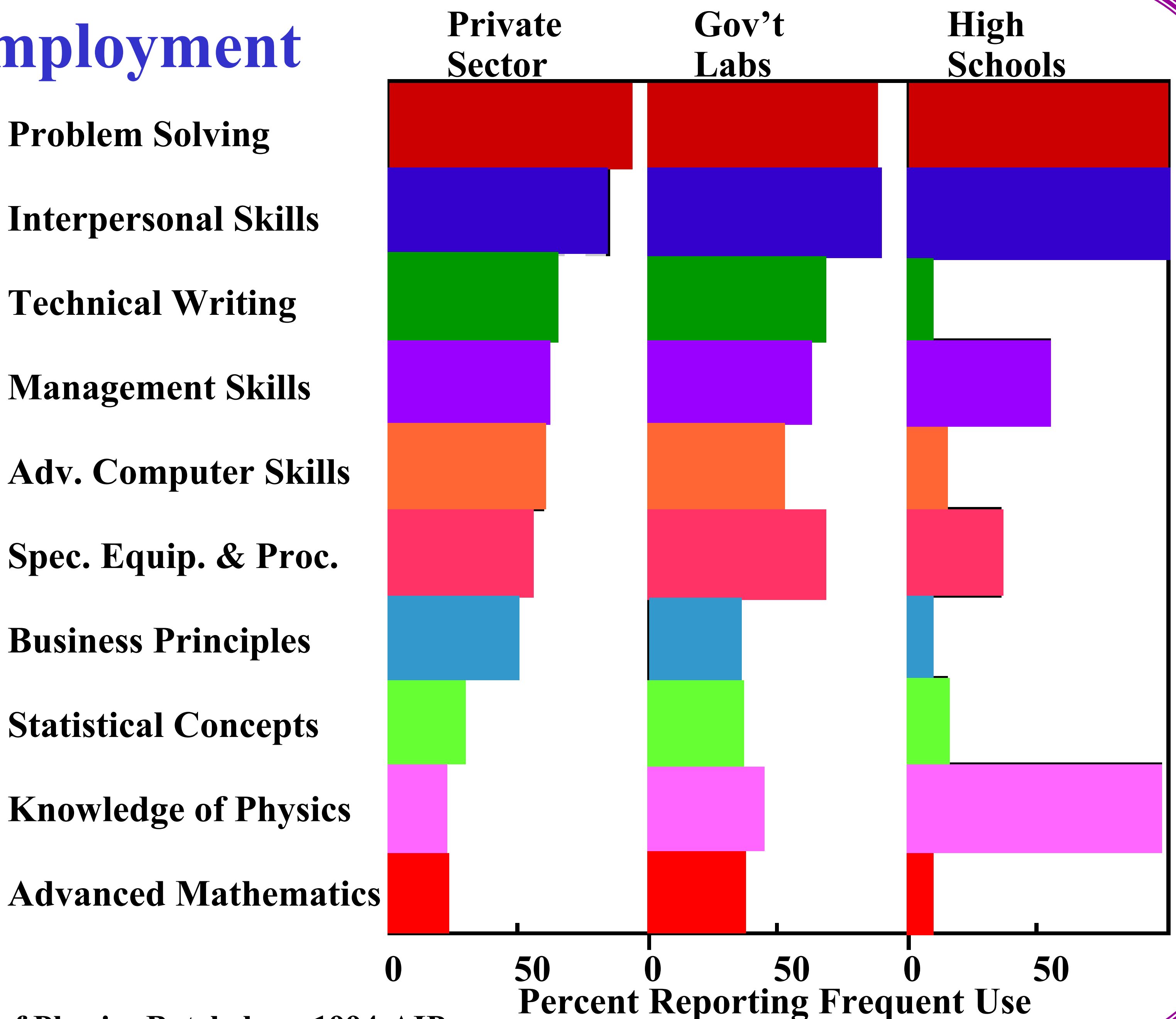


❶ **Writing in a Physics Course**
- **Problem Solving and Writing**
- **Student Background**
- **Instructional Framework**

❷ **Lab Reports**
- **What is a Physics Lab?**
- **What goes in a lab report?**
- **Evaluating lab reports.**

What do you want to discuss that is not here?

Employment



Survey of Physics Batchelors, 1994-AIP

Teaching Students to Solve Problems

Solving Problems Requires Conceptual Knowledge:

From Situations to Decisions

- Visualize situation
- Determine goal
- Choose applicable physics principles
- Choose relevant information
- Construct a plan
- Arrive at an answer
- Evaluate the solution

Students must be able to
communicate these actions in writing

- English
- Organization
- Pictures

Explicit Problem-solving Framework

Used by experts in all fields

STEP 1 — **Recognize the Problem**

What's going on?

STEP 2 — **Describe the problem in terms of the field**

What does this have to do with ...... ?

STEP 3 — **Plan a solution**

How do I get out of this?

STEP 4 — **Execute the plan**

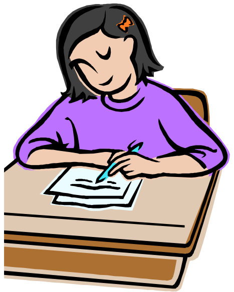
Let's get an answer

STEP 5 — **Evaluate the solution**

Can this be true?

Importance of Laboratory Reports

- **Learning through synthesis of information**
  - Students write reports to communicate to themselves and their instructor their understanding of:
    - Logical reasoning
    - Physics concepts
    - Data analysis choices
    - What they've learned
    - What they've not learned

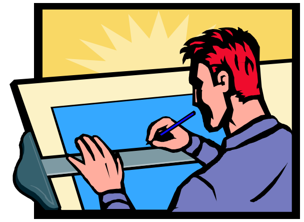
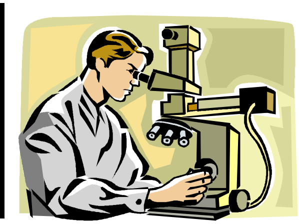


- **Clear & Concise technical communication**
  - Necessary for upper level courses in all majors
  - Sought-after skills by employers
    - What is the decision
    - Basis for the decision
    - Consequences of the decision

Calculus Based Physics
1200 students/term

Majors

Engineering	75%
Physics/Astro	5%
Chemistry	6%
Mathematics	5%
Biology	9%


Male	79%
Had Calculus	80%
Had HS Physics	87%

Freshman	64%
Sophomores	22%
Juniors	10%

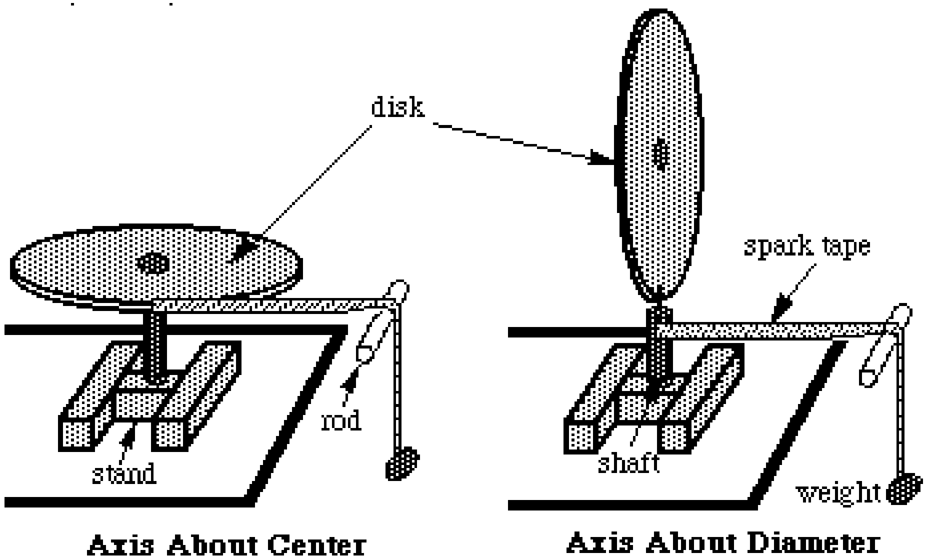
Expect A	61%
Work	53%
Work more than 10 hrs/wk	25%

Course Structure

LECTURES	**Three hours each week. (200 students)**
RECITATION SECTION	**One hour each week – solving a problem in 3 person cooperative groups. Peer coaching, TA coaching. (15 students)**
LABORATORY	**Two hours each week -- *same* groups solve experimental problems. *Same* TA. Peer coaching, TA coaching.(15 students) Written lab reports every 2 weeks.**
TESTS	**Problem-solving quiz & conceptual questions (usually multiple choice) every three weeks.**

Problem Solving Laboratories

- Closely integrated with lecture & recitation
- Always context-rich problems
- Emphasize modeling real systems
- Work in Cooperative Groups
- Lab reports are short technical memos



- Each student hands in an individual laboratory report about every two weeks
- Each group member reports on a different problem
- TA assigns each student a problem at the end of each unit
- Student does not knows which problem will be assigned.
- Report is due in 2 days.

A Lab Problem:

Forces in Equilibrium

Mechanics Lab III, Problem #2

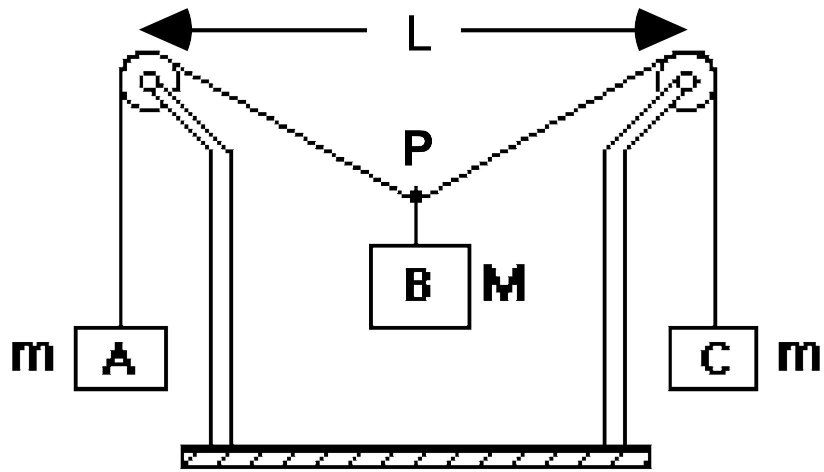
You have a summer job with a research group studying the ecology of a rain forest in South America. To avoid walking on the delicate rain forest floor, the team members walk along a rope walkway that the local inhabitants have strung from tree to tree through the forest canopy. Your supervisor is concerned about the maximum amount of equipment each team member should carry to safely walk from tree to tree. If the walkway sags too much, the team member could be in danger, not to mention possible damage to the rain forest floor. You are assigned to set the load standards.

The Problem

Each end of the rope supporting the walkway goes over a branch and then is attached to a large weight hanging down. You need to determine how the sag of the walkway is related to the mass of a team member plus equipment when they are at the center of the walkway between two trees. To check your calculation, you decide to model the situation using the equipment shown below.

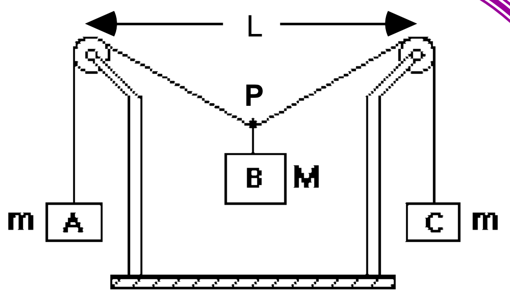
? **How does the vertical displacement of an object suspended on a string halfway between two branches, depend on the mass of that object?**

Equipment



The system consists of a central object, B, suspended halfway between two pulleys by strings. The picture above is similar to the situation with which you will work. The objects A and C, which have the same mass (m), allow you to determine the force exerted on the central object by the string. You do need to make some assumptions about what you can neglect. For this investigation, you will also need a meter stick and weights to vary the mass of B.

Prediction

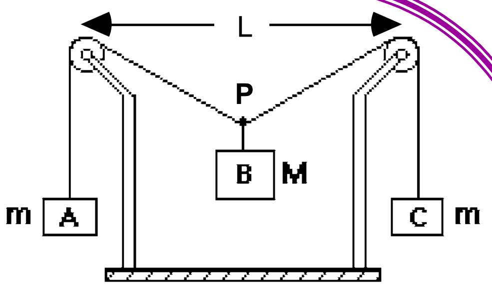


Calculate the change in the vertical displacement of the central object (B) as you increase its mass. You should obtain an equation that predicts how the vertical displacement of central object B depends on its mass, the mass of objects A and C, and the horizontal distance between the two pulleys.

Use your equation to make a graph of the vertical displacement of object B as a function of its mass.

Methods Questions

(Coaching Problem Solving)



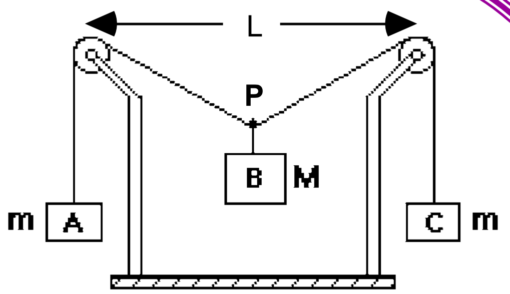
1. **Draw a sketch** like the one in the Equipment section. **Use trigonometry** to show how the vertical displacement of object B is related to the angle that the string between the two pulleys sags below the horizontal.

2. **Identify** the "known" (measurable) **quantities** (L, m and M) and the unknown quantity (the vertical displacement of object B).

3. **Use Newton's laws**. Write down the acceleration and draw separate **force diagrams** for objects A, B, C and for point P. For each force diagram, write Newton's second law along each **coordinate axis**.

4. **Solve your equations** to predict how the vertical displacement of object B depends on its mass (M), the mass (m) of objects A and C, and the horizontal distance between the two pulleys (L). Use this resulting equation to make a graph of how the vertical displacement changes as a function of the mass of object B.

Exploration

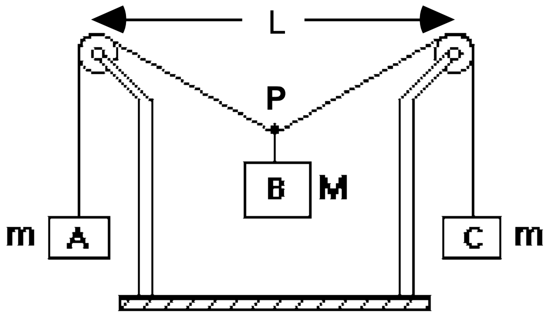


Start with just the string suspended between the pulleys (no central object), so that the string looks horizontal. Attach a central object and observe how the string sags. Decide on the origin from which you will measure the vertical position of the object.

Do the pulleys behave in a frictionless way for the entire range of weights you will use? How can you determine if the assumption of frictionless pulleys is a good one?

Add mass to the central object to decide what increments of mass will give a good range of values for the measurement. Decide how many measurements you will need to make.

Measurement



Measure the vertical position of the central object as you increase its mass. Make a table and record your measurements.

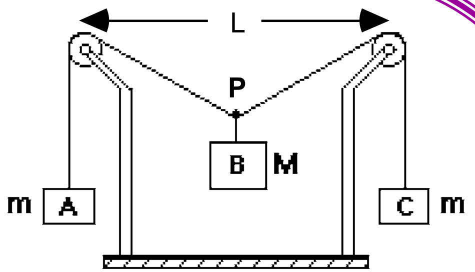
Analysis

Make a graph of the vertical displacement of the central object as a function of its mass based on your measurements. On the same graph, plot your predicted equation.

Where do the two curves match? Where do the two curves start to diverge from one another? What does this tell you about the system?

What are the limitations on the accuracy of your measurements and analysis?

Conclusion



What will you report to your supervisor? How does the vertical displacement of an object suspended on a string between two pulleys depend on the mass of that object? Did your measurements of the vertical displacement of object B agree with your initial predictions? If not, why? State your result in the most general terms supported by your analysis.

What information would you need to apply your calculation to the walkway through the rain forest?

Estimate reasonable values for the information you need, and solve the problem for the walkway over the rain forest.

Guideline for grading laboratory reports

Problem Report:	Score
ORGANIZATION (clear and readable; correct grammar and spelling; section headings provided; physics stated correctly)	
DATA AND DATA TABLES (clear and readable; units and assigned uncertainties clearly stated)	
RESULTS (results clearly indicated; correct, logical, and well-organized calculations with uncertainties indicated; scales, labels and uncertainties on graphs; physics stated correctly)	
CONCLUSIONS (comparison to prediction & theory discussed with physics stated correctly ; possible sources of uncertainties identified; attention called to experimental problems)	

Given to TAs & Students in Lab Manual

General Criteria for evaluating technical Reports

(Dr. Lee-Ann K. Breuch, Dept. Of Rhetoric, U of MN)

- **Content:** What is the subject? What information needs to be included?
- **Context:** What is expected in the discipline for this type of document?
- **Audience:** To whom is the document written? How will it be used?
- **Organization:** How can the information be best organized? Can the information be divided into sections?
- **Support:** What details, facts, and evidence can be used to illustrate main points?

Example of quality levels - Content

	Satisfactory	Adequate	Poor
Addresses content accurately and thoroughly	Accurate and complete technical information, including formulas, explanations, theory, and data.	Accurate technical information, but has missed some important information.	Does not include accurate or complete information.
Score	3	2	1

Example of quality levels - Context

	Satisfactory	Adequate	Poor
The format is as suitable for a short technical document.	Meets the requirements of the assignment; includes proper format & sections that assignment requires.	Adequately meets requirements of the assignment; does not always display proper format.	Does not meet the requirements of the assignment as specified.
Score	3	2	1

Example of quality levels - Audience

	Satisfactory	Adequate	Poor
The paper can be understood by classmates in this physics class.	Writes appropriately for classmates, including proper terms, explanations of concepts, formal register.	Does not always include proper terms, concepts, or register (perhaps is too informal).	Does not include proper terms, concepts, or register to effectively address audience.
Score	3	2	1

Example of quality levels - Organization

	Satisfactory	Adequate	Poor
The paper is logically organized	Has complete, concise, paragraphs; includes strong topic sentences that indicate focus of paragraph or section; includes strong forecasting statements; includes appropriate headings & subheadings; demonstrates coherence throughout report.	Adequate overall format; does not display concise paragraph or topic sentences; does not have all appropriate headings & subheadings; paragraphs are not clearly coherent.	Does not use appropriate headings or subheading; paragraphs do not logically connect nor are they concise; topic sentences are not effective.
Score	3	2	1

Example of quality levels - Support

	Satisfactory	Adequate	Poor
The paper has adequate support for statements	Has necessary illustrations or figures. Refers to appropriate readings, theories, & relevant background information; includes relevant graphs & tables; with proper labeling & cross-references figures, tables, & graphs.	Has appropriate readings & background information, but does not use clear logic; has tables & graphs but they are not always labeled or cross-referenced.	Does not include necessary support in the form of logic, background information, tables, or graphs. No labeling, & cross-references.
Score	3	2	1

Example

Satisfactory:

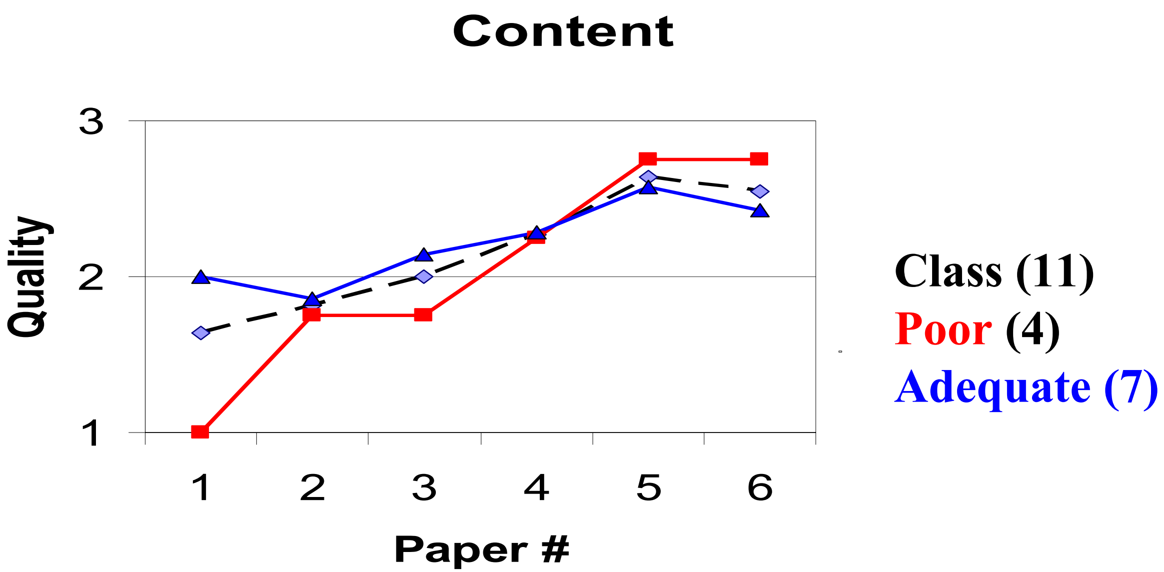
- While the beam was rotating we timed how long it took to make five revolutions. We did this to determine the angular velocity, ω. Once we knew ω we plugged that value into the equation $v = R\omega$, where R is the radius. Our group and I concluded that the linear velocity (v) of a point on the beam increases when the radius increases with a constant angular velocity. There is a graph at the end of the report that shows this relationship for easier understanding.

Poor:

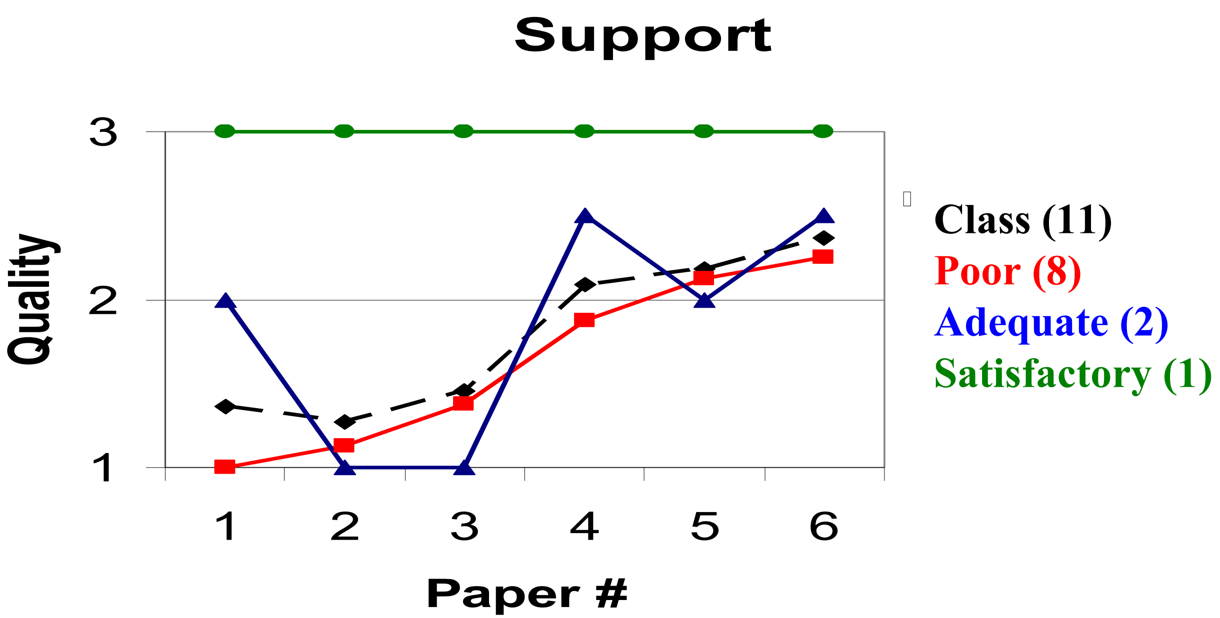
- I observed that the acceleration is zero at the time where the cart switches from going up the track to down the track. This is what we predicted to happen. Our group ... The graph is a constant slope from left to right because the acceleration is always negative and this is why the graph is an upside down parabola. This lab has helped me understand ... The acceleration is always negative (in this respect) which is a little hard to comprehend at first but it was nice to observe this in lab.

A Lab Section

- One class of 15 students
  - 11 of which had all 6 laboratory reports from the entire 15-week semester (n = 11)
- Each student is placed into one of three groups based on the grade of the first report
  - Poor
  - Adequate
  - Satisfactory



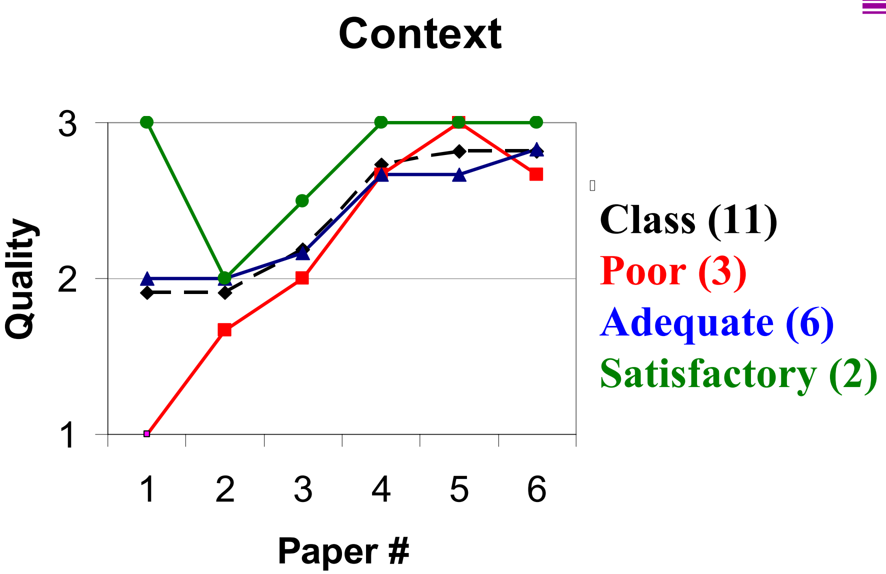
Content: What information needs to be included?

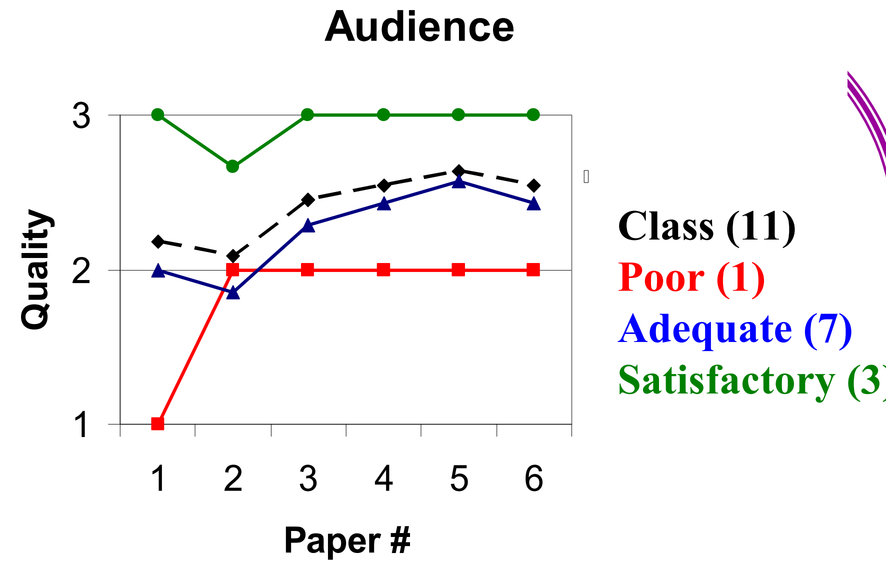


Support: What details, facts, and evidence are used?

Topic of paper number:

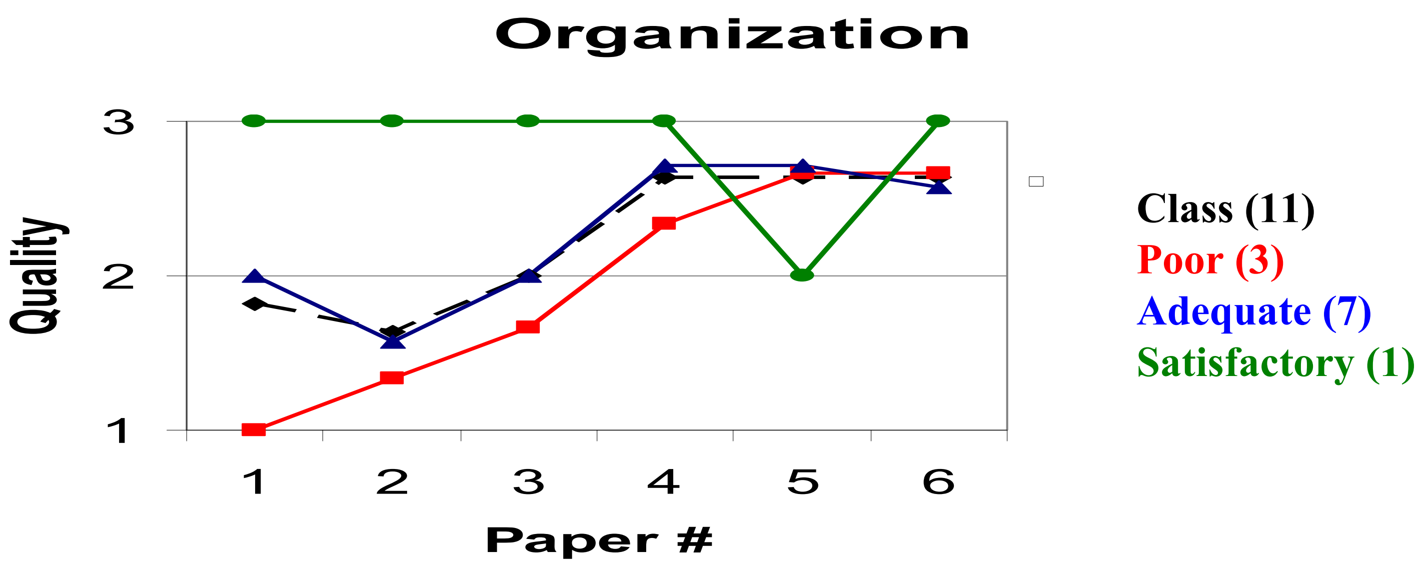
1) 1-D Kinematics
2) 2-D Kinematics
3) Forces
4) Conservation of Energy and Momentum
5) Rotational Kinematics
6) Rotational Dynamics





Audience: To whom is the document written?

Context: What is expected for this type of document?



Organization: Is the logic evident in the presentation?

Discussions

- Students at all starting levels showed improvement in each of the criteria
  - Except for those students that were initially-satisfactory, average rating of each group reached approximately the same quality by the end of the 15-week semester

- **Identifiable increases in quality apparent by 3rd or 4th report**
  - **content, context, audience, & organization**

- **Slower increases in quality of support**
  - **majority of students only slightly higher than "adequate"**

The End

Please visit our website for more information:

http://www.physics.umn.edu/groups/physed/