Autumn 2005
Engineering 181
Student Lab Packet

181 Student Lab Manual Contents

MEMO

To: Instructor's Name and GTA's Name
From: Group X (Section 5A, 1:30 PM); Your Name(s)
Date: 01/15/04
Subject: Title of the Lab

Introduction

This is a short paragraph. In the first sentence or two, list what the goals and objectives of the lab are. HINT: the goals/objectives of the lab can be found in your course packet. The next sentence should indicate what is contained within the memo. For example: This memo contains results, discussions, and conclusions from Lab X.

Results

The results section is portion of the memo where you **list THE RESULTS**. Although this may seem very simple, it is a common source of error for many students. This is not the place for either Procedure (which is not required for most labs in ENG181), or Discussion (which is presented under the next heading). Provide the results that are asked for in the Memo Grading Guidelines, no more, no less.

The Results section will generally be thin. Usually, this section is one or two small paragraphs of text referencing where the results are stored within the memo. You can choose to store the actual results in the memo by either inserting the tables and graphs directly into the text of the memo (recommended) OR appendicizing them at the end of the memo. For example, if I were completing a lab on the conversion of length from imperial units to metric units, I would do it in one of the following ways:

A study of the conversion of length from imperial units to metric units has been conducted. The raw data is presented in Table 1. The relationship between measurements of length in feet and meters is graphed in Figure 1. Alternately I could tabulate and graph the information in an appendix (see Table 2 and Figure 2).

Feet	Meters
1	0.30
2	0.61
3	0.91
4	1.22
5	1.52
6	1.83
7	2.13
8	2.44
9	2.74
10	3.05

Table 1: By right-clicking on the table you can insert captions for tables and graphs. This feature is very helpful when you are assembling larger documents, like the lab REPORT later in the quarter.

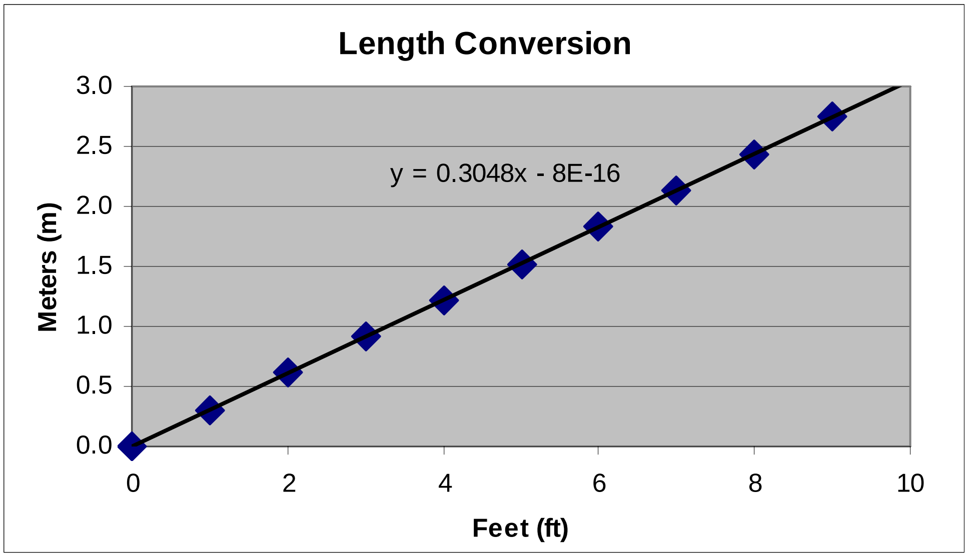

Figure 1: Notice how there is an appropriate title, and both axes are appropriately labeled (units included in brackets). Also notice that the equation for the trend line is appropriately placed close to the trend line it represents.

Discussion

The purpose of this section is to **test your comprehension** of the concepts used in the lab, and to **stimulate your thinking** and **application** of these concepts. Many of the answers to the discussion questions are contained in the lab presentation. It is therefore a good idea to pay attention during the presentation before the lab begins. Additionally, the presentation slides can be downloaded from WebCT for review at a later point and time. Include each discussion question separately and answer it in one or two short paragraphs. Discussion questions for reports usually carry more weight, and should be appropriately more detailed (half a page at least). An example is given below.

1) **Discuss why weather in Columbus fluctuates such a great deal over the year.**
Columbus falls under the region of the country generally termed as the Midwest and have mostly flat plain topography. The major weather patterns are from the south and the west, and easily affect Ohio since there are no mountains or topographical features to act as natural barriers. However, we are also influenced by the Great Lakes and arctic weather moving in from Canada. Hence, a combination of all these weather patterns affects the weather in Columbus. The fluctuation of weather is therefore a result of either the sum of all the above effects or the most dominant pattern affecting the region.

2) **Discuss discrepancies between theoretical and experimental results.**
The major source of error for this experiment is human error. A member of our team made a mistake in reading the dial for the deflection. Also, since we did not have a stop watch, we approximated the time taken for deflection to be 15 seconds, which proved to be too great when compared with the theoretical value of 10 seconds.

Conclusions

The content of this section is again dictated by the Memo Grading Guidelines. Summarize the results if necessary, but **it is important that you draw a conclusion** from them. For example, if the deflection of a steel beam is lower than that of an aluminum beam, you may logically conclude that the steel beam is a stiffer and stronger structure.

Generally, you will be asked about changes and improvements that can be made to the lab. Think of one or two changes or improvements that can be made to the lab that could **realistically** produce more accurate results or make the lab easier to perform. This section should be a four or five sentence paragraph; clear and concise.

NOTE: Reports usually follow a similar format, but are different in that they have a cover page, a list of figures, a list of table and an executive summary. Samples of these are shown in your course packet.
The book included in your course packet "A Guide to Writing as an Engineer" is also a very helpful resource. You may find pages 78 and 98 especially helpful.

APPENDIX

Feet	Meters
1	0.30
2	0.61
3	0.91
4	1.22
5	1.52
6	1.83
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8	2.44
9	2.74
10	3.05

Table 2: Length Conversion Table

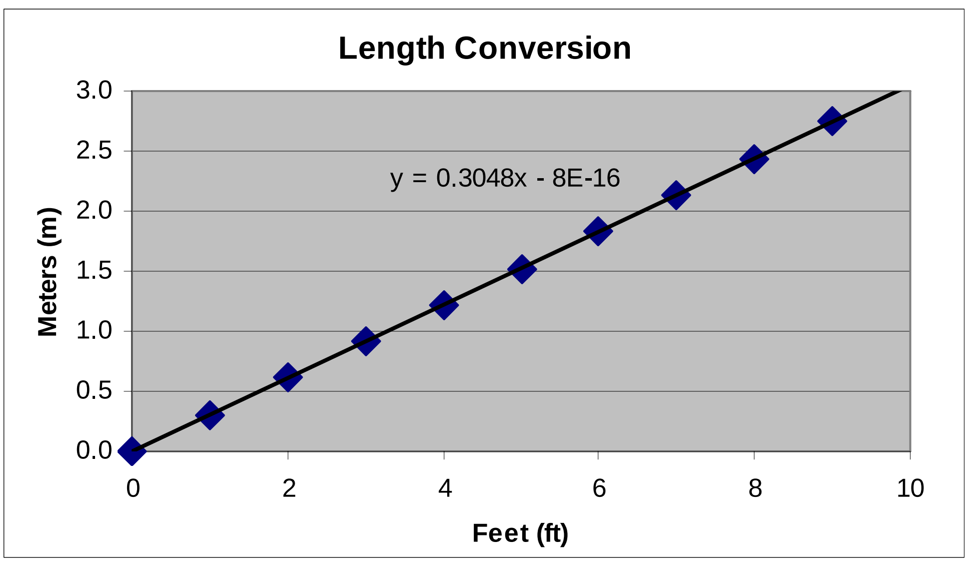


Figure 2: Noticing that the relationship between the metric and imperial measurements of length is 'linear', a trendline has been inserted to graphically show the relationship. To insert a trendline, right click on the data series in excel and select trendline.

Additional Requirements:

(This is not a section to be included in your actual memo; these are just additional tips on how to create a good memo.)

- Follow the MEMO GRADING GUIDELINES carefully. This is EXACTLY the marking scheme that your memo will be graded on; no tricks! If you provide everything that is asked for, you will undoubtedly get a good mark. Additionally, ONLY provide what is asked for; including extra information wastes your time creating the memo, and the markers time reading the memo.
- Marks will NOT be awarded for length, in fact if a memo is unnecessarily wordy marks may be deducted for grammar. BE CONCISE!!! Say what you intend to say in as few words as it takes to effectively get your point across!
- Attach the MEMO GRADING GUIDELINES to your lab memos, this is a courtesy to the marker, so that he/she does not have to print out 40 copies every time that memos must be marked. <u>A small point deduction will occur if you do not attach the Memo Guidelines.</u>
- In the bulk of the memos, there is NO PROCEDURE write-up required. You can assume that you are writing the memo to someone who already has sufficient knowledge of the experiment that you performed. If you decide that experimental procedure is necessary to effectively explain other parts of the memo, procedural information must be in its own section titled: ‘Procedure’. It is NOT to be placed in the Introduction, Results, or Discussion sections.
- Notice in the memo above how the headings (Introduction, Results, Discussion, and Conclusion) are clearly identifiable from the text of the memo. Headings help organize the memo and should not hide in the text. Underline them; use a bold font, use an italic font, or use any combination of the above to adequately separate the headings from the text.
- The memo should be at the very least ‘semi-formal’. Avoid words like “I”, “we”, “Chris”, “Sarah”, etc… The memos are supposed to be a professional communication tools, not a letters to a friend. When a lab memo becomes too informal, it takes on a ‘sloppy’ feel, due to the nature of the document. As such, marks may be deducted for sloppiness/grammar if necessary.
- An INDIVIDUAL MEMO requires only your name on the top and does not require attachment of the lab participation coversheet (even if the Memo Grading Guideline says it is required; these are free marks).
- A GROUP MEMO requires both a lab participation coversheet and all group members names at the top of the memo.

Disclaimer: This is only a sample outline of a lab report. It does not reflect the actual guidelines specific to any particular lab.

Transport Phenomena Lab Report

Submitted to

Dr. Jay Anderson (Laboratory Instructor)
&
Mr. Sean Peterson (Teaching Assistant)

Prepared by

Group 5 (7:30 am Section DD)
Jane Busuttil
Anne Morley
Paul Roche
Patrick Salisbury

Engineering 181
The Ohio State University
College Of Engineering
Columbus, OH
May 05, 2003

Table of Contents

List of Figures and Tables

- List all your figures, plots, sketches, and tables here in the order that they appear in the Report. Do not forget to include the page numbers and the figure/plot/table numbers.

For example…

Executive Summary

-Summary of project purpose *and conclusions contained in the report.*

-Do not write anything else on this page.

1. Introduction

- **Introduction to the objectives and goals of the lab**
- **Introduction to contents of the report**

- The rest of the lab report should be organized depending on the experiment. Look through the Report grading guidelines for more details on what to include in each section.
- Make sure all figures, tables and plots are correctly numbered and referred to in the text of the report.
- Review Chapters 5 and 6 of **"A Guide to Writing as an Engineer "-** David Beer and David McMurrey for more details.
- Identify each sub-section with a sub-heading.

For example……

2. Lab A – Task 1- Falling Sphere Viscometer

- Discussion of Experiment results
- Worksheet A1
- Answers to Discussion Questions
- Etc...

3. Lab A – Task 2- Capillary Flow Viscometer

- …
- …

4. Lab B – Task 1- Heat Transfer Measurements

- …
- …

5. Lab B – Task 2- Vital Capacity

- …
- …

6. Conclusions

Lab Reporting Requirements
Lab Memos, Lab Reports, & Lab Worksheets

General Information

All labs in the 181 lab sequence will require some type of data collection and reporting. Credit for the labs will be based on your **attendance** and the **completion** of the reporting task associated with each lab. The purpose of this section is to outline the different types of reporting styles: memos, reports, and worksheets. You will also find a guide to formatting references. Regardless of the type of reporting, each lab has its own requirements and a point distribution guideline to help assist you in focusing your discussions. Each lab will require that all members sign a *Lab Participation Agreement*, which will count as a small portion of each of the lab assignments. Copies of this can be downloaded from WebCT.

The three kinds of documents you will be working with this quarter are- Memos, Reports and Worksheets. To assist you in writing good engineering documents, you will need to use the book A Guide to Writing as an Engineer, by David Beer and David McMurrey. Whether you are writing a report or a memo as an individual or as a team, you need to keep in mind the following key issues about writing a good engineering document. The corresponding chapter/page numbers are given alongside each of the topics.

Common issues in writing

• Using a computer	Chap. 10
• Voice / Tense	Chap. 3, pp. 52
• Formatting the content	Chap. 2
• Headings / paragraphs / margins	Chap. 2, pp 24-32
• Editing the content	Chap. 3, pp 68-68
• Writing as a group	Chap. 2, pp 33-34
• Research (Finding Information)	Chap. 7
• Giving Presentations	Chap. 8

Writing Technical content

• Including figures /sketches	Chap. 6
• Measurement units / abbreviations	Chap. 3, pp. 58-66
• Presenting lab specific issues	Chap. 6
• References	Chap. 6, pp 150-152

You will be graded based on all of the above issues. Make sure you take some time to read through the corresponding chapters before you write your first engineering document. Though the above issues are common for both memos and reports, there are a few differences in the way they are organized. Use the information in the chart above to find chapters applicable to specific issues. Information on writing memos and reports follows. You should use the Beer and McMurrey book for specific formatting and style purposes. Lab memo requirements and grading guidelines found in your course packet will serve as your guide to what content should be included.

Lab Memos [Chapter 4]

- Two words characterize a well-written memo: informative and concise.
- You will be required to write memos as an individual and as part of a team.
- If there is a pre-lab assignment, the amount of points given for completing the pre-lab assignments will be listed in the memo grading guidelines in your course packet.
- In general, memos should be 3-5 pages in length, including tables and figures.
- All memos must be typed in 10 to12 point font and double-spaced.
- Be sure to check your procedure for requirements and your grading guideline for point distribution.

The following is a list of labs for which you will need to write memos:

Individual Lab Memos	Team Lab Memos
Lab 2: Fundamental Concepts A	Lab 4: Bridge Building Competition
Lab 7: Camera Lab A (Shutter)	Lab 8: Camera Lab B (Circuits)
Lab 9: Camera Lab C	

Lab Reports [Chapters 5 & 6]

- Lab Reports are more formal and comprehensive than lab memos.
- The report must be double-spaced with a 10 to 12 point font.

The only required report in 181 is a team lab report for the Transport Phenomena Lab sequence. It covers both Transport Phenomena Lab A and Transport Phenomena Lab B. In the next course in this sequence, you will be required to write a large, comprehensive lab report that covers your entire quarter-long lab experience. The Transport Phenomena Lab report should be excellent preparation for that experience.

Worksheets

In many of the labs you will be required to fill out worksheets during lab to help you analyze data you have collected. However, in the Static & Dynamic Measurements lab, you will have no writing requirement, just the worksheets to fill out. In a case such as this, worksheets or a list of questions to answer will be provided in your lab manual. Still, be sure to include your name and section on the worksheets. There is no specific writing requirement to accompany these worksheets.

Lab Participation Agreement

Team Name:

Date:

Lab Title:

Lab Instructor:

We as a team agree to have actively contributed towards the above-mentioned lab and memo. We have used only approved materials and processes as documented in our course material. Furthermore, each team member has equally contributed to the analysis and documentation involved.

	Print Name	Signature
Team Member 1:		
Team Member 2:		
Team Member 3:		
Team Member 4:		

General Reference for Mathematical Formulae:
The Greek Alphabet

Name	Upper Case	Lower Case	Pronunciation
alpha	A	α	AL-fuh
beta	B	β	BAY-tuh
gamma	Γ	γ	GAM-uh
delta	Δ	δ	DEL-tuh
epsilon	E	ε	EP-sih-lahn
zeta	Z	ζ	ZAY-tuh
eta	H	η	AY-tuh
theta	Θ	θ	THAY-tuh
iota	I	ι	ie-OH-tuh
kappa	K	κ	KAP-uh
lambda	Λ	λ	LAM-duh
mu	M	μ	MYOO
nu	N	ν	NOO
xi	Ξ	ξ	ZIE
omicron	O	o	OH-mih-crahn
pi	Π	π	PIE
rho	P	ρ	ROE
sigma	Σ	σ	SIG-muh
tau	T	τ	TAW
upsilon	Υ	υ	OOP-sih-lahn
phi	Φ	ϕ	FIE
chi	X	χ	KIE
psi	Ψ	ψ	SIE
omega	Ω	ω	oh-MEG-uh

JD Chovan, PhD, PE

Team Agreement

Group D

- Each member of the team agrees to respect the other members of the team.
- Each person will be given the opportunity to express ideas and concepts.
- Each member needs to be responsible for attending meetings and class. If a member cannot make a meeting they are responsible to contact the members of the group.
- Each member is expected to contribute and complete a fair portion of the workload.
-
- Each member is expected to be prepared and to attempt to be on time for meetings and class.

Signatures: Charles Westenberger

Seunghyun Hong

Erin Lamb Erin Lamb

Rahul Kapoor

Page 1

Team Agreement

Group C
Lab 214
1:30 – 3:18
Engineering 182

We, the members of Group C, do hereby agree to the following for the common goal to complete our sorter machine and to receive the highest grade possible throughout the entire process of creating our machine.

- Show up to all labs on time and be alert and ready to contribute
- If a person will not be able to make it to the week's lab, they will notify at least one person a day before hand
- Meet every Wednesday at 2:30 pm at the front steps of the Main Library to work on the week's assignments
- Everyone does their fair share of the work
- One person will not do all the work; the work will be divided up evenly and fairly
- Work together cooperatively and constructively
- No destructive criticism of any ideas. Every idea is important while brainstorming
- Have faith in one another's performance; we all want to get an 'A'

Blake Betz

Blake Betz

Jacqueline D Teasley

Jacqueline Teasley

Craig Kleinhenz

Craig Kleinhenz

Keith Norman

Keith Norman

Engineering 181
Lab 1: Team Building Workshop

"Coming together is a beginning;
Keeping together is progress;
Working together is success."
Henry Ford

Workshop Goals

- To provide students with an overview of various types of teams;
- To reflect and discuss models for decision making;
- To give students a chance to practice teamwork skills.
- To evaluate learning styles.

Enhancing Team Performance

Team Performance = (Individual Performance + Assembly Effect) - Process Losses

Individual Performance

- Each member of a group brings knowledge, skills, and a psychological set.
- The collective knowledge and skills represent the resource base that acts as a constraint on group effectiveness.

Assembly Effect

This phenomenon is based on the notion that positive things can happen when people interact.
Examples:

- Synergy is experienced when the whole is greater than the sum of the parts.
- High interdependence can yield high synergy effect
- Plusses
    - Not being defensive
    - Present Views logically
    - Be willing to listen

Process Loss

These are team dynamics that reduce the effectiveness of the team. Examples:

- Group think
- Social loafing
- Free-riding

The primary goal: to minimize process loss.

Team Working Agreements

(reference: Smith, Chapter 2)

- A Team Working Agreement is list of <u>expectations</u> each team has for its members.
- These team agreements should be designed with <u>your team</u> in mind.
- The agreement is effectively a <u>contract</u> you sign with all members.
- You will be expected to abide by that contract.
- Tailor your agreement to meet the specific needs of your members.
- All members need to be accountable for the statements in the agreement

- Each member of your group needs to have input.
- The agreement is a chance for all members to voice their opinion on the importance of potential problems.

- Creating Your Agreement
  - Brainstorm in your group and record all possibilities for your agreement
  - Compile all your ideas and write concise statements on your ideals and expectations.
  - Work Together!!

- Sample Statements
  - Show up to all team meetings on time; always let others know of time conflicts ahead of time.
  - Respect other members. Criticize ideas, not people. Don't take constructive criticism personally.
  - Let all members participate and share the workload evenly.
  - Take <u>responsibility</u> for your actions, ideas, and words.
  - Avoid distractions and keep meetings on topic, and on time.
  - Have fun and reward the team for positive ideas!
  - Always be prepared to work the full time allotted for meetings.

- Possible Issues to Address
  - Effective communication method
  - Participation by all members
  - Decision-making
  - Problem solving approaches
  - Management of conflict or differences
  - Responsibilities and conduct

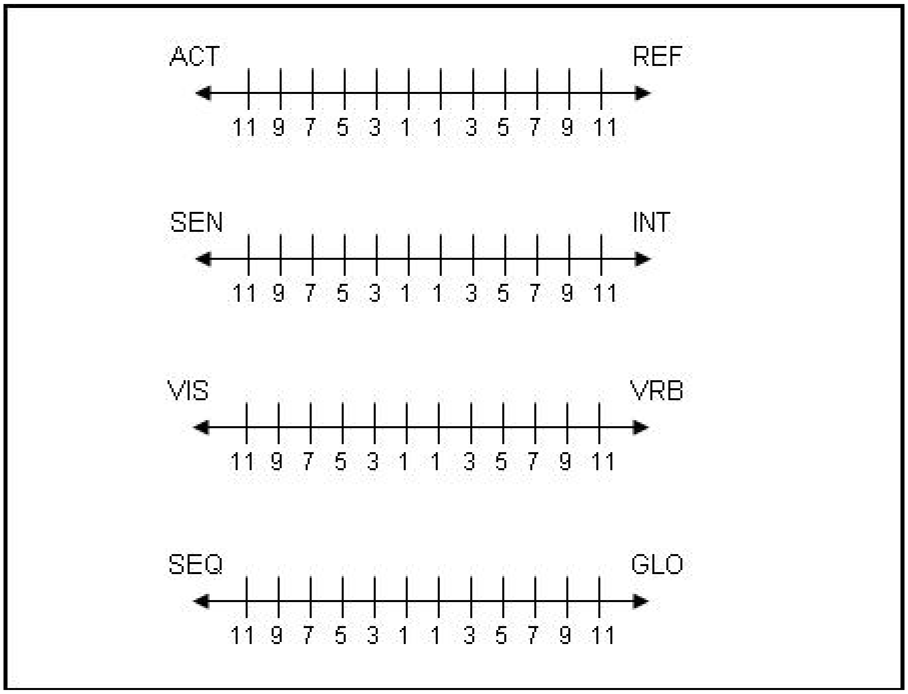
- Statements to Build Team Performance
  - **Do** establish urgency and direction.
  - **Do** pay close attention at all meetings.
  - **Do** set clear rules of behavior.
  - **Do** set performance-oriented goals.
  - **Don't** accept the first solution to a problem.
  - **Don't** avoid conflicts.
  - **Don't** criticize team members.
  - **Don't** let issues get personal.

Reminder:
In Basics 3 and 4, we will be studying Microsoft Excel. The instructional team has made the assumption that you are familiar with spreadsheets and how to use them in a general fashion. If you feel as though you need more instruction on Excel prior to these lectures, please visit the following website for tutorials and practice: http://www.usd.edu/trio/tut/excel

Learning Styles Index

- We would like to understand more about your learning styles as students and
- We would like you to understand more about teaching and learning styles.
- The following inventory is directed to this end.

- Completing the Index
    - Log into WebCT. Go To Course Tools. Click on the link marked, Learning Styles Inventory.
    - Complete Inventory and Submit – Please put Seat Number with name
    - Print Results
    - Record your results below and give your GTA or peer mentor your print out



- Evaluating Your Results
    - What is measured is preference, NOT competence
    - Better understanding of how you learn can help regardless of the teacher's style
    - Understanding your preference and that of others may help in teamwork and engineering practice
    - The following article further describes the learning styles measured in this exercise.

LEARNING STYLES AND STRATEGIES

Richard M. Felder
Hoechst Celanese Professor of Chemical Engineering
North Carolina State University

Barbara A. Soloman
Coordinator of Advising, First Year College
North Carolina State University

ACTIVE AND REFLECTIVE LEARNERS

- Active learners tend to retain and understand information best by doing something active with it--discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first.
- "Let's try it out and see how it works" is an active learner's phrase; "Let's think it through first" is the reflective learner's response.
- Active learners tend to like group work more than reflective learners, who prefer working alone.
- Sitting through lectures without getting to do anything physical but take notes is hard for both learning types, but particularly hard for active learners.

Everybody is active sometimes and reflective sometimes. Your preference for one category or the other may be strong, moderate, or mild. A balance of the two is desirable. If you always act before reflecting you can jump into things prematurely and get into trouble, while if you spend too much time reflecting you may never get anything done.

How can active learners help themselves?

If you are an active learner in a class that allows little or no class time for discussion or problem-solving activities, you should try to compensate for these lacks when you study. Study in a group in which the members take turns explaining different topics to each other. Work with others to guess what you will be asked on the next test and figure out how you will answer. You will always retain information better if you find ways to do something with it.

How can reflective learners help themselves?

If you are a reflective learner in a class that allows little or not class time for thinking about new information, you should try to compensate for this lack when you study. Don't simply read or memorize the material; stop periodically to review what you have read and to think of possible questions or applications. You might find it helpful to write short summaries of readings or class notes in your own words. Doing so may take extra time but will enable you to retain the material more effectively.

SENSING AND INTUITIVE LEARNERS

- Sensing learners tend to like learning facts, intuitive learners often prefer discovering possibilities and relationships.
- Sensors often like solving problems by well-established methods and dislike complications and surprises; intuitors like innovation and dislike repetition. Sensors are

more likely than intuitors to resent being tested on material that has not been explicitly covered in class.

- Sensors tend to be patient with details and good at memorizing facts and doing hands-on (laboratory) work; intuitors may be better at grasping new concepts and are often more comfortable than sensors with abstractions and mathematical formulations.
- Sensors tend to be more practical and careful than intuitors; intuitors tend to work faster and to be more innovative than sensors.
- Sensors don't like courses that have no apparent connection to the real world; intuitors don't like "plug-and-chug" courses that involve a lot of memorization and routine calculations.

Everybody is sensing sometimes and intuitive sometimes. Your preference for one or the other may be strong, moderate, or mild. To be effective as a learner and problem solver, you need to be able to function both ways. If you overemphasize intuition, you may miss important details or make careless mistakes in calculations or hands-on work; if you overemphasize sensing, you may rely too much on memorization and familiar methods and not concentrate enough on understanding and innovative thinking.

How can sensing learners help themselves?

Sensors remember and understand information best if they can see how it connects to the real world. If you are in a class where most of the material is abstract and theoretical, you may have difficulty. Ask your instructor for specific examples of concepts and procedures, and find out how the concepts apply in practice. If the teacher does not provide enough specifics, try to find some in your course text or other references or by brainstorming with friends or classmates.

How can intuitive learners help themselves?

Many college lecture classes are aimed at intuitors. However, if you are an intuitor and you happen to be in a class that deals primarily with memorization and rote substitution in formulas, you may have trouble with boredom. Ask your instructor for interpretations or theories that link the facts, or try to find the connections yourself. You may also be prone to careless mistakes on test because you are impatient with details and don't like repetition (as in checking your completed solutions). Take time to read the entire question before you start answering and be sure to check your results

VISUAL AND VERBAL LEARNERS

Visual learners remember best what they see--pictures, diagrams, flow charts, time lines, films, and demonstrations. Verbal learners get more out of words--written and spoken explanations. Everyone learns more when information is presented both visually and verbally.

In most college classes very little visual information is presented: students mainly listen to lectures and read material written on chalkboards and in textbooks and handouts. Unfortunately, most people are visual learners, which means that most students do not get nearly as much as they would if more visual presentation were used in class. Good learners are capable of processing information presented either visually or verbally.

How can visual learners help themselves?

If you are a visual learner, try to find diagrams, sketches, schematics, photographs, flow charts, or any other visual representation of course material that is predominantly verbal. Ask your instructor, consult reference books, and see if any videotapes or CD-ROM displays of the course material are available. Prepare a concept map by listing key points, enclosing them in boxes or circles, and drawing lines with arrows between concepts to show connections. Color-code your notes with a highlighter so that everything relating to one topic is the same color.

How can verbal learners help themselves?

Write summaries or outlines of course material in your own words. Working in groups can be particularly effective: you gain understanding of material by hearing classmates' explanations and you learn even more when you do the explaining.

SEQUENTIAL AND GLOBAL LEARNERS

- Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it."
- Sequential learners tend to follow logical stepwise paths in finding solutions; global learners may be able to solve complex problems quickly or put things together in novel ways once they have grasped the big picture, but they may have difficulty explaining how they did it.

Many people who read this description may conclude incorrectly that they are global, since everyone has experienced bewilderment followed by a sudden flash of understanding. What makes you global or not is what happens before the light bulb goes on. Sequential learners may not fully understand the material but they can nevertheless do something with it (like solve the homework problems or pass the test) since the pieces they have absorbed are logically connected. Strongly global learners who lack good sequential thinking abilities, on the other hand, may have serious difficulties until they have the big picture. Even after they have it, they may be fuzzy about the details of the subject, while sequential learners may know a lot about specific aspects of a subject but may have trouble relating them to different aspects of the same subject or to different subjects.

How can sequential learners help themselves?

Most college courses are taught in a sequential manner. However, if you are a sequential learner and you have an instructor who jumps around from topic to topic or skips steps, you may have difficulty following and remembering. Ask the instructor to fill in the skipped steps, or fill them in yourself by consulting references. When you are studying, take the time to outline the lecture material for yourself in logical order. In the long run doing so will save you time. You might also try to strengthen your global thinking skills by relating each new topic you study to things you already know. The more you can do so, the deeper your understanding of the topic is likely to be.

How can global learners help themselves?

If you are a global learner, it can be helpful for you to realize that you need the big picture of a subject before you can master details. If your instructor plunges directly into new topics without bothering to explain how they relate to what you already know, it can cause problems for you.

Fortunately, there are steps you can take that may help you get the big picture more rapidly. Before you begin to study the first section of a chapter in a text, skim through the entire chapter to get an overview. Doing so may be time-consuming initially but it may save you from going over and over individual parts later. Instead of spending a short time on every subject every night, you might find it more productive to immerse yourself in individual subjects for large blocks. Try to relate the subject to things you already know, either by asking the instructor to help you see connections or by consulting references. Above all, don't lose faith in yourself; you will eventually understand the new material, and once you do your understanding of how it connects to other topics and disciplines may enable you to apply it in ways that most sequential thinkers would never dream of.

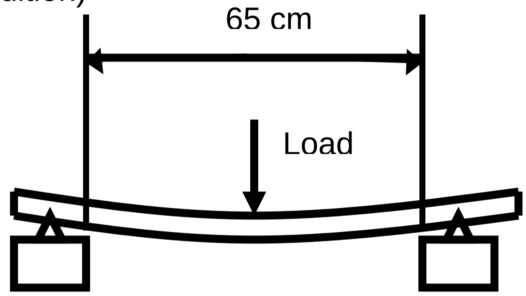
For more information on learning styles and teaching styles, please visit:

http://www2.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/styles.htm

Simply Supported Beams (Exercise)

"The beam, or flexural member, is frequently encountered in structures and machines, and its elementary stress analysis constitutes one of the more interesting facets of mechanics of materials. A beam is a member subjected to loads applied transverse to the long dimension, causing the member to bend." (Higdon, et al., Mechanics of Materials, 2nd Edition)

Simply Supported Beam with Center Load



Preliminary Step – Assigning Principal Roles

Making sure not to repeat roles from previous exercises, decide and record who will take responsibility for each of the following roles during this exercise.

Facilitator ____________________
(makes sure all members have chance to participate)

Recorder __________________________
(makes a written records)

Referee __________________________
(keeps the discussion directed)

Standards Expert __________________________
(unique to this exercise makes sure all specifications are met)

On the following page you will be given a problem description. Please note the constraints and specifications carefully. You will have approximately **ten minutes** as a team to create a solution to the problem. It is recommended that as a team you follow good problem solving techniques, such as:

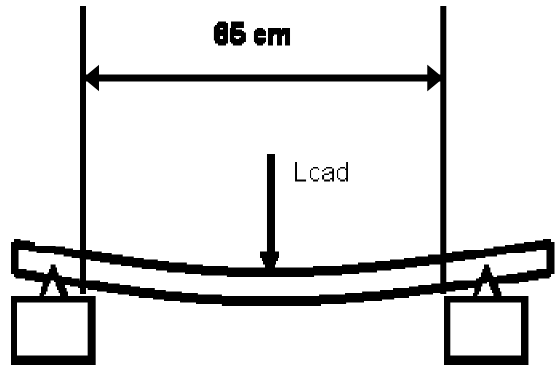
1. Make sure the problem is clearly understood;
2. Brainstorm/idea generation;
3. Implement the design;
4. "Test" the idea; and
5. Repeat each step as needed.

DO NOT TURN THE PAGE OVER UNTIL INSTRUCTED TO DO SO!

Simply Supported Beams
Exercise Handout

You are to design and build a structure with the ability to hold the weight provided given only the following materials:

1. Two sheets of newsprint
2. One file label or one piece of tape
3. Two plastic cups



Note: 65 cm is from inside edge of cup to inside edge of

You must abide by the following conditions:

1. All group members must participate in the exercise.
2. The file label, or piece of tape, can only be used to bind or reinforce the newsprint, but may NOT be used to attach the paper to the supports (cups).
3. The weight must be suspended in the middle of the beam only.

Your final design must meet the following requirements:

1. It must be able to suspend the weight given to you.
2. The free span must be at least 65 centimeters.

Procedure

Goals:

This week in the laboratory you will perform a bending test on a series of materials of different shapes. This test will allow you to compare different materials and shapes by measuring the deflection using a cantilever beam.

The objectives for the bending tests are as follows:

- To make measurements for cantilever beam bending.
- To compute the deflection of different materials and shapes.
- To understand how engineers compare different materials.
- To understand why cross-sectional shape is important in design.

Background:

Bending of a Cantilever Beam

The deflection of the beam depends on:

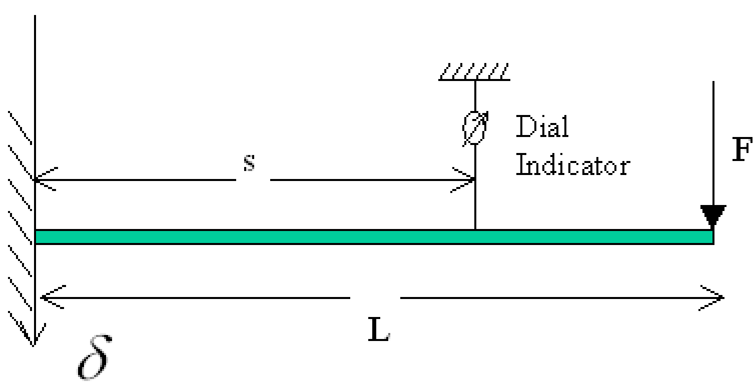
- The load. More deflection with larger load.
- The length of the beam. The deflection increases with the length.
- Material stiffness. Higher stiffness produces less deflection.
- The geometry of the cross section. Higher moment of inertia results in less deflection.

Bending Tests:

In the lab, three cantilever beams will be set up in order to compare their deflection. Two of the beams have the same cross section geometry (rectangle), but one is made of steel and the other is made of aluminum. The third beam is made up of aluminum with a smaller cross sectional area than the first two beams, but with a box cross-section.

To do the bending tests, you will clamp the beams to the bench top and measure deflection while you apply known loads. By clamping the beam to the bench you are creating a cantilever beam. You will use a dial indicator to measure the deflection.

The third beam is made of aluminum and has a lesser amount of material in its cross-sectional area than the two solid beams, and has a box cross-section.



Theoretically, the deflection of the beam at the location of the dial indicator is given by

$$\delta = -\frac{Fs^2}{6EI}(3L - s)$$ *

where:
L = distance to load
s = distance to dial indicator
F = load
d = deflection
E = elasticity (Young's) modulus
I = moment of inertia of the cross section

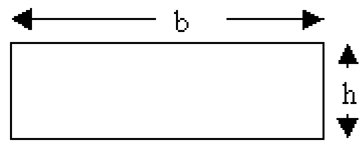
* The negative sign represents the direction of bending (i.e. bending in the downward direction). You may neglect it in your comparison with the Experimental Deflection. Hence, both your Experimental and Theoretical deflections will be POSITIVE values.

Moment of Inertia

1*. Rectangular:*

The formula for the moment of inertia for a rectangle cross section is

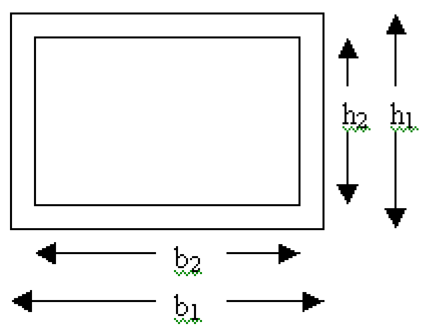
$I = b_1\, h_1^3/12$



2. Box:

The formula for the moment of inertia for a bar with a box cross section is

$I = b_1\, h_1^3/12 - b_2\, h_2^3/12$



Lab Experience

Material Bending Tests

1. For each of the three beams (steel rectangular, aluminum rectangular, and aluminum box)
2. Clamp beam and position the dial indicator such that L = 12.5 in. and s = 11.5 in.
3. Load (by placing 2.5 lb. weights in the bucket) incrementally up to F_{max} = 12.5 lbs.
4. Record the deflection (d) for each load using given tables.
5. Measure the beam's cross-section dimensions and calculate moment of inertia *I*.
6. Record all measurements and calculations using tables provided.

Worksheet A

	Modulus of Elasticity E (psi)	Width, *b* (in.)	Height, *h* (in.)	Wall Thickness (in.)	Moment Of Inertia I (in^4)
Steel Beam	$29x10^6$			N.A	
Aluminum Beam	$10.1x10^6$			N.A	
Aluminum Box	$10.1x10^6$				

Steel Rectangular -

Load F (lbs)	0	2.5	5	7.5	10	12.5
Deflection Experimental δe (in)						
Deflection Theorectical δt (in)						

Aluminum Rectangular -

Load F (lbs)	0	2.5	5	7.5	10	12.5
Deflection Experimental δe (in)						
Deflection Theorectical δt (in)						

Aluminum Box -

Load F (lbs)	0	2.5	5	7.5	10	12.5
Deflection Experimental δe (in)						
Deflection Theorectical δt (in)						

Requirements for Lab Memo

For this lab, the memo will be written *individually* and should be in the *standard memo format* addressed to the instructor. An example of a *standard memo format* is provided in your course packet. Follow the guidelines given below for preparing the lab memo. Organize the memo content in the same order as below.

Beam Bending Memo Guidelines:

Content	Point Value	Points Received
Header Information	**5 pts (for header and memo format)**	
Acknowledgement*	**5 pts**	
Introductory Paragraph	**10 pts**	
1. Objectives/Goals of the Labs	8	
2. Brief Description of Contents of the memo	2	
Results:	**50 pts**	
1. For each beam, use Excel to create a scatter plot to graph – a. Theoretical & Experimental data vs. Load (F) for $0<F<F_{max}$. b. Add a linear trend line for the Experimental and Theoretical data. c. Show the equations for the Theoretical data.	 5pts/graph 5 5	
2. Create a scatter plot of Experimental data vs. Load for all three beams on ONE graph.	5	
3. Include *sample calculations*** for the following: • moment of inertia for one beam type • theoretical beam deflection for one beam type for 5 pound load.	10	
4. Attach Worksheet A to the memo. Attach the Excel spreadsheet to the memo.	10	
Discussion	**20 pts**	
1. Compare the theoretical deflections with the measured deflections. Explain differences that exist.	10	
2. Given the same three beams, which one would you use to design and build an object that incurs high stress. Explain your answer.	10	
Conclusion	**10 pts**	
1. State conclusions regarding the effects of cross section and material used in beams.	8	
2. Describe difficulties in performing the lab procedure and improvements to the lab, if any.	2	

Note : The GRADING NOTES below apply to ALL memos/reports for the quarter.

Expectations

- All memos should be considered as business communication tools between yourself and the instructor (manager, in a professional setting).
- Worksheets should be attached with the memo.
- Neat sketches, with title and detailed labeling should be attached with the memo.
- Sketches and plots may be embedded in the text of the memo. Otherwise they must be at the end.
- Follow standard memo organization that provides good information flow, like the one detailed above.

Point Deduction

- Spelling and grammar – 0.5 for each error (max. of 5 points).
- Untidy sketches – 2 to 4 points each. (max. of 10 points).
- Sketches without labeling/details/title – 2 points each (max. of 6 points).
- Insufficient or wrong explanation to questions posed – Insufficient explanation or partial explanation – half credit; wrong answer – take off full points.

****Acknowledgement*** – This section is a declaration that **you** are responsible for the preparation of this memo. In addition, you must acknowledge the participation of all team members who contributed to the lab activities.
****Sample Calculations-*** Show correct formulae and substitute appropriate values to calculate the final result.

Fundamental Concepts B:
Static & Dynamic Measurements

Goals
Part A
The goal in this part is to find a correlation between the weight of the bicycle rider and the stress/strain due to bending in the front fork in a static condition.

Part B
The goal in this part is to observe the stress conditions in the front forks of your bicycle under actual field conditions, and to make judgments about the adequacy of the fork design.

General Information

This lab requires the use of a data logger. The data logger is an electronic device that collects and saves voltage information on up to four different input channels. The logger is currently configured to accept voltages within the range of –5 to +5 volts, but can also accept input from certain special sensors that are of no concern here. *The data logger has its own internal power source and is continuously powered ON*. Its power source can last up to two years under normal use.

The data logger may be installed in a 'Black Box'. The box has two switches, a mini-jack, and a 9-pin connector. The switch marked *'BATT' controls only the power to whatever is plugged into the 9-pin connector* (generally strain gages on a bicycle, in the OSU case). Because the strain gages can quickly drain the battery, **the BATT switch should be OFF at all times other than when data is actually being collected or observed**. The switch marked LOGGER controls only the start (ON) and stop (OFF) of data collection. *Communications between the PC and the data logger can be performed with both BATT and LOGGER switches OFF*. However, *valid data* is obtained from the strain gages only when the 'BATT' switch is ON. Finally, the mini-jack is used to communicate with the PC via a black cable with a mating end.

Lab Procedure

NOTE: For details of any data logger function, see the *separate "XR-440 Data Logger Reference Guide".* Also, either Part A or Part B can be performed first.

Part A

Collect voltage data from strain gages using a data logger while each team member in turn is sitting and then riding a bike mounted in a training stand.

Use the following sequence for each trial (all times are approximate). **(Note: *Riding position* is defined as feet motionless on the pedals, and hands in normal position on the handle bar)**.

1. **Insure** the bicycle is properly mounted in a training stand, **toggle** the LOGGER switch ON then OFF (to put the data logger in idle mode), **insure** that **both toggle switches** on the Black Box are **OFF**, and that the Box is **connected** to the PC via the black cable. *The black cable must be routed through the FRONT*

of the bicycle so as to minimize the chance of catching the cable by a rider's foot while pedaling.

2. **Record the weight of each team member.**
   Name   Weight (lbs)

   _______________   __________

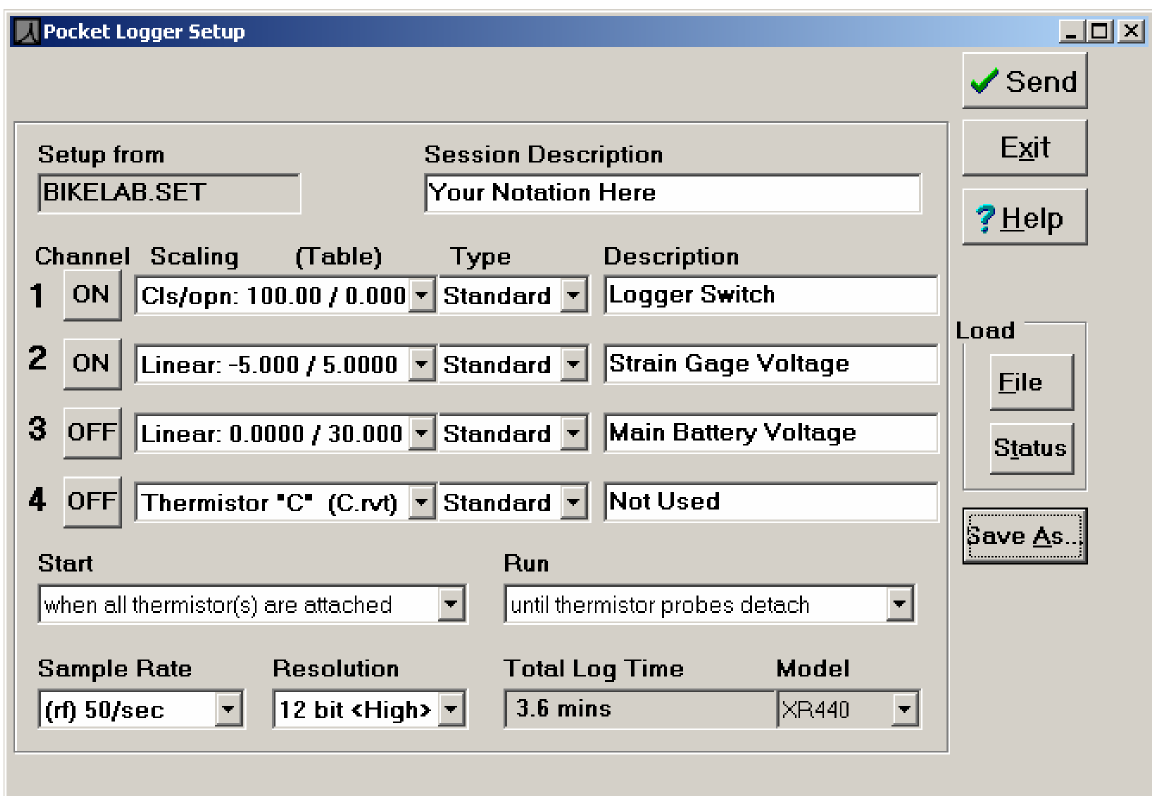
   _______________   __________

   _______________   __________

   _______________   __________

3. **Start** the **Pocket Logger Software Application** and **setup the data logger** by performing the following steps:

   a. **Click on** the '**Send**' menu selection.
   b. **Click on** '**Setup**' .
   c. **Click on** the '**File**' button in the 'Load' area of the screen window.
   d. **Select** the **file 'BIKELAB.SET'** found via **C:\Program Files\PSLOG** and **open it**. The screen dialog should look like the following:



4. **Enter** a pertinent **Session Description** in the appropriate box.

5. **Click** on the **'Send'** **<u>button</u>** (upper right hand corner of dialog box) and **click OK** for **each resultant dialog**. If another dialog about saving changes appears answer in the negative, that is do NOT save.
6. **Then click** the '**Exit**' **<u>button</u>**.
7. Now **Flip** the **BATT switch** to **ON.**
8. **Wait** about one minute and get each rider ready.
9. **Flip** the **LOGGER switch** to **ON**.
10. **Use the following sequence** for each team member (all times are approximate and <u>LEAVE THE LOGGER SWITCH ON until all team members have ridden</u>):

    - 5 seconds for an unloaded bike.
    - 5-10 seconds for rider 1 in riding position (no pedaling).
    - 15 seconds for rider 1 pedaling
    - 5 seconds for unloaded bike.
    - 5-10 seconds for rider 2 in riding position (no pedaling).
    - 15 seconds for rider 2 pedaling.
    - **Repeat** (for remaining team members but do not exceed 3 minutes total data collection time, i.e., the time the LOGGER switch is ON, or the data will be lost).

11. **Once all riders are finished, <u>and with no rider on the bike</u>, wait 5 seconds** then **Flip** the **LOGGER** switch to **OFF**.
12. **Flip** the **BATT** switch to **OFF**.
13. **Upload** the data from the data logger to the PC by the following:
    a. **Click** on '**Receive**' menu bar selection, and then on '**Data**'.
    b. **Select** the floppy or Zip drive, enter a file name of meaning to you, click the '**Save**' button and **wait** for the data to be transmitted (this file is a .PL1 file and is special to this application). A dialog box will eventually pop up…**click** the '**Yes**' button and a graph should appear.
14. **Export** the data to a floppy or Zip disk as a .csv (i.e., comma separated values) file. Export the data to other team member's disks as necessary. (Note: The data may be exported multiple times from the Graph window *without another upload*).
    To Export:
    a. **Click** '**File**' then '**Export**' from the <u>menu bar in the graph window</u> .
    b. File type should be **ASCII**, then **click** the **OK button**.
    c. **Insure Type** selection here is '**Comma Separated Values**' and that **Data** selection is '**All Points**'.
    d. **Click** in the '**Save as**' box and **select** an appropriate drive and enter a file name (name extension will be added automatically).
    e. **Click** the '**Save**' button and **verify** the path/file shown in the 'Save as' box. Then **click** the **OK** button.
    f. Another dialog box should appear…**click OK**.

    The data has now been exported for use in Excel or other application.

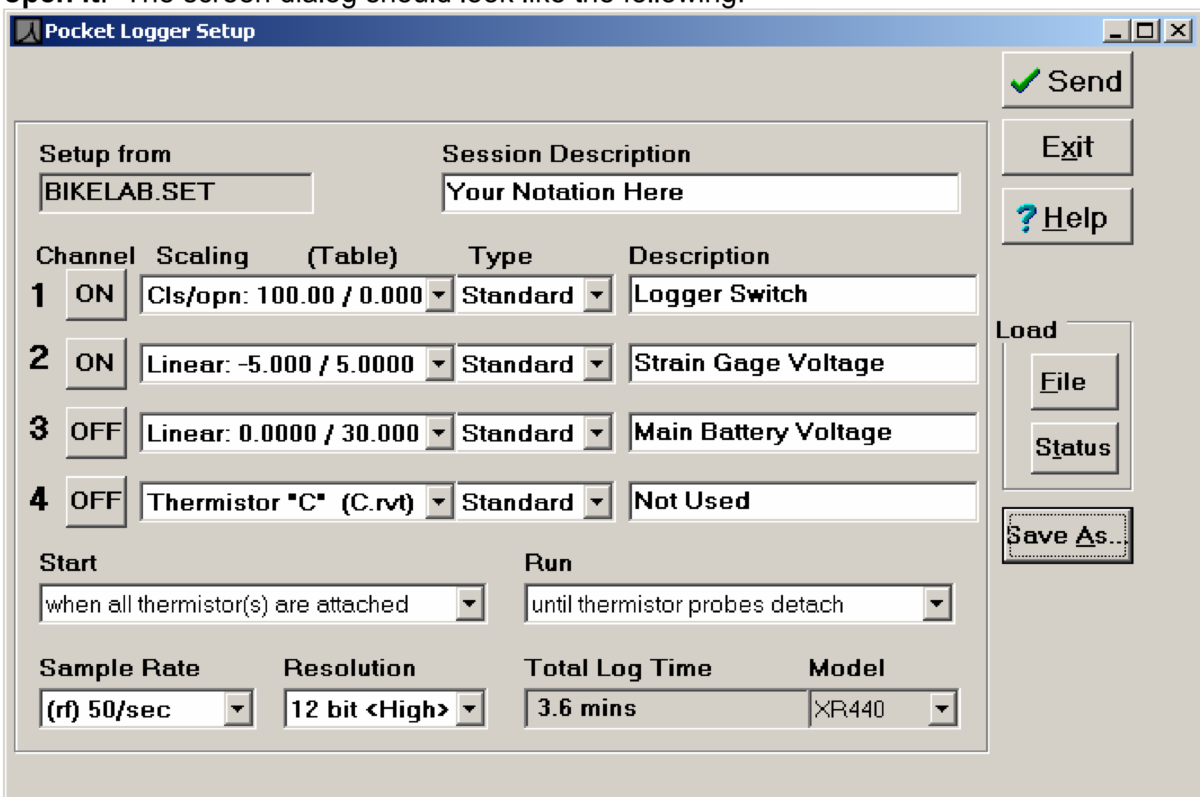
15. **Start up** Excel, **Open** the .csv file to **insure** the file is readable and that the data is there. (Note: In order to see the .csv file, you must set the file selection in Excel to be .csv type or 'All Files').

Part B

Two riders <u>with noticeably different weights</u> will ride the bikes outdoors.

1. **Flip** the LOGGER switch to ON, **wait** 2 seconds, then **flip** it OFF.
2. **Start** the **Pocket Logger Software Application** and **setup the data logger** by performing the following steps:

   a. **Click on** the ‘**Send**’ menu selection.
   b. **Click on** ‘**Setup**’ .
   c. **Click on** the ‘**File**’ button in the <u>Load area</u> of the screen window.
   d. **Select** the **file ‘BIKELAB.SET’** found via **C:\Program Files\PSLOG** and **open it**. The screen dialog should look like the following:



3. **Enter** a pertinent **Session Description** in the appropriate box.
4. **Click** on the **‘Send’ <u>button</u>** (upper right hand corner of dialog box) and **click OK** for **each resultant dialog**. **Then click** the ‘**Exit**’ **<u>button</u>**.
5. **Toggle** the **LOGGER** switch **ON** then **OFF** to put the data logger in idle mode.
6. **Flip** the BATT switch ON.
7. **View data** from the data logger ‘as it happens’ (this is called ‘real time data’) by **clicking on** “Receive” then “Real Time” from the menu bar. Be aware that in this mode the data logger updates the readout every 2 seconds only!
8. **Manually record** the strain gage voltage signal (channel 2) for the *<u>unloaded bike</u>*. If the readout is varying, visually average to get a single value.

   Initial signal = _________ volts

9. Have *each rider sit in riding position* on the bike and **manually record** the respective weight and strain gage voltage signal.

Rider 1:
weight = ______ lbs., signal = _____ volts

Rider 2:
weight = ______ lbs., signal = _____ volts

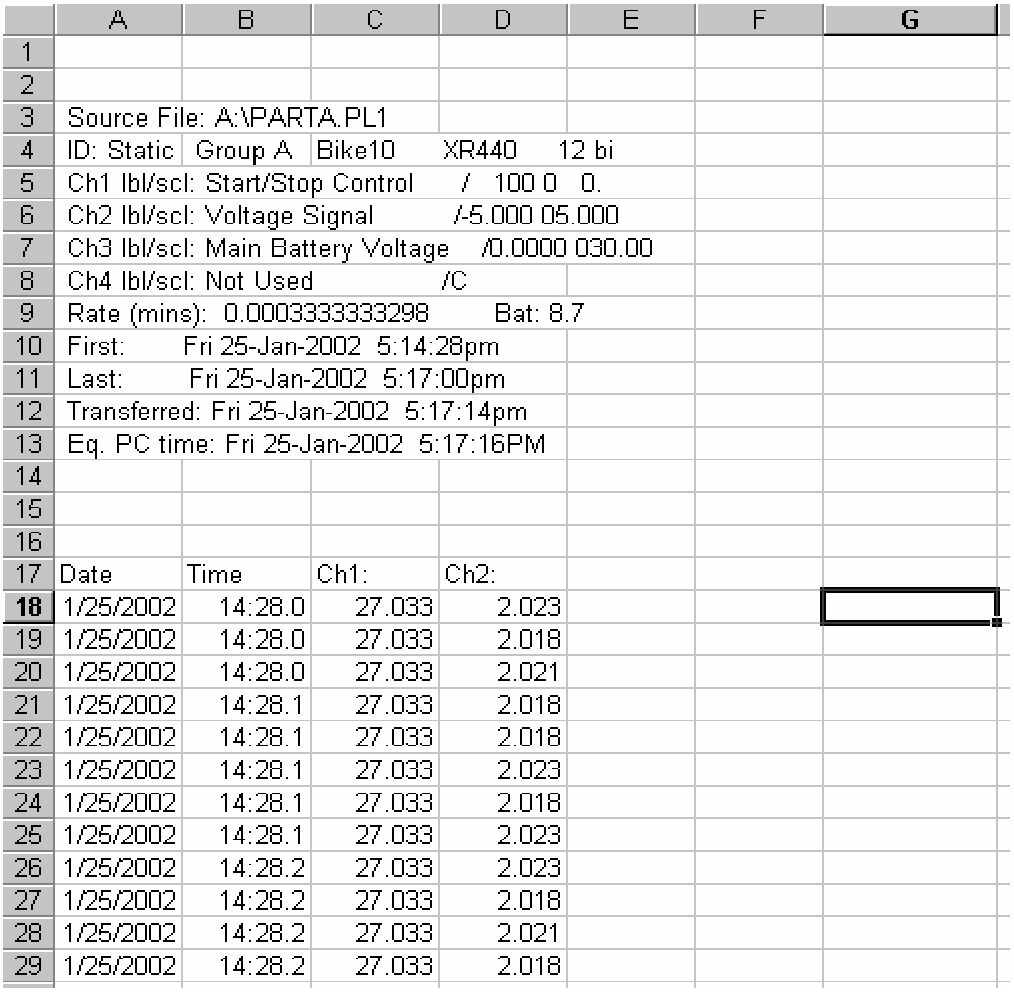
10. **Flip** the BATT switch OFF.
11. **Click on** “Ok” to close the real time window.
12. **Repeat steps 2 though 4 only** (to re-setup the data logger).
13. ***By holding the small connector plug body*, *Carefully Disconnect*** the black cable from the Black Box.
14. ***Carefully Remove*** the bicycle from the training stand, and **take** the bicycle and a helmet **outside.** When it is about your team’s turn to test, have the **first rider don the helmet,** and **flip** the BATT switch ON. When ready to test, **flip** the LOGGER switch ON and with bike unloaded, **wait** 5 seconds. Then have the **first rider proceed** to ride for no more than 45 seconds. *Leave the bike **sit unloaded*** between riders for a few seconds while the **second rider dons the helmet**. That few seconds of data will allow one to know when riders were changed. Have the **second rider proceed** for no more than 45 seconds. Have the **second rider get off the bike** and **let the bike stand unloaded** for 5 seconds. Now **FLIP** THE **LOGGER SWITCH** OFF and **THEN FLIP** THE **BATT SWITCH** OFF.
15. **Bring the bike back** to the lab. **Replace** the bike into the training stand and tighten the retaining screws only until the bike is stable in the stand.
16. **Reconnect** the black cable from the PC to the Black Box mini-jack, and **Upload** your data from the data logger to the PC. **Use Part A steps 12 through 14 to accomplish this**. (**Note**: **Insure** Part A file names are different from Part B filenames !!).
17. **INSURE both BATT and LOGGER switches are OFF.**

After Lab

During the lab, the data logger was used to collect bike strain gauge data for static and dynamic loading conditions. The data was initially stored in .pl1 format and later was exported from the graph to be stored in .csv format (comma separated value) on the ZIP/ Floppy disk. Use the following steps for data reduction and necessary computation required for Bike Lab Part A and Part B.

1. Open your “comma separated value” (.csv) file in Excel. Excel will recognize .csv files; however, to see the file name in the open file dialog, you will need to tell the dialog to show “all files” or to show .csv type files and certain others.

2. Once the .csv file is open you can see that it will have four basic data columns: Date, Time, Ch1:, Ch2:. The number of records (rows of data) varies depending upon actual test conditions, but is generally more than 5000 records. The Fig 1 shows the first part of a sample data file for Bike Lab Part A:



	A	B	C	D	E	F	G
1							
2							
3	Source File: A:\PARTA.PL1						
4	ID: Static	Group A	Bike10	XR440	12 bi		
5	Ch1 lbl/scl: Start/Stop Control / 100 0 0.						
6	Ch2 lbl/scl: Voltage Signal /-5.000 05.000						
7	Ch3 lbl/scl: Main Battery Voltage /0.0000 030.00						
8	Ch4 lbl/scl: Not Used /C						
9	Rate (mins): 0.0003333333298 Bat: 8.7						
10	First: Fri 25-Jan-2002 5:14:28pm						
11	Last: Fri 25-Jan-2002 5:17:00pm						
12	Transferred: Fri 25-Jan-2002 5:17:14pm						
13	Eq. PC time: Fri 25-Jan-2002 5:17:16PM						
14							
15							
16							
17	Date	Time	Ch1:	Ch2:			
18	1/25/2002	14:28.0	27.033	2.023			
19	1/25/2002	14:28.0	27.033	2.018			
20	1/25/2002	14:28.0	27.033	2.021			
21	1/25/2002	14:28.1	27.033	2.018			
22	1/25/2002	14:28.1	27.033	2.018			
23	1/25/2002	14:28.1	27.033	2.023			
24	1/25/2002	14:28.1	27.033	2.018			
25	1/25/2002	14:28.1	27.033	2.023			
26	1/25/2002	14:28.2	27.033	2.023			
27	1/25/2002	14:28.2	27.033	2.018			
28	1/25/2002	14:28.2	27.033	2.021			
29	1/25/2002	14:28.2	27.033	2.018			

Fig 1: Screen shot of Sample data file for Bike lab Part A

3. Once your data is in Excel, add another column for Time, adjacent to the existing columns. In the Time column insert data starting at zero and incrementing the time in each successive cell by the increment, which corresponds to your sampling rate, e.g. 0.02 seconds if the sample rate was 50 per second. To do this fill in value 0.00 and 0.02 in the first two rows of the time column. Then highlight these two values in the time column. Take the cursor to the bottom right of the highlighted cells (The cursor will turn to a Plus sign) and double click. With the above action Excel™ will automatically fill values with increment of 0.02 in all the cells corresponding to values in Ch2 column. Refer Fig 2(next page).

16								
17	Date	Time	Ch1:	Ch2:	Time Sec.	Δ Vout	Strain	Stress(psi)
18	1/25/2002	14:28.0	27.033	2.023	0.00			
19	1/25/2002	14:28.0	27.033	2.018	0.02			
20	1/25/2002	14:28.0	27.033	2.021				
21	1/25/2002	14:28.1	27.033	2.018				

Fig 2.

4. Add another column titled ΔV_{out}. The values in the ΔV_{out} column are obtained by subtracting a no load voltage reading from all reading in Ch2 column.

   ΔV_{out} = Ch2 – (No-load-Voltage)

   The no-load-voltage reading is an average of all the readings in Ch2 from the first record to the point after which we see obvious variations in Ch2 reading.
   Do not include the value with good enough variation in the average.

5. Add a column titled Strain as seen in Fig2 .The values in Strain column are obtained by solving the equation given below for strain (ε). The change in the output voltage from the Wheatstone Bridge is related to the strain of the strain gage by:

$$\Delta V_{out} = V_{in} \cdot A \cdot S_g \cdot \varepsilon$$

where:

$V_{in} = 5.0$ *Volts* — ε *is the strain*

$A = 500$ *(amplification)* — ΔV_{out} *is the change in the voltage*

$S_g = 2.085$ (*gagefactor*)

Note that ΔVout is the voltage_read minus the 'voltage_with_no_load_on_the_bike' as calculated in step 4 above.

6. Add a column titled Stress as seen in Fig 2. The values in the Stress column are obtained using the Hooke's Law equation and theoretical modulus as given below. The stress (σ) in the fork can be calculated from the strain (ε), by using Hooke's law:

$$\sigma = E\varepsilon$$

Where E is the Modulus of Elasticity
For the bike fork (steel) E = 29.0 x 10^6 psi (pounds force per square inch).

Fig. 3(next page) is an example of computation worksheet with all the above steps completed.

16											
17	**Date**	**Time**	**Ch1:**	**Ch2:**	**Time Sec.**	**V out**	**Strain**	**Stress psi**		Rider Weight	Avg. Strees
18	1/25/2002	14:28.0	27.033	2.023	0.00	0.005	9.59E-07	28		140	1600
19	1/25/2002	14:28.0	27.033	2.018	0.02	0.000	0.00E+00	0		153	1750
20	1/25/2002	14:28.0	27.033	2.021	0.04	0.003	5.76E-07	17		160	1900
21	1/25/2002	14:28.1	27.033	2.018	0.06	0.000	0.00E+00	0		200	2250
22	1/25/2002	14:28.1	27.033	2.018	0.08	0.000	0.00E+00	0			
23	1/25/2002	14:28.1	27.033	2.023	0.10	0.005	9.59E-07	28			

Fig 3.

Graphs for Part A

1. **Create** a scatter plot chart of the Delta voltage (V_{out}) data vs. time and identify each event on the chart, i.e. unloaded bike, rider 1 gets on, rider 1 sits on bike, rider 1 pedals bike, etc by writing or using Excel text functions. Refer example in Fig 4.

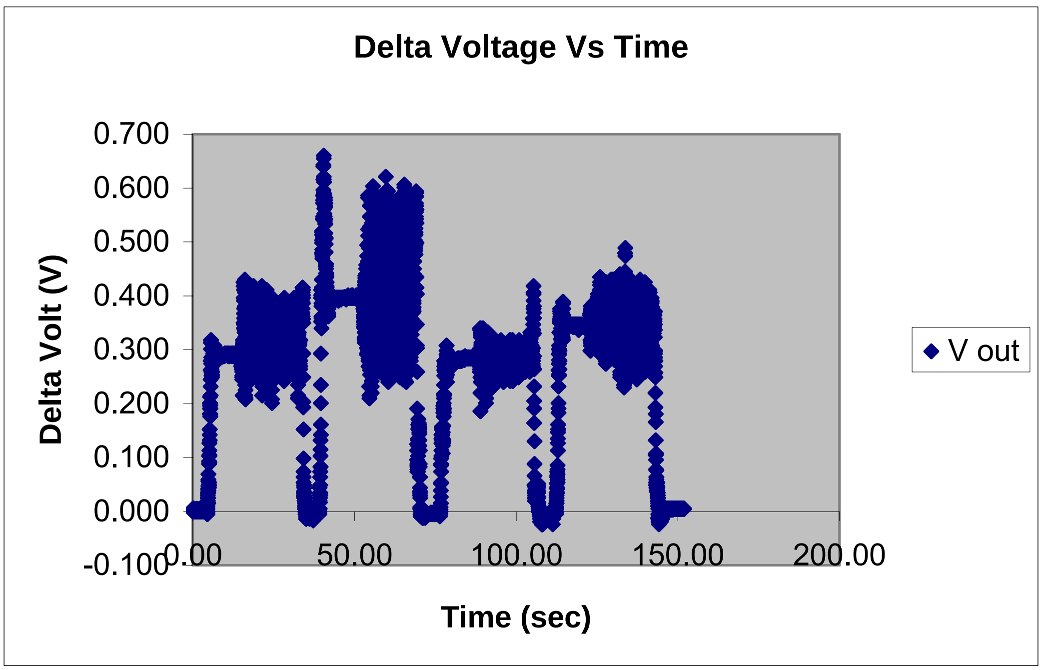


Fig 4. Chart of Delta Voltage Vs Time (Note that the chart does not have events labeled. Students have to label various events in their charts)

2. **Create** a chart of stress vs. time. Label your chart. Refer example in Fig 5.

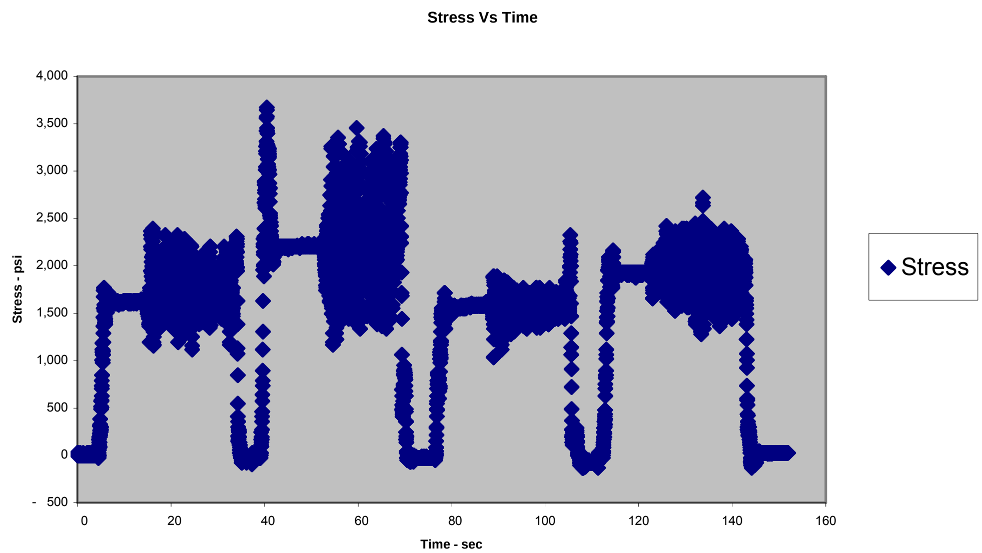
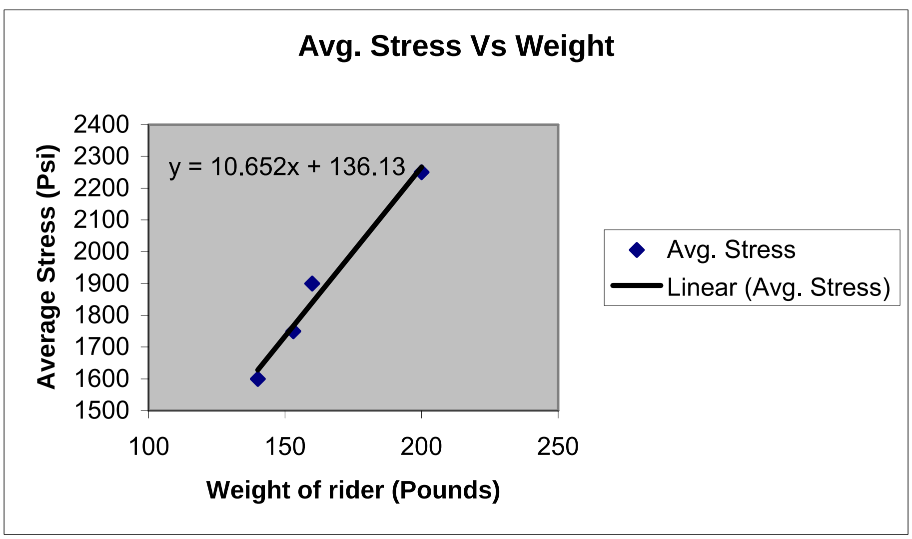


Figure 5.

3. Using average value of stress for each rider in the riding position while pedaling, **create** a Scatter plot of stress vs. weight of each rider. **Create** a linear trend line for the data and **show** the equation of the line on the chart. Refer example in Fig 6



Graphs for Part B

1. **Create** a plot of stress vs. time for the experimental data. **Label and add** a legend to your chart.

Static and Dynamic Worksheet Guidelines:

This is a Team Assignment.

Content	Points Worth	Point Value
Part A. Results	**65 pts.**	
1. 3 plots		
a. Plot of raw voltage data. Label in the plots what activities are causing the fluctuations in the graph.	15	
b. Plot of stress vs. time	15	
c. Average Value of stress vs. Weight	15	
2. Spreadsheet A – **first page only**	10	
3. Sample Calculations of stress & strain on a separate sheet.	10	
Part B. Results	**30 pts**	
Plot of stress vs. time	15	
Spreadsheet B – **first page only**	15	
Discussion Questions – extra credit	**20 pts.**	
1. **Find** the *maximum stress* observed for each rider. What percent of the yield stress for your bike frame is this maximum value? (The steel used in the bike fork has a yield stress of about 36000 psi).	6	
2. How *many times larger* is this dynamic stress than the stress observed when the rider was sitting still?	4	
3. Considering the fork design of your bicycle, do you think it is over-designed, under-designed, or just right? Explain.	4	
4. Considering the weight of the rider, the life expectancy of the bike, and the yield stress of the bike frame material, what rider weight limit would you impose for this fork design? Why?	6	
Lab Participation Agreement	**5 pts.**	

XR-440 DATA LOGGER
REFERENCE GUIDE

The data logger is an electronic device that collects and saves voltage information on up to four different input channels. The logger is currently configured to accept voltages within the range of –5 to +5 volts, but can also accept input from certain special sensors that are of no concern here. The data logger has an internal power source and is continuously powered ON. Its power source can last up to two years under normal use.

The data logger may be installed in a 'Black Box'. The box has two switches, a mini-jack, and a 9-pin connector. The switch marked *'BATT' controls only the power to whatever is plugged into the 9-pin connector* (generally strain gages on a bicycle, in the OSU case). Because the strain gages quickly drain the battery, **the BATT switch should be OFF at all times other than when data is actually being collected or observed**. The switch marked LOGGER controls only the start (ON) and stop (OFF) of data collection. Communications between the PC and the data logger can be performed with both BATT and LOGGER switches OFF. However, *valid data* is obtained from the strain gages only when the 'BATT' switch is ON. Finally, the mini-jack is used to communicate with the PC via a black cable with a mating end.

<u>Starting the Pocket Logger Software:</u>

Double click on the "Pocket Logger Software" icon on the Windows Desktop.

<u>Configuring the Logger Software:</u> (only need to do this only once after software startup)

1. Select "**Settings**" from the main menu. A new window will pop up.
2. Select the communications port that the data logger is connected to (**COM1** on these computers).
3. Select the "**19.2k**" option.
4. Everything else remains with the default settings.
5. Click "**OK**" to exit.

<u>Real Time Receive Mode:</u>

(Allows the user to view continuously updated readings of the data logger channels at a very slow update rate (2 seconds between updates). This operation *will not function* and *communications with the data logger will fail* if the data logger is *set* to take data at a rate greater than one sample every 2 seconds but is waiting for the LOGGER switch to be flipped ON, or, if the data logger *is* currently taking data at a rate greater than one sample every 2 seconds. **However, this mode can be used regardless of setup sample rate if the**

LOGGER is in 'idle' mode, i.e., the LOGGER switch has been cycled ON and OFF.)

The black data cable must be connected from the PC to the data logger.

1. **Flip** the LOGGER switch ON then OFF. (This action cancels any pending recording).
2. **Select** "Receive" menu item and then 'Real Time' option.
3. A **new window** should pop and **display** the data logger and channel information.
4. **Click** the "OK" button to stop this function and return to the main menu.

Sending a Setup:

(Sets the data logger for collecting and recording data. Also, a setup *will erase all previously recorded data.* **A Setup can be done only once unless and until data has been collected via the LOGGER switch**. That is, the data logger will not accept further Setup requests until data collection from the previously sent Setup has been initiated and concluded via the LOGGER switch. Most communications problems during a Setup can be resolved by cycling the LOGGER switch ON then OFF, and then trying the Setup again.)

1. **Select** "**Send**" from the main menu. Then **select** the "**Setup**" option. A new setup window will appear:
2. **Type in** the description of the experiment on the "**Session Description**" Option (*i.e., **ENG 181 Static Test, Group #N, Bike #***).
3. **Turn ON Channels 1 and 2 and turn OFF Channels 3 and 4** by clicking on the channel number on/off button.
4. **Select** the following settings for Channel 1:
    a. "**cls/opn**" under the "{Table}" option by using the scrolling menu.
    b. "**Standard**" under the "Type" option using its scrolling menu.
    c. **Type** "***Start /Stop Control"*** in the "Description" box.
5. **Select** the following settings for Channel 2:
    a. "**New Linear Scale**" on the "Table" option by using the scrolling menu. Type a value '–5' for the "Lo value" and a value '5' for the "Hi value". (Do not type the apostrophes!).
    b. "**Standard**" on the "Type" option using its scrolling menu.
    c. **Type** "***Voltage Signal"*** in the "Description" box.
6. **Select** "when ch1 temp probe is attached" for the option "**Start**" and "until ch1 temp. probe is detached" for the option "**Run**".
7. **Set** the data logger model option to "**XR-440**".
8. **Set** the resolution in the "**Resolution**" option to 12 bit.

9. **Set** the sampling rate in the “**Sample Rate**” box to the value specified in the lab procedure. Much of the time "(rf) 50/s" is used (50 samples per second).
10. The total log time will be determined automatically based on the model of data logger, resolution, and sampling rate. It will be displayed on the box “log time”. As a reference, typical settings for the bicycle data should give you slightly more than 3.5 minutes of data collection time.
11. **Insure** the logger is connected to the computer via a black data cable and then click on the “**Send**” button to download the settings to the data logger.
12. **Click** on “OK” in response to the warnings.
13. The data logger **is now ready** to record voltage data (and will do so when the LOGGER switch is flipped to ON).
14. *If the computer is unable to communicate with the data logger, flip the LOGGER switch ON then OFF and try the setup procedure again. If it still fails to accept the setup then ASK FOR HELP.*
15. **Click** on the ‘Exit’ button to return to the main window. In general, DO NOT save changes when asked. The changes you make will be current as long as the Pocket Logger software is not restarted.

Running a Test

(In most cases, the BATT switch would be turned ON shortly before a test is run. Always remember to flip the BATT to OFF immediately after flipping the LOGGER switch off, or immediately after leaving real time display, or any time data is not really needed).

1. After ‘Send’ing the setup to the data logger, you may disconnect the black cable from data logger if you wish or if the logger will be moved from the lab (e.g., for bike riding data).
2. When you want to acquire data, flip the LOGGER switch to ON.
3. You might want to keep track of how long you acquire data just to verify that the maximum collection time was not exceeded. Recall that the maximum log time is given in the setup window.
4. You stop collecting data by flipping the LOGGER switch OFF.
5. Any time the LOGGER switch has been flipped ON then OFF, the logger must be again connected to the PC and a Setup through the “Send” menu choice must performed before data can again be collected.

Receiving, Viewing, and Exporting Data from Data Logger

1. If you disconnected the data logger, reconnect it now. Select the options “**Receive**” then “**Data**” from the main menu. A new window will appear asking for a filename and a location for it to be saved to. Save to a unique

file on the floppy or Zip disk. The software will communicate with the data logger and will upload the data.

2. To display the data on a plot, click “**yes**” after downloading the data. Under the “**Change**” menu, select “**Viewports**.” Hide the channels that are not of interest (*i.e.,* the channel 1 start/stop data in most cases).
3. To export the data for manipulation and further plotting, **from the graph window**, under the “**File**” menu select “**Export**”. Choose “**ASCII**” and click “**ok**”. Then select “**comma separated values**”, “**all points**”, and click on “**Save As**.” When prompted to save the exported data, give it a unique name and save it to the floppy or Zip disk.

Checking the Status of Data Logger

(This operation *will not function* and *communications with the data logger will fail* if the data logger is set to take data at a rate greater than one sample every 2 seconds but is waiting for the LOGGER switch to be flipped ON, or, is currently taking data at a rate greater than one sample every 2 seconds).

Select “**Receive**” from the main menu, and then **select** the option “**Status**”. The program will communicate with the data logger and will display its current settings. These settings should match the settings that were last sent to the data logger.

Overview of the Use of the Data Logger in this Lab

Note that this is not the lab procedure, but a reference sheet to use during various parts of the lab. If you run into difficulties, more detailed instructions are available in the next handout, the XR-440 Data Logger Reference Guide.

Starting and Initializing the Data Logger

Follow instructions on page 1 of the Data Logger Reference Guide.

"Real time" mode (Used in Part B) – Displays data to screen, no storage

- Logger switch OFF, Battery switch ON
- Cable connected to the logger box and COM1 on the computer
- Selected by "Real Time" on the "Receive" menu
- Data display is updated every two seconds
- Display only! - No data is stored! ALT-Print Screen to save the window as a picture to the clipboard

Storage mode (Used to collect and store measurements into the data logger in both parts A & B)

- Logger & battery switches OFF
- Cable connected to the logger and the computer
- Select "Setup" on the "Send" menu
- Load the settings file (click the "File" button in the "Load" button group)
    - You'll use "BIKELAB.SET" settings file for this lab
- Send the setup to the logger (click the "Send" button)
    - This clears the logger memory and prepares it to receive new data
    - Do this <u>every time</u> you need a new data set
    - Once the setup has successfully been sent, you can disconnect cable from the logger box, if need be
- Turn ON the BATTERY and LOGGER switches (in that order) to start collecting data
- Turn OFF the LOGGER and BATTERY switches (in that order) to stop collecting data
- Upload data to the computer
    - Reconnect the cable between the PC and the logger, if need be
    - Select "Data" on the "Receive" menu to transmit data from the logger to the computer
    - You will be prompted for a file name and location. Store your data on a floppy or Zip disk.
    - Graph the data when the computer prompts you
- Export to a format that Excel can read
    - In the graph window, select "Export" on the "File" menu
    - Select "ASCII" and "OK"
    - Select "Comma Separated Values", "All Points" and "Save as"
    - You will be prompted again for a file name and location. Store your files on floppy or Zip
- To take another data set, send another setup to the logger to prepare it to take data, and continue from there.

Engineering 181 Bridge Design Competition

This package contains all the information required for the Bridge Design Competition. Please note that you have a limited amount of time to acquaint yourself with your team members, select a likely design and start the process of building your bridge, so please plan wisely.

Contents

1. Goals

The purpose of this competition is to provide students with a structured activity that will allow them to work as a team in a time-restricted project. The exercise is designed to foster an ability to apply scientific and engineering knowledge to a practical construction problem. Hopefully, this will be a challenging but enjoyable exercise.

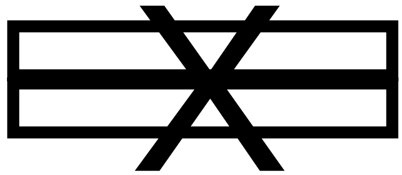
Each team will be expected to design and fabricate a balsawood bridge to span a distance of 10”. The bridges will be tested to failure during the competition in Lab 4. Each team is required to submit a memorandum report.

2. Competition Rules

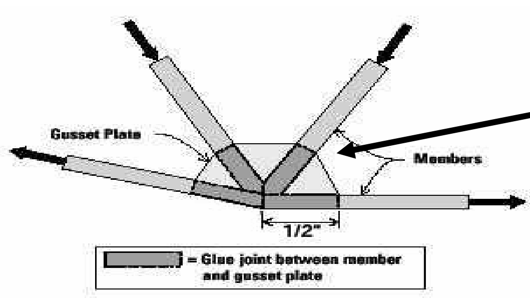
These rules form the basis of this competition. Unforeseen circumstances may arise and teams should consult their teaching associates or laboratory instructor if they have any questions.

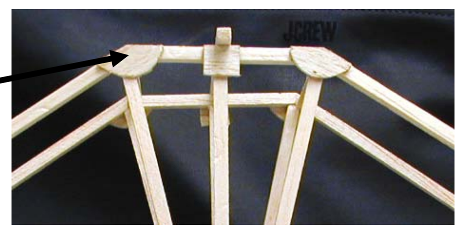
1) Materials used in the construction of the bridge shall consist only of materials supplied including commercially available balsawood and glue as listed in the section detailing materials supplied.
2) Students may not substitute the balsawood with bass wood or any other material, and as a check for this condition, each bridge submitted may not exceed 50 gm in weight.
3) All students in the group must read and sign the attached Bridge Competition Honor Statement. This statement is to be submitted with the memorandum report.
4) Each bridge submitted shall be tested to failure on the testing bench described in the section titled Testing Bench.
5) To conform to the testing bench each bridge shall be freestanding and stable (paper shims will be provided to compensate for small leveling differences).

6) Overall bridge dimensions shall not exceed 14” in length, 10” in height and 5” in width.
7) The bridge shall span a length between supports of exactly 10” (Teams should allow for support lengths on either side of the bridge that do not exceed the criteria given in rule 5).
8) Bridge members may not be laminated or glued together to form larger or thicker structural members.

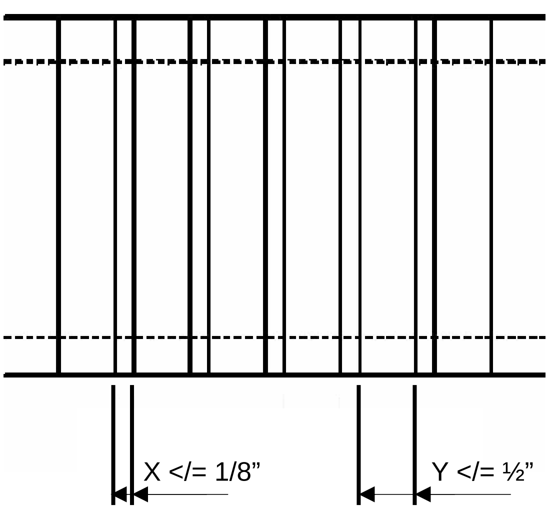


9) Joints or nodes in the bridge structure shall be constructed using gusset plates Gusset plates (a plate used to connect several members that intersect at a node or joint) may not extend more than ½ “ in any direction of a structural member.
10) The center top part of the bridge shall have a 3/16” x 3/16” member glued to gusset plates across its width to accommodate the testing harness.





11) A reasonably level and smooth roadway or deck consisting of pieces (Y) no wider than a ½” and placed across the width of the bridge must be included. Gaps (X) between these pieces should not exceed 1/8”.



12) The overall structure shall allow a model truck with a 2.25” square cross-sectional area to pass through it from one end of the bridge to the other without touching any part of the structure besides the roadway or deck itself.
13) The 1/16 “ x 3” x 36” balsawood piece may be used to construct the roadway (deck), gusset plates or for decorative purposes. It may not be used for any other structural purposes; for example: a side covering glued across the length of the bridge.
14) All decorative pieces may only be spot glued to the structure.
15) Glue, resin, paint, or any other product may not cover the bridge and bridge members.

3. Materials Supplied

The following is a list of the official supplies to be used for this project. Please check your supplies to make sure that your inventory is complete.

- 4 No. 3/16” x 3/16” x 36” balsawood
- 4 No. 1/8” x 1/8” x 36” balsawood
- 1 No. 1/16” x 3” x 36” balsawood
- 1 No. Light Duty Hobby precision knife
- 1 No. Sheet 400 gauge SA4 sanding paper
- 1 No. 1 ¼” Fl. Oz Elmer’s Glue

Students are advised that they should plan well in advance of starting construction as the materials are limited and some designs simply cannot be built with the materials provided.

4. Testing Bench

A testing bench has been fabricated to accommodate each bridge. This bench consists of:

- Two wooden supports clamped to a workbench
- Bucket and supporting cables
- Weights

5. Assignment

Each team shall construct a bridge that conforms to the Competition Rules. This bridge shall be presented for inspection on the day of the competition that will be conducted in the first hour of Lab 4. Each team shall produce a lab memo in the standard format addressed to their laboratory instructor. The memo shall be submitted for grading at the beginning of Lab 5. The memo should be 2-3 pages in length **excluding** any figures and tables or the honor codes. The memo should include:

- The results of the competition relevant to the team submission including:
  - The bridge weight
  - Weight supported
- Provide a summary of the quantity of balsa materials used in the final bridge.
- A commentary section on how the team’s bridge design could be improved within the confines of the Competition Rules.
- **A commentary on how the team functioned throughout the competition. Please include information on the organization of your team meetings, your productivity levels, and the mistakes and problems you encountered. Finally,**

describe what type of processes you used to overcome difficulties throughout the project.

- The honor code statement provided at the end of these materials.

Please note that this is a true memo, you are not expected to have any sub-headings (“Introduction”, “Results”, “Discussion” etc).

6. Failure Criteria

- Visible structural separation particularly at joints
- Partial or complete fracture of members
- Failure does not include deck or spot glued aesthetic member.

7. Assessment Criteria

The following table details the broad assessment criteria for the Bridge Competition. Points for any category may be withheld in part or as a whole as a penalty for violating any of the Competition Rules.

		Points
Balsawood Bridge		
	Bridge Aesthetics (Overall appearance of bridge and other details including joint and deck work).	10
	Strength of Bridge (Assessed as a class weighted ratio of weight supported to weight of bridge)	10
	Subtotal	20
Memorandum Report	See Memo Guidelines	80
Total Points		**100**

8. Possible Timeline

Meeting 1

- Prior to this meeting individual team members should try to research possible design alternatives.
- The first meeting should be held to confirm a possible working project timeline and to discuss and possibly select a few design alternatives.
- Finally, the team should decide on the possible method to be used for building the bridge components.

Meeting 2

- Prior to this meeting, full-size sketches should be completed.
- Build component sections as time allows, clamp where possible and provide adequate gluing time.
- Remove excess glue with sandpaper or a file.

Meeting 3

- Prior to this meeting the team should assess their progress and make adjustments to the fabrication process as required.
- Join the bridge parts or sections and again clamp where possible and provide adequate gluing time.
- Remove excess glue with sandpaper or a file.

Meeting 4

- Prior to this meeting the team should assess their progress and make adjustments to the fabrication process as required.
- Complete the bridge fabrication including any detailing work. Remember to clamp were possible and provide adequate time for the glue to set and dry.
- Remove excess glue with sandpaper or a file.
- Weigh your bridge if possible and make sure that you have not violated any of the other Competition Rules. Allow adequate time to make changes as required.

Contest Day

- All team members should arrive ahead of time.
- Present bridge for inspection.
- Bring materials to effect any last minute changes.
- Present bridge for official weigh-in and testing.
- Record weight of bridge and the weight successfully carried by the bridge.

9. *Bridge Building Tips*

- Use a small balsawood saw (about $3) instead of a light duty hobby knife to make cuts for the thicker members.
- Cut small and precise notches to connect bridge components
- Fewer pieces mean fewer construction problems
- Clamp or tape down glued pieces for about half an hour (use protective strips to avoid damaging the balsa). If you don't have any clamps you can use clothes pegs.
- Design for strength at the load application point and support points
- Construct roadway of thin, narrow strips of balsa
- Use minimal support under roadway
- Most bridges bend inwards (as viewed from one end); consequently they require horizontal bracing
- Double check that all Competition Rules are met by your submission throughout the fabrication process.
- Do not cover your bridge with any material. Glue should be used only to join components

Common Errors

- Using a single sheet of balsa for roadway (cut into strips)
- Making inside width 5” instead of outside dimension
- Making overall length 10” instead of span of the bridge and allowing an extra length for the supports.
- Forgetting that the bridge should allow for a model truck (2.25” x 2.25”) to pass through the structure on the deck without touching any part of the bridge.
- Not allowing for the testing harness by gluing the 3/16” x 3/16” member at the center top part of the bridge.

Hints
Please note that several members have zero load but they are still required to allow for structural stability.

10. REFERENCES

Balsawood Competitions

http://www.ndrs.org/physicsonline/bb-menu.html

Bridge Sites

http://www.howstuffworks.com/bridge.htm

Balsawood Construction Tips

http://www.abcdpittsburgh.org/kids/kids.htm

Bridge Building Memo Guidelines:

This is a TEAM memo and should be in the *standard memo format* addressed to the instructor. An example of a *standard memo format* is provided in your course packet.

The memo is graded out of 80 points and the remaining 20 points is for bridge aesthetics and bridge testing.

Contents	Points Worth	Point Value
Header Information	**5 pts** (for header and memo format)	
Introductory Paragraph	**5 pts**	
Objectives/Goals of the Labs	3	
Brief Description of Contents of the memo	2	
Results	**10 pts**	
Sketch of the bridge	10	
Discussion Questions	**45 pts**	
1) Discuss how the team bridge design could be improved within the limits of the Competition Rules.*	35	
2) Commentary on the team function.**	10	
Problems Encountered	**10 pts**	
Discuss bridge design and construction problems encountered	8	
Possible Changes to improve this lab	2	
Lab Participation Agreement* **	**5 pts**	

**Hint: Your team may answer this in many ways. The main point to discuss is a BRIDGE FAILURE ANALYSIS- (i) the location of failure of the bridge, (ii) how it failed - buckling, truss member failure, joint failure, gusset plate failure, etc, (iii) what was your anticipated failure point. Suggestions for the improvement should address the failure along with other ideas that may improve the design and the improvements should be "legal" according to the rules.*

***Include information about the team meetings, your productivity, team work/problems encountered. Discuss the type of team work processes that were used to overcome the difficulties throughout the project.*

***** Remember you are not allowed to use any materials except those provided to you by the instructional staff**.

Lab 5: Transport Phenomena Lab A
Fluid Flow, Viscosity and Introduction to Rheology

Lab Objectives:

The objectives of the lab are:

- Introduce transport phenomena – fluid, energy and mass flow
- Introduce rheology (the study of the deformation and flow of fluids) and fluids classification
- Relate viscosity to flow behavior by measuring the viscosity and flow rates of Newtonian fluids using simple methods.
- Measurement of viscosity using falling ball viscometer
- Measurement of viscosity using capillary viscometer
- Determine the relationship of fluid density to fluid viscosity.
- Relate the concepts of flow and viscosity to heat transfer by applying data obtained in Lab A to solve heat transfer problems in Lab B.

Background Information:

Introduction to Transport Phenomena

The movement and use of energy in various forms is of concern to all engineering disciplines at some level. It is the basis of an area of study known as thermodynamics in which one learns that in any process (except those involving nuclear fission) energy is neither created nor destroyed. However, keeping track of the various forms of energy in a process is a complicated task and we will just touch on some simple principles in this laboratory exercise.

Most of us don't think twice about plugging an instrument or device into an outlet and making use of the electricity provided. In doing so, we are taking advantage of electrical energy and converting it to mechanical energy (turning a shaft on a motor), chemical energy (shooting electrons at a phosphor screen on a monitor), and thermal energy (heat). Our practical experience tells us that the latter form (heat) is *always* present no matter what. In fact, it is often a large part of the design process to reduce the amount of energy lost as heat because the heat can in some cases prove fatal to the device (for example in large integrated circuits). Roughly speaking, we define the efficiency of a process or device as the percent of the energy consumed by that device that is converted to uses *other* than heat (unless that is the purpose of the device). Devices that are designed to convert one form of energy directly into heat (gas furnaces for example) are typically some of the most efficient possible.

Chemical, civil, and mechanical engineers (and all others to some extent) are interested in the movement of **energy, mass and momentum** from place to place. The collective study of these movement processes is called "transport phenomena". This term simply conveys the fact that many transport processes in science and engineering are caused by forces that can be described by the same general equations. For example, the same mathematical equations that describe how heat transfers away from an integrated circuit chip can be used to describe how temperature changes in a chemical reactor. Savvy engineers are able to recognize these similarities and study them as the related fields they truly are. One of the basic principles in all transport phenomena calculations, including heat transfer, is that the rate of transport is directly related to the measured driving force. For example, in transport of momentum (fluid flow), pressure is the driving force and a difference in pressure between two points causes fluid to flow. Similarly in transport of energy (heat transfer) the rate of movement of heat energy from a hot body to a cold body is related to

the difference in temperatures between the bodies. The exact formulation of these equations is very complex and beyond our scope here, however it is useful to recognize the relationship
In the Transport phenomena labs we will deal with transport of momentum (fluid flow – in today's lab) and heat (energy flow in lab B). Before examining fluid flow, rheology and classification of fluids will be introduced.

Introduction to Rheology and classification of fluids

Rheology is defined as the science of deformation and flow of matter. It describes the material properties of fluids (including gases) and semi-solid materials. Rheology is interdisciplinary and is used to describe interrelation between applied force (or stress), deformation, and time for a wide variety of materials such as oils, food, inks, polymers, clays, concrete etc. The common factor is that these materials exhibit some type of inelastic deformation or "flow" under stress and, therefore, cannot be treated as solids.

Fluid rheology is used to describe the consistency of different products, normally by the two components **viscosity** and elasticity. Viscosity describes resistance of the fluid to flow or its thickness. For example, the viscosity of molasses is higher than the viscosity of water. It can be measured in several ways. Elasticity describes the fluid's "memory" and results in a delay of the fluid's reaction to stress.

Based on flow behavior, fluids are normally divided into different groups.

- **Newtonian fluids** – whose viscosity is dependent only on temperature
  Examples: Water, milk, sugar solution, mineral oil

- **Non-Newtonian fluids (time independent)** – whose viscosity is dependent not only on temperature but also on shear rate. Depending on how viscosity changes with shear rate, the flow behavior is characterized as:
  - Shear thinning, whose viscosity decreases with increased shear rate
    Examples: Paint, shampoo, fruit juice concentrates, molten plastic

  - Shear thickening, whose viscosity increases with increased shear rate
    Examples: wet sand and concentrated starch suspensions

  - Plastic, which exhibits a so-called yield value, *i.e.* a certain shear stress must be applied before flow occurs
    Examples: toothpaste, hand cream, grease

- **Non-Newtonian fluids (time dependent)** – whose viscosity is dependent on temperature, shear rate and time. Depending on how viscosity changes with time the flow behavior is characterized as:
  - Time thinning - viscosity decreases with time
    Examples: yogurt, paint

  - Time thickening - viscosity increases with time
    Example: gypsum paste

In this lab, we will deal only with simple and commonly available Newtonian fluids. We will measure viscosity of such fluids using inexpensive (and approximate) methods.

Fluid flow

Fluid flow deals with transport of momentum. A flow occurs when there is a difference in pressure between two areas, and the flow is from a higher pressure point to a lower pressure area. Fluid flow is typically described as being laminar (streamlined with layers of similarly moving molecules) or turbulent (chaotic movement). See Figure 1. The equations that will be used in this lab assume laminar flow, although a means of confirming whether flow is laminar or turbulent is provided using Reynold's number.

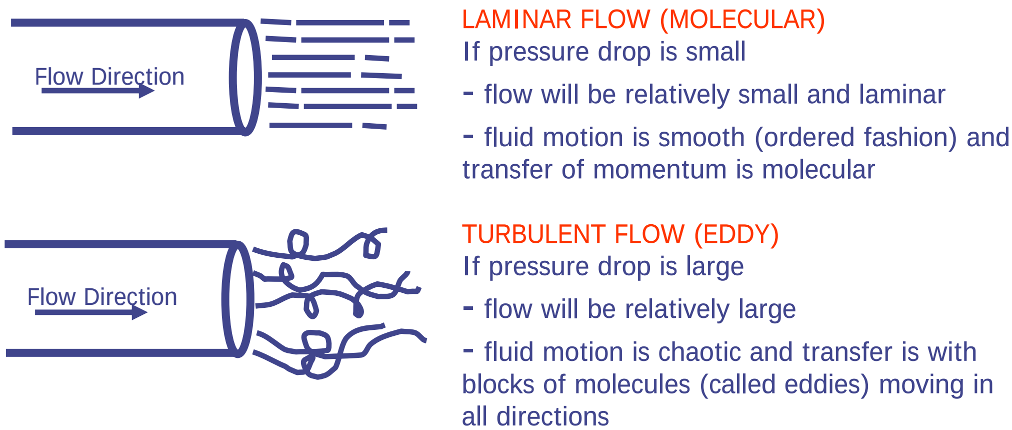


Figure 1: A comparison of laminar and turbulent flow in fluids.

The concepts discussed in this lab encompass many disciplines, including chemical engineering, mechanical engineering, industrial engineering, civil engineering, environmental engineering, food engineering, and bio-medical engineering, to name a few.

Equipment:

For this lab, the nine groups of four will join into three super groups of twelve. Teams A, B, and C will become Super Group 1, Teams D, E, and F will become Super Group 2, and Teams G, H, and I will become Super Group 3. Super groups are designated only for assigning equipment. Each team will perform 3 trials for each fluid. There will therefore be 9 trials per fluid per super group that will be shared amongst the teams of the super group.

Each super group will be provided with the following materials and equipment for this lab:

- (Task 1) Three sealed transparent acrylic cylinders on stands, each containing a 1/8" diameter steel ball bearing and one of each of the following substances:
  - Castor Oil
  - Corn Syrup
  - Glycerol
- (Task 1) One Neodymium rare earth magnet
- (Task 1 & 2) One stopwatch (Application on the PC)
- (Task 2) Three plungerless graduated syringes with transparent Tygon tubing attached, mounted to vertical dowels on stands at separate tables (to eliminate fluid contamination).
- (Task 2) Three Tygon tubing clamps.
- (Task 2) Three Nalgene wash bottles for transferring fluids to the plungerless, mounted syringes, and catching fluid draining from the capillary tube apparatus. Fluid containers/reservoirs contain each of the following fluids:
  - Canola Oil
  - SAE 30 Motor Oil
  - Castor Oil

CAUTION: The magnet is very powerful (much more so than a refrigerator magnet) and should be kept away from watches, magnetic data storage (floppy disks!), and electronic devices.

NOTE: In this lab, all units should be in <u>meters (m)</u>, <u>kilograms (kg)</u>, <u>seconds (s)</u>, <u>kilograms per meter-second^2 (kg/m-s^2)</u> for pressure, and <u>kilograms per meter-second (kg/m-s)</u> for viscosity. For your information, 1" = 2.54 cm. 1 cm^3 = 1mL. <u>Pressure</u>: 1 Pa = 1 N/m^2 = 1 (kg/m^2)(m/s^2) = <u>1 (kg/m-s^2)</u>. <u>Viscosity</u>: 1 Pa-s = 1 N-s/m^2 = 1 (kg-s/m^2)(m/s^2) = <u>1 (kg/m-s)</u>.

Newtonian Fluid Properties and Relationships:

Task 1: Falling Sphere in Cylinder of Fluid

Reynold's number (dimensionless, must be <<1 to indicate laminar fluid flow around an object such as a sphere, for the remaining relationships to hold true)

$$Re = \frac{d_s V_t \rho_f}{\mu_f}$$

Terminal velocity (Figure 3)

$$V_t = \frac{2r_s^2(\rho_s - \rho_f)g}{9\mu_f}$$

Ratio of experimental time to theoretical time (wall effects correction)

$$\frac{t_{experiment}}{t_{theoretical}} = 1 + 2.1044\frac{d_s}{d_c}$$

Volume of Sphere:

$$v_s = \frac{4\pi r_s^3}{3}$$

Density of sphere

$$\rho_s = \frac{M_s}{v_s}$$

Task 2: Fluid Flow Rate Through a Capillary

Reynold's number (dimensionless, must be <<2000 to indicate laminar fluid flow in a pipe or tube, for the remaining relationships to hold true)

$$Re = \frac{d_{cap} V_{avg} \rho_f}{\mu_f}$$

Average fluid velocity

$$V_{avg} = \frac{Q}{A_{cap}}$$

Fluid flow rate

$$Q = \frac{-\pi r_{cap}^4}{8\mu_f}\frac{\Delta P}{\Delta Z}$$

Cross-sectional area of capillary

$$A_{cap} = \pi r_{cap}^2$$

Change in pressure (Figure 2)

$$\Delta P = -\rho_f g \Delta Z$$

Term	***Meaning***	***Constant Given***	***Preferred Units***
R_e	*Reynold's number*	<>	<>
d_s	*Diameter of sphere*	*1/8"*	*m*
V_t	*Terminal velocity*	<>	*m/s*
ρ_f	*Density of fluid*	<>	kg/m^3
μ_f	*Viscosity of fluid*	<>	*kg/m-s*
r_s	*Radius of sphere*	*1/16"*	*m*
v_s	*Volume of sphere*	<>	m^3
M_s	*Mass of sphere*	*0.000131 kg*	*kg*
ρ_s	*Density of sphere*	<>	kg/m^3
g	*Acceleration of gravity*	$9.81\ m/s^2$	m/s^2
$t_{experiment}$	*Experimental descent time*	<>	*s*
$t_{theoretical}$	*Theoretical descent time*	<>	*s*
d_c	*Diameter of cylinder*	*1.50"*	*m*
d_{cap}	*Diameter of capillary tube*	*1/8"*	*M*
V_{avg}	*Average velocity of fluid*	<>	*m/s*
Q	*Flow rate*	<>	m^3/s
A_{cap}	*Cross-sectional area of capillary*	<>	m^2
r_{cap}	*Radius of capillary tube*	*1/16"*	*m*
ΔP	*Change in pressure*	<>	$kg/m\text{-}s^2$
ΔZ	*Average level of fluid (includes capillary length)*	*.155 m*	*m*

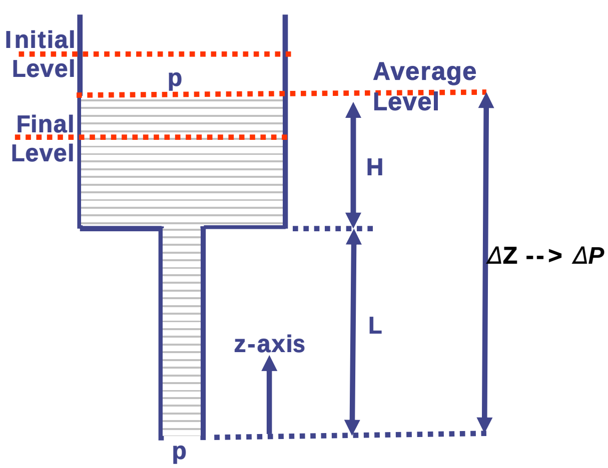


Figure 2: Capillary fluid height and resulting difference in pressure.

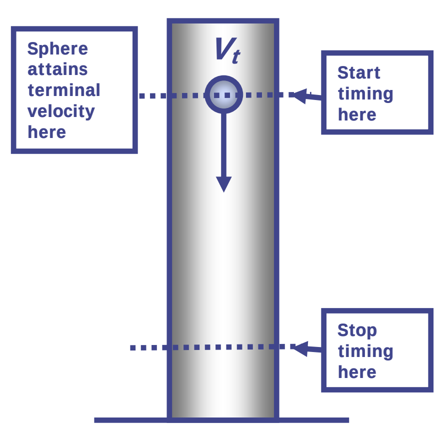


Figure 3: Timing the sphere's descent at a terminal velocity over a fixed distance.

Sample Calculation:

If a sphere with radius of 0.1 cm and mass of 0.01 g is falling through a cylinder of fluid with radius of 6 cm reaches a terminal velocity of 0.01 m/s, what is the viscosity of the fluid assuming the fluid has a density of 1000 kg/m^3 and is Newtonian and the flow of fluid around the sphere is laminar? Confirm that the flow of fluid around the sphere is laminar.

① SETUP

$r_s = .1\ cm = .001\ m \rightarrow d_s = .002\ m$

$M_s = .01 g = .00001\ kg$

$V_s = \frac{4}{3}\pi r_s^3 = \frac{4}{3}\pi(.001)^3 = 4.19\times10^{-9}\ m^3$

$\rho_s = M_s/V_s = .00001\ kg / 4.19\times10^{-9}\ m^3 = 2387.32\ kg/m^3$

$\rho_f = 1000\ kg/m^3$

$r_c = 6\ cm = .06\ m \rightarrow d_c = 2r_c = .12\ m$

$g = 9.81\ m/s^2$

$V_{exp} = .01\ m/s$

② CORRECTION FACTOR

Since $\frac{t_{exp}}{t_{theory}} = 1 + 2.1044\frac{d_s}{d_c}$, and since $\frac{V_{theory}}{V_{exp}} = \frac{t_{exp}}{t_{theory}}$;

$\frac{V_{theory}}{V_{exp}} = 1 + 2.1044\frac{d_s}{d_c}$

$V_{theory} = \left(1 + 2.1044\frac{d_s}{d_c}\right)V_{exp}$

$= \left(1 + 2.1044\frac{.02\ m}{.12\ m}\right)(.01\ m/s)$

$= .0135\ m/s$

③ VISCOSITY CALCULATIONS

$V_t = 2r_s^2(\rho_s - \rho_f)g/9\mu_f \rightarrow \mu_f = 2r_s^2(\rho_s - \rho_f)g/9V_t$

$= 2(.001\ m)^2(2387.32\ kg/m^3 - 1000\ kg/m^3)(9.81\ m/s^2)/9(.0135\ m/s)$

$= .224\ m^2\ kg/m^3\ m/s^2\ s/m$

$= .224\ N\text{-}s/m^2 = .224\ Pa\text{-}s$

④ LAMINAR

$Re = d_s V_t \rho_f/\mu_f = \frac{(.002\ m)(.0135\ m/s)(1000\ kg/m^3)}{(.224\ kg/m\text{-}s)} = .121 << 1$

Therefore, the flow is laminar.

HINT: For multiple calculations, USE A SPREADSHEET!!!

Lab Procedure:

This lab has two tasks and is to be done in super groups of twelve. Each of the 3 teams is to complete 3 trials of each fluid for each task. Super group teams are to share data so that there will be 9 trials for each fluid for each super group.

Task 1: Falling Sphere in Cylinder of Fluid

1.0 Familiarize yourself with the stopwatch application on the PC.
1.1 The three one meter tubes are marked as castor oil, corn syrup, and glycerol accordingly. Select one of these with which you have not yet experimented.
1.2 Using the magnet, pull the steel ball bearing up the wall of the cylinder from the bottom to the top. Once you get to the top, carefully move the magnet over the edge to the top and center of the cylinder so that the ball is centered along the axis of the cylinder at the very top (in other words, the magnet will be *on top of the cylinder* at this time with the ball below it hanging centered beneath the top of the cylinder).
1.3 With one teammate holding the sphere at the top in the ready position with the magnet and another watching closely with the stopwatch, release the ball bearing from the magnetic force of the magnet by pulling the magnet away from the cylinder. The ball bearing should begin to descend.
1.4 On the cylinder there are several markings and lines circumscribing its surface. The first of these lines is labeled "V_t" and indicates the point by which the sphere should reach its terminal velocity. When the sphere reaches this line, the teammate with the stopwatch should begin timing.
1.5 The next line, labeled "50 cm", indicates a distance of 50 cm from the terminal velocity point. The teammate timing the sphere's descent should stop timing once the sphere reaches this line.
1.6 It is very important that during timing, the sphere does not ride along the side of the cylinder. To get the most accurate results, it is important that the sphere stays as centered as possible during its descent. If the sphere is too close to the wall of the tube during its descent, repeat from step 1.2 and ignore the current measurement.
1.7 Record the time in Worksheet A1.
1.8 The last line on the tube, "D_b", indicates the minimum distance to the bottom before the effects of the bottom of the vessel skew the results and slow the speed of the sphere by more than 1%. You should not be concerned with this as you will stop timing the sphere's descent prior to this point.
1.9 Go back to step 1.2 and repeat until you have 3 trials for this fluid.
1.10 Go back to step 1.1 and continue until you have experimented with all three fluids.
1.11 Be sure to exchange data with the other teams in your super group so that you will have 9 trials for each fluid.

Task 2: Fluid Flow Rate Through a Capillary

2.1 The three plungerless syringes and fluid containers are marked as canola oil, SAE 30 motor oil, and castor oil accordingly. Select one of these with which you have not yet experimented.
2.2 Clamp the end of the transparent Tygon tube.
2.3 Remove the transparent Tygon tube end from the hole in the bottle cap.
2.4 Pick up the bottle and hold it so that the small nozzle is in the syringe opening and, with your thumb over the hole in the bottle cap, carefully squeeze an adequate amount (at least 20 mL so that the syringe is full, but not at risk of spilling!).
2.5 Replace the bottle below the transparent Tygon tubing.
2.6 Once you have filled the syringe, be absolutely sure that the container is placed under the hanging end of the capillary tube and that the capillary tube is actually hanging through the hole in the bottle cap with its end inside the bottle so that the flowing fluid is recycled into the container and not spilled or wasted!
2.7 With one teammate holding the tube clamp and another watching closely and ready with the stopwatch, remove the clamp from the tube. The fluid should begin to immediately flow through the capillary and into the fluid container.
2.8 The vertical plungerless syringe is graduated. When the fluid reaches the 15 mL line, begin timing with the stopwatch.
2.9 When the fluid level reaches the 10 mL line, stop timing.
2.10 Record the time in Worksheet A2.
2.11 Go back to step 2.2 and repeat until you have 3 trials for this fluid. It is important to refill the syringe for each experiment and to time the flow only between the 15ml and 10ml markings. This avoids exit effects on the flow that interfere with the measurement.
2.12 Go back to step 2.1 and continue until you have experimented with all three fluids.
2.13 Be sure to exchange data with the other teams in your super group so that you will have 9 trials for each fluid.
2.14 Clean up any and all spills immediately and inform your lab instructor or teaching assistant.

Reporting Requirements:

TRANSPORT LAB A & B COMBINED TEAM REPORT (not memo) DUE two weeks from today. Refer to the handout following Transport Phenomena Lab B (next week) for reporting requirements and discussion questions.

Transport Phenomena Lab A, Worksheet A1

Distance:	.5 m
Gravity:	9.81 m/s^2

SPHERE (SI Units only!)		Diameter:		Radius:	
Mass:	.000131 kg	Volume:		Density:	

$t_{theoretical}$ = ____________ x $t_{experiment}$

Experiment	Fluid (room temp.)	Density (kg/m^3)	Viscosity (kg/m-s)	Reynold's Number		1	2	3	4	5	6	7	8	9	Mean
Lab A (cylinder)	Corn Syrup	1360			$t_{experiment}$										
					$t_{theoretical}$										
					$V_{theoretical}$										
Lab A (cylinder)	Glycerin	1258			$t_{experiment}$										
					$t_{theoretical}$										
					$V_{theoretical}$										
Lab A (cylinder)	Castor Oil	970.0			$t_{experiment}$										
					$t_{theoretical}$										
					$V_{theoretical}$										

HINT:
First, during the lab period, record all the experimental times.
Afterwards, calculate the theoretical times given the relationship provided earlier between theoretical and experimental times.
Given the time to travel 0.5 m, find the terminal velocities.
Then, calculate the averages.
Use the terminal velocity equation provided earlier and solve for viscosity using the average of the terminal velocities and theoretical times for each fluid.
Finally, calculate Reynold's number to determine whether the fluid flowed laminarly (calculations are valid) or turbulently (calculations are invalid).

Transport Phenomena Lab A, Worksheet A2

Radius (SI units!):	
Diameter (SI units!):	

Cross-sectional area:	
Fluid Height:	0.155 m

Volume:	5 mL		
Pressure Change:			
	Castor Oil	SAE 30	Canola Oil

Experiment	Fluid (room temp.)	Density (kg/m^3)	Viscosity (kg/m-s)	Reynold's Number		1	2	3	4	5	6	7	8	9	Mean
Lab A (capillary)	Castor Oil	970.0			t										
					$Q_{experimental}$										
					V_{avg}										
Lab A (capillary)	SAE 30 Motor Oil	878.0			t										
					$Q_{experimental}$										
					V_{avg}										
Lab A (capillary)	Canola Oil	910.0			t										
					$Q_{experimental}$										
					V_{avg}										

HINT:
First, during the lab period, record all the experimental times.
Afterwards, calculate the flow rate using the volume and experimental times.
Given the cross-sectional area of the capillary, find the average velocities.
Then, calculate the averages.
Use the fluid flow rate equation provided earlier and solve for viscosity using the average of the flow rates for each fluid.
Finally, calculate Reynold's number to determine whether the fluid flowed laminarly (calculations are valid) or turbulently (calculations are invalid).

For your information:

Experiment	Fluid (room temp.)	Density (kg/m^3)	Viscosity (Pa-s)
Lab B (heat transfer)	Water	998.2	0.001
<none>	Air	1.239	$1.60x10^{-5}$

(assuming room temperature and normal atmospheric pressure)

Lab 6: Transport Phenomena Lab B –
Energy Flow and Instrumentation

Goals:

- Identify and measure two forms of energy (heat and kinetic) and discuss how engineers must design for proper energy flow.
- Measure heat transfer coefficient
- Relate heat transfer to property of fluid and property of flow (we examined fluid flow property in Transport Phenomena - Lab A by measuring viscosity)
- Use thermistors and transducers for process measurements.
- Define and describe vital capacity of the lungs.
- Explain the importance of instrument calibration.
- Collect and analyze data from a computer data acquisition system.

IMPORTANT: While working on this lab, you will measure and calculate many quantities. It is important to use the right units for the quantities. Conversion factors will be provided when required. Also, there are a few quantities that do not have any units (e.g. Reynolds Number).

Background Information:

Refer to "Introduction to Transport Phenomena" in Transport Phenomena Lab A. In this lab, we will deal with transport of energy (heat transfer) and relate it to property of fluid and property of flow (from Transport Phenomena Lab A)

Energy Principles

Heat Energy

Heat flow deals with transport of energy. Flow occurs when there is a difference in temperature between two bodies, and the heat energy flows from a hot body to cold body.

In the heat energy portion of this lab we are interested in measuring the **heat transfer** necessary to freeze a given mass of water. One item of clarification before we describe the equations we will use: temperature is not heat but is the physical property we can observe to determine the quantity of heat being transferred.

Because of the difficulty of directly measuring the rate of heat transfer we will back out an *average heat transfer rate* by measuring the change in energy of a fixed mass of water over a period of time. We can measure the change in energy of the water by following its temperature: $q(Joules) = mC_p(T_{final} - T_{initial})$

where m is the mass of water (grams), T represents the temperature of the water (°C) and Cv is a constant called the "Constant Volume Heat Capacity". For water it has a value of 4.182 J/g-C (both the units gram and °C are in the denominator). Note that this relationship only gives us the *amount* of energy transferred to the water and not the rate.

Let's take an example of boiling water for making pasta. If we fill a pot with 1 liter (about 1000 g) of tap water at 21°C (about 70 °F) and put it on the stove top, it takes about 20 minutes for the water to reach 100 °C and begin to boil. What is the rate of heat transfer from the stove to the water? Well we first calculate the change in energy of the water:

$$q = 1000\ g * 4.182 \frac{Joules}{g - °C}(100\ °C - 21\ °C) = 330378\ Joules$$

Since the process took about twenty minutes, we can find the average rate by dividing the total amount of energy transferred by the total time.

$$\dot{q}_{rate}\ (J/s) = \frac{330378\ Joules}{20\ min * (60\ sec/min)} = 275\ Joules/sec = 275\ Watts$$

For comparison, a light bulb uses energy at a rate of 60 Watts and a laptop computer uses energy at a rate of about 42 Watts.

Momentum or Mechanical Energy

In the 18th century, Daniel Bernoulli studied the relations between mechanical work and flowing fluids. The Bernoulli equation is often referred to as the "mechanical energy balance" and is used to design everything from public water works to artificial hearts. In simple terms, the Bernoulli equation balances the forces on an element of fluid and includes a term for the potential energy, kinetic energy, and external pressure forces on that fluid. Through Bernoulli's equation we can relate the velocity of a fluid (and hence it's kinetic energy) to the pressure of that fluid at two different points (pressure drops are easy to measure).

Given a fluid's velocity and the size of the duct through which it is flowing we can determine the volumetric flow rate of that fluid. In many cases, we don't go to the trouble of calculating all the intermediate quantities like the velocity. Instead, we try to *calibrate* a sensor or measurement device (e.g. pressure transducer) to the final quantity we want (volumetric flow rate).

Instrumentation

Because of our interest in efficiency, we need ways of measuring and monitoring the energy flow in and out of a system. Today we will learn about two sensors for doing so, a thermistor and a pressure transducer. Thermistors are a semiconductor material whose electrical resistance drops dramatically as the temperature increases. Through a simple calibration point (often provided by the manufacturer) we can make a relatively easy electrical measurement and convert it to a process temperature. It is essential to be able to electrically measure temperature so that the process being monitored can also be controlled by the computer. For example, most chemical reactors must be temperature controlled to insure product purity and avoid accidents. Measuring the temperature continuously allows the automated control system to determine how much cooling or heating is needed on a second by second basis.

The thermistors used in the ice cream makers are already compensated for our specific data loggers and can be used by simply connecting them and starting the software.

Pressure transducers are more closely related to the strain gauges used on the front forks of the bicycle in an earlier lab. Here again, the sensor takes advantage of the change in electrical properties (resistance) in response to an external force (strain or pressure in this case). Typically, a pressure transducer is a thin metal diaphragm carefully drawn or rolled and then connected to a circuit in combination with very precise resistors, amplifiers and signal conditioners. The diaphragm flexes very slightly in response to an applied force from the fluid thus changing the resistance of the circuit. The output signal is typically a voltage that is proportional to the applied pressure or pressure drop. Transducers can be designed to measure anything from very low pressures (0.1 psi) to very high pressures (10,000 psi). Below is an example of a differential pressure transducer that measures the difference in pressure between two fluid streams or two positions in the same stream.

Figure 1: A differential pressure transducer.

Calibration:

You should never believe a number out of an instrument (sensor or transducer) unless you know and understand that the instrument gives a true reading. This is often done through a process known as *calibration* and depending on the accuracy required, the calibration may need to be certified to international standards. As engineers, we often try to make the measurement as simple as possible (within reason of course) and we are fond of linear relationships. One method of calibrating a transducer that gives a voltage output involves using the following equation to describe a voltage/physical measurement relationship.

$$Q = a * V$$

where Q is the desired physical measurement and V is the measured voltage. In order to get from V to Q, we need to know ‘a’. The process of finding ‘a’ is known as calibration. In this lab we will try to find a relationship (not necessarily linear) between the measured voltage from a pressure transducer and the air flow rate.

So how do we find the calibration constant?

If the relationship is linear, it is easy! We just have to take a known value of Q and introduce it to our system. Then it is just a matter of measuring the output voltage V. With Q known and V measured it is just an easy step to find ‘a’ by the formula Q/V.

Finding ‘a’ for our experiment:

Unfortunately for us, the pressure difference produced across the pnuemotachometer (flow tube) is not linear. Because of this, we will have to measure several values of ‘a’ for different known flow rates and produce a graph of flow ‘a’ vs. flow rate. We can then use a curve fitting algorithm (Excel can do this for us) to come up with an approximate expression to describe the resulting graph. Now we have an expression (most likely a polynomial) that we can plug our voltage into and achieve the resulting flow rate.

Equipment:

Ice Cream Maker

The Ice Cream maker is an example of a simple technology that uses the concepts of transport phenomena, which are fundamental to the chemical, mechanical, and aeronautical engineering disciplines and also applied in civil, materials science, and food engineering. An ice cream freezer has an outer insulating tub that helps maintain the freezing temperatures needed to make the ice cream. These temperatures are achieved by using a freezing mixture of salt and ice. The ice cream is held in a metal container to ensure that the heat from the cooling ice cream mixture flows efficiently and uniformly into the freezing mixture of salt and ice. Uniform cooling is essential to maintain the texture of ice cream that is produced, and determines the quality of the ice cream. This uniform and efficient cooling is achieved by using a motor and a set of gears to rotate the can while a set of scrapers continually clean the inner wall of the can to improve the heat transfer.

This lab involves setting up a thermistor inside the ice cream maker to measure the temperature change with time. The sensor is connected to the data logger to monitor the temperature change of cooling water (rather than of an ice cream mix).

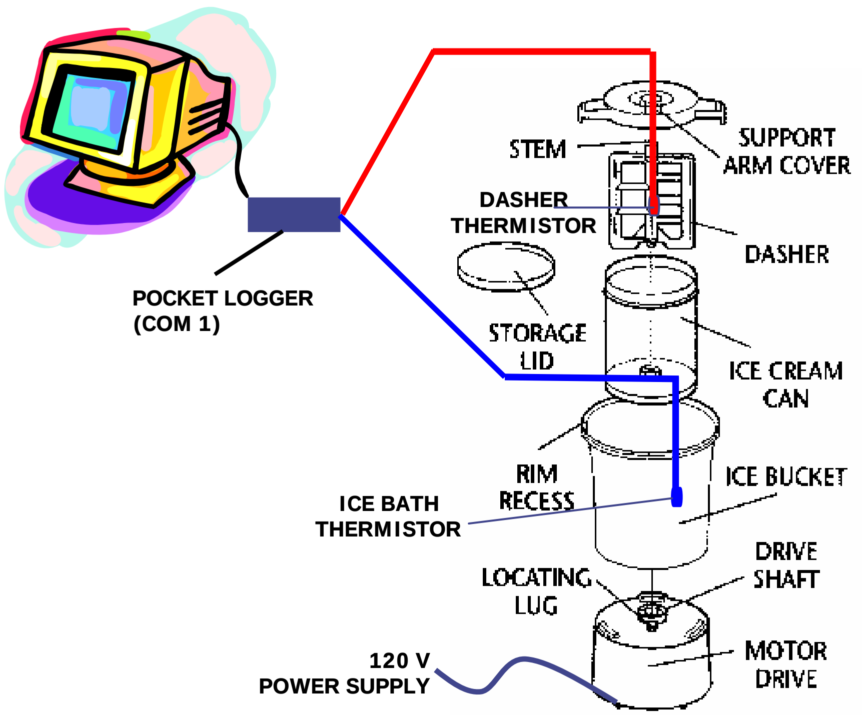


Figure 2: Schematic Diagram of the Ice Cream Maker setup. The Outer Bucket holds the freezing mixture of Salt and Ice. The can containing the ice cream mix or test water is placed inside the outer bucket. The motor moves the can while the dasher is held stationary. The central and peripheral heat sensors feed temperature data to the data acquisitioning system. The ammeter measures the current drawn by the motor.

The test water (hot body) is at a higher temperature than the freezing mixture of salt and ice (cold body). Salt is added to ice to reduce the melting point of the resulting mixture. The melting point of a mixture is *almost always less* then either of the pure components. There is a minimum melting point at a certain composition known as the "eutectic" point. For sodium chloride and water this minimum temperature is about –21 °C at approximately 22 wt% NaCl. The point of this is to have a liquid phase that is colder than pure ice so that we get *efficient* heat transfer out of the ice cream.

As the test water is being frozen the properties of the freezing water changes with time. How these changes affect the rate of heat transfer is governed by complex equations. With the knowledge of the heat transfer principles and the test water properties (how they change with temperature) an engineer would be able to design efficient equipment that ensures uniform cooling. These heat transfer calculations would provide the amount of refrigeration (Note: industrial refrigeration is done using ammonia, propane, or freon and is very similar to the household refrigerator) needed to maintain the test water at desired temperatures.

Another aspect of the design of the ice cream maker is to specify the kind of motor that should be used. Note that the motor generates a range of torque, so using a motor that generates too much torque or using a motor that doesn't generate enough torque would result in a bad design. An engineer would be able to specify the kind of stirrer needed to ensure proper mixing (this aspect becomes crucial when handling dangerous explosive mixtures where a non uniform concentration could result in an explosion) and this would be based on mass transfer equations, which are similar to those that govern heat transfer. As the amount of torque needed to turn the stirrer is related to the ice cream properties and this information can be used to decide when the ice cream is ready for consumption, it can be used to incorporate the auto shutoff feature.

Finally, we should look at the materials choices that were made in the design of this product. Almost everything is made of plastic because it is cheaper and easier to fabricate than metal or wood. The can is still made of metal though – why is this? There are probably many reasons, but it is the major moving part and may need to be stronger than plastic. Metal will also conduct heat out of the ice cream much more quickly than plastic because it has a higher thermal conductivity.

Lung Volume Apparatus

In the mechanical energy portion of this lab we will use a method to measure the lung's vital capacity. But before we can do that, we need to understand a couple of definitions.

Definition (Vital Capacity):

Vital Capacity = total lung volume – the residual volume

Definition (Residual Volume):

The **residual volume** is the amount of gas (air usually) that remains trapped in our lungs after we have expired as much air as physically possible. For the average adult this amount tends to be about 1.5 liters. Surprising?

So basically we want to measure the maximum amount of air that can be exhaled after a maximum inhalation. Since we cannot physically rip somebody's lungs out to measure the volume that results after they have taken in a maximum breath, we have to find a more humane method.

If we can measure the amount of air flowing out of the lungs as a person exhales, we can translate this flow into a volume. How? By multiplying the air flow (which has units m^3/time) by time. This is actually accomplished by calculating the area under the flow curve (calculus, and you thought the course was useless.)!

To measure airflow, we need the following items:

- A pneumotachometer (flow tube)
- A pressure transducer
- A data acquisition system

Below is an example of a pneumotachometer. Basically, it is a tube with two different size openings. As air flows through the tube, the different orifices allow a pressure difference to develop. It is this pressure difference that we are going to want to measure. How will this help us? The pressure difference is directly proportional to the amount of air flowing through the tube. Thankfully, this proportion can be made linear and we can find a constant that will allow us to directly calculate airflow from pressure difference.

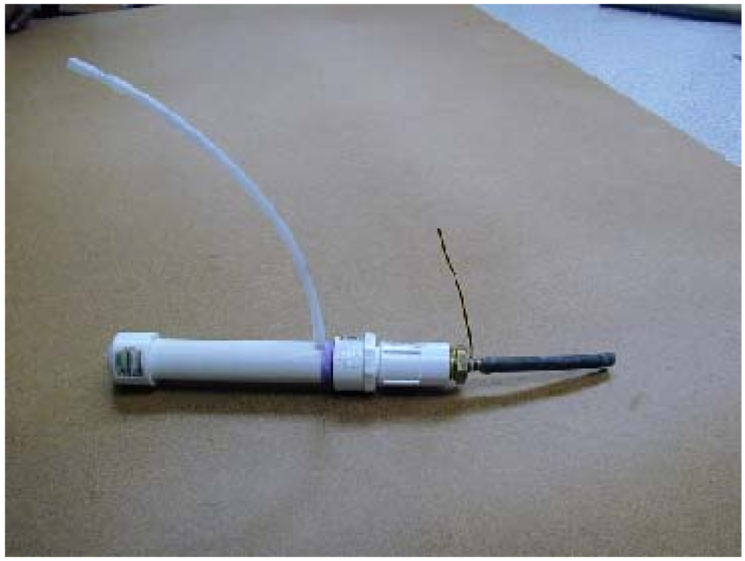


Figure 3: Example of a pnuemotachometer (or flow tube).

In order to measure this pressure difference we need to understand a little about pressure transducers and they are described in the next section. Once we have a measurement device, we have just about everything we need to measure the vital capacity. We just need something to record the measurements at some given interval. You should have already learned about data acquisition systems by this point. Our data logger will record the voltages associated with the airflow. This will provide us with a curve of volumetric flow rate versus time from which we will be able to measure the volume.

The goal of this portion is find the vital capacity of your lungs. So far we have found a curve that shows how the volumetric flow changes with respect to time. Think about this for a second. If we could add up all of the flows for every instant in time we would get the total volume of gas that flowed through the device. But this is hard because time is not discrete but is continuous. This means that we would have to sum the gas flow for an infinite amount of time values. Unless you have a lot of time on your hands, this method is not suggested.

Clearly, we need something a little bit better. Let's try dividing the time axis into very small increments and draw connecting lines to the curve from our increments (Figures 4 and 5). Now we have a graph divided into little rectangles and we can approximate the total amount of gas flow for each rectangle by multiplying the width (time) by the height (gas flow). If we add up all of the areas for the rectangles we get an estimate for the lung volume.

Now, imagine letting that the width of the rectangles starts to get very small. Each rectangle approximates our curve better and we get a more accurate estimate. If we let the width approach zero then we get the exact amount of air that was in the lungs. This process is known as integration in calculus and it allows us to find the area under a curve. In this case this area represents the volume of air that we were able to expel from our lungs.

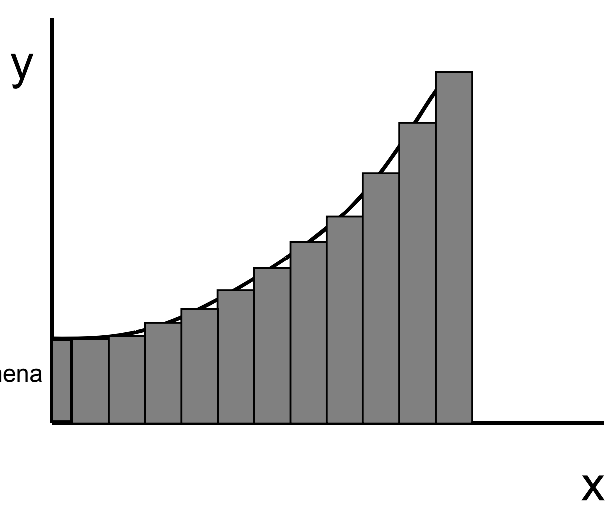


Figure 4: Example of summing the squares to approximate the area

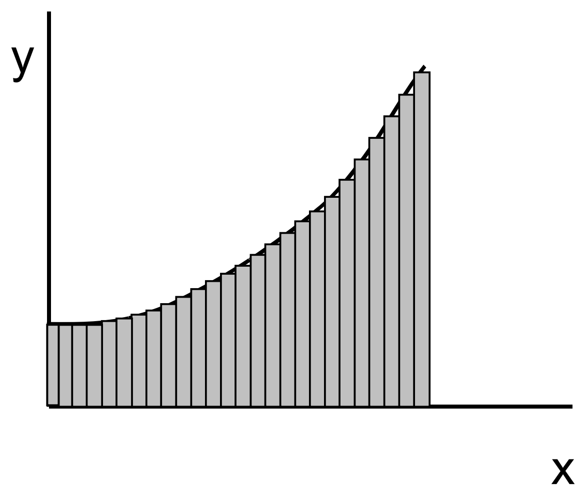


Figure 5: Example of summing the squares for a smaller approximating rectangle.

The Clinical Estimate of Vital Capacity

What if we just wanted a quick guess at what a person's vital capacity should be? Is there a correlation between sex, age, and height? The answer is 'Yes'! The following equations have been proposed that give an approximate guess at what your vital capacity should be given those characteristics mentioned.

$$males: VC = 5.2 \cdot height - 0.022 \cdot age - 3.60$$
$$females: VC = 5.2 \cdot height - 0.018 \cdot age - 4.60$$

VC in liters **height** in meters **age** in years

Now we have all the background information that we will need and we can get started on implementing our idea.

Lab Procedure:

This lab will be done in groups of 4 students. Because the data loggers are needed for both parts, you use the ice cream maker at one table and the lung volume apparatus at another. (The data logger records voltage data from the sensors.)

This lab involves **two** separate measurements using two types of sensors. There are three tasks to be performed:

1) Measurement of heat transfer during the freezing of water
2) Calibration of a pressure transducer in a flow meter
3) Measurement of your lung capacity using the flow meter

There are worksheets B1 and B2 for of the lab. Take your data on these worksheets and use them to complete your calculations.

Task 1: Heat transfer measurements during water freezing

Use Worksheet B1 (found at end of lab procedure) for recording all measurements

NOTE: Three teams must be ready to freeze water before doing this task!

1. Place the ICE BUCKET on the motor drive and rotate until it drops securely in place, engaging the coupler and drive shaft

2. Using the scale provided and a measuring cup put **approximately** 1000 grams of water into the ICE CREAM CAN. You will measure the weight of the full cup and then the weight of the empty cup to determine the mass of water. You will need to repeat this process a few times to get 1000g because the scales are limited. It is not important to have exactly 1000 g but it *is* important to know how much you have.

3. Measure the depth of water in the ice cream can – note it down in Worksheet B1

4. Measure the diameter of the ice cream can - note it down in Worksheet B1

5. Place can in ICE BUCKET. Be sure can engages drive hub of BUCKET. Do not put the DASHER in yet.

6. Setup the pocket logger software to collect real time data. The following steps are to be performed to set up the logger for real-time recording **by one team member**:
    a. Start up the **Pocket Logger** software by clicking on the icon on the PC Desktop.
    b. Load Pocket Logger setup information into the program by:
        i. Clicking on 'Send', then on 'Setup'
        ii. Click on the 'File' button in the 'Load' control area
        iii. Select the setup file '**ice4.set**' by double-clicking on that name
    c. The logger has a small switch attached to it. Toggle the switch back and forth one time, and insure it is left with its 'handle' pointing toward the switch's red wire lead (the OFF position). That action will allow the logger to receive and properly process the settings information.
    d. **Send** the settings file information to the logger by clicking on the "Send" button.
    e. Close the setup window by clicking on the 'Exit' button.
    f. Click the "**Receive**" menu item and select "**Receive Real-Time Graph**". You should now see a plot of the logger's four data channels; one representing the data switch and three representing each of the three ice cream maker's temperature versus time. **This plot contains no data that**

can be directly processed; it is just a picture to use mainly for monitoring the progress of your experiment

7. **When all three makers are ready, turn the Pocket Logger switch to ON** (towards the black wire lead). The logger is now storing your data to its memory. Note that the DASHER is equipped with a thermistor sensor placed in the center of the DASHER that monitors the temperature at the center of the can (refer to figure 2). Insure the thermistor is captured by a nylon tie near the bottom of the dasher. Insert DASHER into ICE CREAM CAN. Be sure that the bottom of DASHER fits into the indentation at the bottom of ICE CREAM CAN. You should observe a slight drop in the temperature being monitored by the data logger. Wait a few minutes to allow the temperature reading to level out. **This will be your initial temperature of the water.** Plug power cord into 120 volt AC outlet. NOTE: The DASHER does not move; the can turns around it. While the ice cream maker is running, pour about ½ cup of cold water into the ICE BUCKET.

8. Measure out 3/4 cup (6 ounces) of rock salt.

9. Add a layer of ice about 2" deep and sprinkle a thin layer of salt over the ice. Alternate layers of ice and salt up to the mold line of the ICE BUCKET. Do not use more than 3/4 cup of salt TOTAL.

10. Collect temperature data vs. time until the motor stops. This will take approximately 10-13 minutes. Should the ice cream maker stop before you expect it to (i.e. before the temperature of the DASHER is 0 °C (32 °F), check to see if large cubes are jammed against the rotating ICE CREAM CAN. If this happens, try to gently turn the can manually to break the jam. If you cannot do so, UNPLUG the ice cream maker and remove the offending ice cubes with your hand. Be careful!

11. NOTE: If for any reason the ice cream maker does not stop when the freezing is complete, unplug it after 20 minutes. DO NOT ALLOW UNIT TO RUN LONGER THAN 20 MINUTES AT A TIME.

12. You can save the screen image with "ALT + PRINT SCREEN" at any time, and past it into MS Word if you like. Save your plot **(plot 1)** (trace from data logger).

13. When the icemaker has stopped, you **unplug the power cord from the electrical outlet**. You are now ready to upload data from the Pocket Logger to the PC.
    a. **Close the real time graph** by clicking in the upper right corner X button, and then clicking the 'Yes' button in the dialog box that pops up.
    b. Turn the Pocket Logger switch to **OFF**.
    c. Select 'Receive' menu item and then 'Data' selection. Select the drive you are using for data storage (generally floppy or Zip disk) and enter a file name of 8 or fewer characters. Click the 'OK' button and wait for the PC to receive all the data.
    d. When the graph dialog box appears, click the 'Yes' button. A graph very similar to the real time graph should now show.
    e. Click 'File' and 'Export', and finish the process to get a .csv file on your Zip or floppy disk. - Refer to the "XR-440 Data Logger Reference Guide" for full instructions (see Static & Dynamic Measurements Lab).

14. Observe the contents of the ICE CREAM CAN and note observations for your report.

15. Clean and dry can, bucket, and motor base unit. Remove any water plastic container bin.

Task 2: Calibration of Volume Flow Tube

Due to time constraints for this lab, actual calibrations will not be performed. Instead, typical calibration data is given in the following table.

Volume Flow Rate (Liters per minute, LPM)	Voltage (from pressure transducer)
0	2.232
10	2.252
15	2.286
20	2.328
30	2.444
40	2.640
60	3.111
80	4.030

The following steps can be done in lab or outside of lab.

No equipment is necessary for Task 2, however **be sure to do Task 3 during lab time!!**

1. Enter the above data into Excel in two columns. Volume Flow Rate is the dependent quantity (Y values), while Voltage is the independent quantity (X values).

2. Create another column by subtracting the 'no-flow' voltage value (i.e., the voltage value when the Volume Flow Rate is zero) from each voltage value. As part of the result, this new column should have a value of zero in the first number cell of the column.
3. Create and properly label a chart **(plot 2)** of Volume Flow Rate as a function of this 'new' voltage.

4. Create two new columns of data by taking the LOG10 of the Volume Flow Rate and the 'new' Voltage, respectively. What happens if you take the log of 0.0?

5. Create another chart **(plot 3)** using the two columns of LOG10 values. DO NOT use the values associated with no flow in the chart as they are meaningless in the LOG10 form. The independent values are LOG10(Voltage) while the dependent values are LOG10(Volume Flow Rate). Create a linear trendline ('Add Trendline') for the LOG10 series of data and choose the 'Options' tab under 'Add Trendline' to select a display of the equation of the trendline. Make observations about the plot and trendline and include those observations and the chart in your memo. Save the trendline equation information (a slope value "SLOPE" and a y-intercept value "YINTER") for use in Task 3.

6. Save the Excel worksheet to your disk.

Task 3: Vital Capacity Measurement

This task will result in data from which you can determine your vital lung capacity.

Note: This task involves the use of a sensitive pressure transducer. **It can be easily damaged**. The **amber tubing** must **never be pinched off** in any way and must get its input from the flow tube only. Misuse is the main way a pressure transducer is damaged. You are responsible for the one you use.

1. Go to one of the stations where flow tube apparatus is set up.

2. CAREFULLY lift the lid of a disinfectant tub, lift a small cap from the fluid (isopropyl alcohol; it will not hurt most people's skin), hold the cap above the tub until the fluid stops running from it, and place the cap on a paper towel. Lift a flow tube, **with a number matching the cap** you chose, from the disinfectant fluid, and hold it above the tub until the fluid stops running from the flow tube. Then use a paper towel to further dry the **outside of the tube. Do not push anything into the tube.**

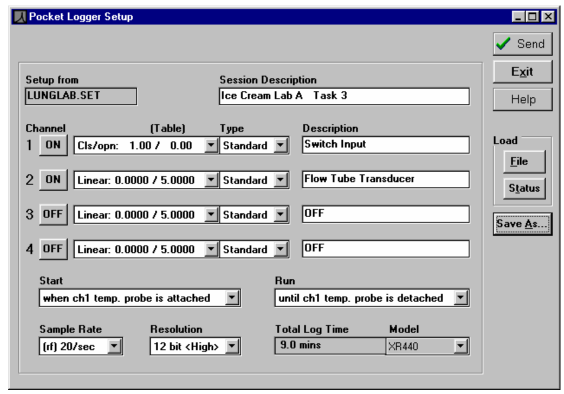
3. **Gently press the cap onto the open end of the tube.** You will have to remove it later.

4. Locate the free end of the amber colored latex tubing and gently push the latex tubing onto the smaller barbed fitting on the flow tube. (The other end of the amber latex tubing goes to a black box with a very sensitive pressure transducer inside. Also, there should already be a black latex tube on the larger barbed fitting).

5. Get a straw and insert it into the free end of the black latex tube. **Gently** twist the small wire 'clamp' only until the straw has no tendency to pull out (when gently pulled).

6. Lay the flow tube assembly on the table while holding only the straw if necessary to keep the straw from touching anything other than the user.

7. Insure the switch to the Pocket Logger is in the OFF position (marked in very small characters on the switch body, or make sure the top of the small toggle lever is 'towards' the red wire), and that the pressure transducer power module is plugged into an electrical outlet.



8. Begin to set up the Pocket Logger by double-clicking on the 'Pocket Logger' icon, click on 'Send' menu item, click on 'Setup', click on 'File' under Load selections, and double-click on the file name 'LungLab.set'. The information should appear as to the right:

9. Now click the 'Send' button. (Then click on 'Ok' button as necessary to finish the Send).

10. Insert your diskette or Zip disk into the respective drive.

11. Flip the Pocket Logger switch to ON and wait 5 seconds.

12. Pick up the flow tube, take a deep breath, pinch your nose closed, and exhale through the straw. Then rest for 5 seconds, take another deep breath, pinch your nose closed, and exhale again but at a different rate. Repeat a third time.
    Never exhale hard enough to feel "pressure" in your head or to make your face turn red!!

13. Lay the flow tube on the table, wait 5 seconds, and then turn the Pocket Logger switch to OFF.

14. Upload the data to the PC by clicking the 'Exit' button in the setup window, click on 'Receive' then on 'Data', select your disk drive and enter a file name of 8 characters or fewer.

15. Wait for the data to upload.

16. Click on 'Yes' to show a graph of the data.

17. If the data looks 'good', then disconnect the flow tube from the amber tubing, remove the straw, remove the cap, put the cap and flow tube separately back into the disinfectant, and discard the straw. (Let another person now start with the flow tube while you finish with data files).

18. 'Export' the data to a .csv file.

19. From Excel, open the .csv file and verify the data is there and looks 'good'.

20. Close Excel, remove your disk, and let another person begin using the PC and PocketLogger.

SUBSEQUENT USERS MUST BEGIN AT STEP #8, BUT INSURE THAT ONLY **ONE** COPY OF THE POCKET LOGGER SOFTWARE IS RUNNING!

The following steps can be done in lab or outside of lab.

Steps in Excel to finish the experiment:

21. Start up Excel and Open the .csv file exported in step 18.

22. In a convenient cell, use =AVERAGE() to get the average of the first 50 voltages in the 'CH2:' column. This is your 'zero' voltage (ZV).

23. In two other convenient cells, type in the slope and y-intercept values from Task 2. Let's call them SLOPE and YINTER respectively.

24. Create a new column by subtracting the ZV value from each value in the 'CH2:' column. Title this new column 'VU'.

25. Create yet another column by using =LOG10() applied to the VU column.

26. Create another column by using the LOG10(VU) column with the SLOPE and YINTER from Task 2 applied. Call this column LOG10(VFR), for Log base 10 of the Volume Flow Rate. (e.g., new column= Log10(VU) * SLOPE + YINTER).

27. Create another column, **with the real volume flow rate**, by raising 10 to the power of LOG10(VFR). Let's call this column VFR.

28. Now the **integration** (area under the curve) can be calculated by creating another column holding the average of each two adjacent flow rates (adjacent rows), and summing those values only within the range of actual airflow (i.e., pick your limits of integration by picking the range to sum over). The sum will be a single value for each exhalation trial within your data set. If you divide that value by the data sample rate (same as multiplying by the time between samples), and divide by 60 seconds per minute, you get your vital capacity in liters.

Example (not real data or cells):

…	F	G		H
1	VFR	VFRavg		VITAL
2				
3	Val 1	=(F3+F4)/2		
4	#NUM!	=(F4+F5)/2		
5	Val 3	=(F5+F6)/2	*	=SUM(G5:G9)/20/60
6	Val 4	=(F6+F7)/2	*	
7	Val 5	=(F7+F8)/2	*	
8	Val 6	=(F8+F9)/2	*	
9	Val 7	=(F9+F10)/2	*	
10	#NUM!	=(F10+F11)/2		
11	#NUM!	=(F11+F12)/2		
12	Val 10	=(F12+F13)/2		
13	#NUM!			

(The ‘ * ‘ is used here for clarity to mark the values for the integration in this example only. You must find the ‘good’ values in your data. There should be a continuous series of good values each time an exhalation occurred. There should be many more values than indicated here. The ‘ #NUM! ‘ indicator is the Excel program’s indicator for overflow, underflow, or operation on an invalid operator, such as the LOG10 of zero or a negative number. Many of these #NUM! may occur for values when there is no air flow through the flowtube)

Do the integration for each exhalation trial you performed.

29. **Combine** all team members’ vital capacities into a table along with the clinical values calculated by the equation given in the class notes.

30. Talk within your team to discover life choices or other factors affecting individual vital capacity (e.g., regular exercise, smoking, etc.), and note those factors in your memo.

31. **Choose one team member’s flow data** and use it to create a chart **(plot 4**) of Volume Flow Rate verses Time. You will have to create a column of times to use. (Remember the time between data points is just 1.0/(sample rate)). Place a text note of (or later hand write) the vital capacity values at each respective exhalation trial on the chart. Properly label the chart and include the chart and written observations in your memo.

Transport Phenomena – Lab B

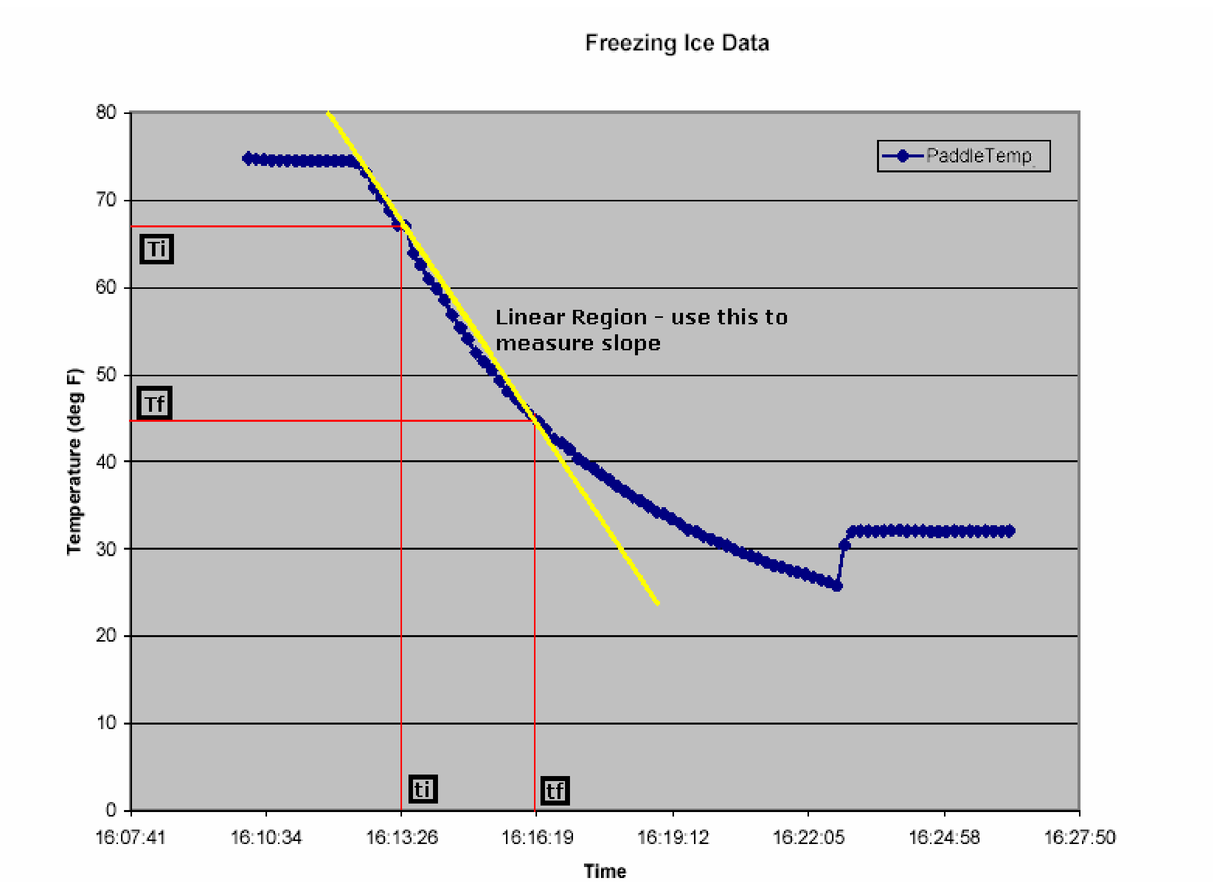
Worksheet B1 – Heat Transfer to Water and Nusselts number calculations

Sample Number	Mass of Water+Cup (g)	Mass of Empty Cup (g)	Mass of Water added to Can (g)
Total Mass of Water			

Depth of water in the ice cream can = _____________ (inches)

Diameter of the ice cream can = ______________ (inches)

The rest of the information should be taken from the data obtained by the data logger. At the end of the procedure for task 1, you will have a plot of temperature vs. time (plot 1) while the heat transfer was in progress. Your plot will look similar to the one shown below:



Identify a linear region in your plot – you will use this to measure slope in that region. From your plot, note the initial and final time (ti, tf) and initial and final temperature (Ti, Tf).

	Initial	Final
Time (min)	ti =	tf =
Temperature (°C)	Ti =	Tf =

Calculations

Work on the calculation after completing all tasks (Task 1 and Task 3) for the lab.

IMPORTANT NOTE:

1. **Pay close attention to the UNITS of all quantities. Conversion formulae will be provided as required.**
2. **All constants will be provided**

Step 1: Constants required for calculations:

Constant volume heat capacity for water [Cv] = 4.182 J/g.ºC = _________J/kg.ºK *(Conversion: 1000 g = 1 kg; Since the* ***°C*** *and* ***°K*** *are the same size, they may be interchanged in the above units)*

Thermal conductivity of water [k] = 0.609 J/m.sec.ºK

Density of water [ρ] = 1000 kg/m³

Absolute viscosity of water [μ] = 0.001 kg/m.sec

Step 2: Measured values and associated calculations:

All values from Worksheet B1 – apply appropriate conversions:

Mass of water [m] = _________kg *(Conversion: 1000g = 1kg)*

Depth of water in ice cream can [d] = _________m *(Conversion: 1m = 100 cm = 39.4 inches)*

Diameter of the ice cream can [D] = _________m *(Conversion: 1m = 100 cm = 39.4 inches)*

Length / Circumference of container [L] = π.D = _________m

Surface area for heat transfer [A] = π.D.d = _________m²

The container was measured to make an average of 15 revolutions in 25 seconds. Hence the linear velocity is:

Linear velocity [v] = Revolutions per second x Circumference of container

= __________ m/s

Step 3: Measurements from Task 1 – plot 1

You should analyze your plot 1 before you fill in the data. You should be able to identify a linear region in the temperature vs. time curve.

Time Interval [Δt] = $t_i - t_f$ = _____________s

Initial Temperature of water in container [Ti] = _________ºK

Temperature of water in container after Δt sec [Tf] = _________ºK
(Conversion: ºK = (ºF +459.67)/1.8)

Difference in temperature [ΔT] = Ti – Tf = _________ºK

Slope of the linear region [ΔT/Δt] = _________ºK/s

Total heat transferred from water (q): _________

Step 4: Calculation of Nusselt number from measured values:

You should state the units when not specified. State “no units” if dimensionless

Change in energy of water [Δq] = m.Cv. ΔT = _________

Average rate of change of energy [Q] = Δq / Δt = _________

Assuming that there is a thin layer of fluid (water) adjacent to the wall and that our container is a flat plate, the heat transferred by convection could be represented by the equation:

$$Q = hm \cdot A \cdot \Delta T$$

where,
hm: Mean local heat transfer coefficient;
A: Surface area for heat transfer;
ΔT: Temperature difference

Thus, mean local heat transfer coefficient [hm] = _________ J/m².sec.ºK

Nusselt number [Nu], is widely used in heat transfer data. It is a measure of heat transfer at the surface and is given by the equation:

$$Nu = hm \cdot L / k$$

where,
hm: Mean local heat transfer coefficient
L: Characteristic length (circumference, in our case)
k: Thermal conductivity of fluid

From our known/calculated values, Nusselt number [Nu] = _____________

What units do you use for Nu? Show derivation below – you may fill the table below to prove:

Units ▼/ Terms ►	hm	L	1/k
Units in Numerator	?	m	m.sec.ºK
Units in denominator	?	?	J

Step 5: Calculation of Prandtl number:

You should state the units when not specified. State "no units" if dimensionless

Prandtl number describes fluid properties and is given by:

$$Pr = Cv.\mu / k$$

where,
Cv: Constant volume heat capacity
μ: Absolute viscosity of fluid
k: Thermal conductivity of fluid (given constant)

From our known/calculated values, Prandtl number [Pr] = ______________

What units do you use for Pr? Show derivation below:

Units ▼/ Terms ►			
Units in Numerator			
Units in denominator			

Step 6: Calculation of Reynolds number:

You should state the units when not specified. State "no units" if dimensionless

As seen in Lab A, Reynolds number describes fluid flow – if the flow is laminar or turbulent. It is given by:

$$Re = L \, . \, v \, . \, \rho / \mu$$

where,
L: Characteristic length (circumference, in our case)
v: Characteristic velocity (linear velocity, in our case)
ρ: Density of fluid
μ: Absolute viscosity of fluid

From our known/calculated values, Reynolds number [Re] = ______________

What units do you use for Re? Show derivation on next page:

Units ▼/ Terms ►				
Units in Numerator				
Units in denominator				

Step 7: Correlation between Nu, Pr and Re:

It is possible to describe heat transfer (or Nu, equivalently) using the fluid property (Pr) and fluid flow property (Re). While, the derivation of correlation equation is beyond scope of this lab, it is given by:

$$Nu = 0.664 \cdot Re^{1/2} \cdot Pr^{1/3}, \quad \text{if } Re < 5 \times 10^5$$

$$Nu = [0.037 \cdot Re^{0.8} - 850] \cdot Pr^{1/3}, \text{ if } 5 \times 10^5 \leq Re \leq 10^7$$

From Re in Step 6, choose an appropriate equation to calculate Nu. List the equation used and compare the result with Nu in Step 4.

Equation used:____

Nu = ___________________

% difference in Nu = _________________

Transport Phenomena – Lab B

Worksheet B2– Lung Volume Measurement

In order to obtain the lung volume, you will need to perform numerical integration:

1. Import your .csv file of your lung volume data.
2. Approximately the first five seconds of your data correspond to the zero flow rate. You should take an average of this five second interval and subtract the average from the entire data set.
3. Using the calibration polynomial that you obtained, convert all of your voltage values to a flow rate. Note: you graph this flow rate vs time and include the graph in your memo.
4. Use the following equation to obtain an approximation of the area under the curve.

$$Volume = \sum_{n=1}^{m-1} \frac{(i_{n+1} + i_n)}{2} \Delta t$$

$$\text{i} = \text{the data sample}$$

$$\Delta \text{t} = 0.05$$

$$\text{m} = \text{the total number of data samples}$$

Task 3 Vital Capacity Table:

	Gender	Age	Estimated Vital Capacity	Measured Vital Capacity 1	Measured Vital Capacity 2	Average Measured Vital Capacity
Member 1						
Member 2						
Member 3						
Member 4						
Average						

Lab Report Requirements -

Note – This is a TEAM REPORT and not a Lab Memo. Use the Lab Report format described in the student course packet.

Transport Phenomena Lab A & B Report Guidelines: (200 pts)

Content	Points Worth	Point Value
Cover Sheet with proper formatting, Table of Contents, Table of Figures, Executive Summary	**5 pts**	
Introduction	**10 pts**	
1. Brief Introduction of objectives/ goals of the labs.	6	
2. Introduction to contents of the report.	4	
Lab A - Task 1 – Falling Sphere Viscometer	**30 pts**	
1. Briefly state the purpose of the experiment.	5	
2. Complete worksheet A1. Show sample calculations on a separate sheet.	15	
3. Show why water was not used in the falling sphere experiment, keeping all other parameters the same. Show your calculations.	5	
4. Does relative density appear to be related to relative viscosity (consider all three fluids to reach a conclusion)? Why or why not?	5	
Lab A – Task 2 – Capillary Flow Viscometer	**40 pts**	
1. Briefly state the purpose of the experiment.	5	
2. Complete worksheet A2. Show sample calculations on a separate sheet.	15	
3. In the capillary flow viscometer, what would be the effect of using a shorter capillary? Show your calculations.	7	
4. By what factor would the flow rate decrease if the capillary radius was reduced by ½? Show your calculations.	3	
5. If the capillary radius was doubled for the canola oil part of the experiment, would the flow become turbulent or remain laminar? Show your calculations.	7	
6. Why do you think corn syrup or glycerin wasn't used for the capillary experiment? Why do you think canola oil wasn't used for the dropping sphere experiment?	3	
Lab B – Task 1 – Heat Transfer Measurements	**45 pts**	
1. Briefly state the purpose of the experiment.	5	
2. Worksheet B1	20	
3. Plot 1: Plot or screen capture– Heat Transfer curve with slope, Ti, Tf, ΔT, ti, tf, Δt clearly marked and calculated	5	
4. The rate of heat transfer measured in the experiment was to cool the water from room temperature to the freezing point. Even though you made some ice, the ice cream maker (should have) stopped before the entire contents of the can were frozen. As water changes state from liquid to ice, the temperature remains constant even though heat is still being lost. This heat is known as the heat of fusion and for water it has a value of 333.6 Joule/g. If the average rate of heat transfer you measured is constant throughout the freezing process, how long will it take to for all the water in the can to change to ice? First calculate the total amount of heat transfer necessary to freeze all the water, then divide by your average heat transfer rate to get the time.	5	

5. Think of a way to increase the heat transfer rate. Sketch what you think the temperature vs. time profile would look like for this higher rate – it could be an approximate plot with clear labels and titles.	4	
6. Think about the design of the ice cream maker - Note that the motor rotates the can while holding the dasher stationary. Why is this better than moving the dasher while holding the can stationary? Also, why is the can the only metal part of the ice cream maker?	3 + 3	
Lab B – Task 2&3 – Vital Capacity (calibration and measurements)	**55 pts**	
1. Briefly state the purpose of the experiment.	5	
2. Complete worksheet B2. Show sample calculations on a separate sheet.	20	
3. Plot 2, 3, 4: Should be clearly labeled	10	
4. How did the measured vital capacity compare to the clinical estimates?	5	
5. Given the other members in your group, how does the vital capacity seem to vary for gender, height, and age? (Note: you might want to obtain additional data from some of the other groups.)	5	
6. What sources of error might be present in the vital capacity measurement?	5	
7. Explain the importance of calibration and how it was used to calculate the vital capacity.	5	
Conclusion	**10 pts**	
Lab Participation Agreement	**5 pts**	

Lab 7: Camera Lab A - Shutter Mechanism Procedure

Goals

This lab exercise will take the camera apart and analyze its components. The first part of the procedure tells you how to do this safely, and in a way that will allow you to put the camera back together completely, if you're careful. We'll help you remove the batteries and discharge the capacitors, so you don't get a nasty shock while working with it. The lab exercise breaks down the procedures into three major steps:

- Task 1 - blur angle analysis
- Task 2 - flash speed
- Task 3 - shutter speed

Background

One of the most important components of any camera is the shutter mechanism. The shutter is crucial because it must be reliable, repeatable, and (in a flash camera like this) it must be perfectly synchronized with the flash circuit – the flash must trigger when the shutter is wide open, otherwise the photos will be ruined. The problems involved in designing and manufacturing a shutter that can do all these things are made even more challenging when the selling price of the camera is only ten dollars. As you take the camera apart, pay close attention to how the Kodak engineers managed to meet all these constraints successfully.

If we're reverse engineering this camera, one of the first things we want to know is, "How fast is the shutter?" Since the camera has a flash, we'd also like to know the duration of the flash itself. We'll use two different methods for determining these values: the photos are in your student course packet, and the photo-sensors connected to the virtual oscilloscopes.

Materials/Equipment

- Plastic protractor
- Light probe with 6' BNC cable (connected to computer)
- Flashlight
- Kodak Max Flash camera

Procedure

<u>Task 1 - blur angle analysis</u>
Blur Angle Analysis

First we'll estimate the shutter speed from the photographs provided, using protractors to measure the "blur angle", and then follow the calculations given in the lecture. Notice that the photos taken with the flash don't really show much spoke blur. (This means that using the photos to estimate flash duration is not highly accurate.)

1.1. Using the blur angle photos and formula sheet from your lab manual (following this procedure):

1.2. Each team member should take a different one of the 'blur' prints and measure the swept angle (blur) made by a wheel spoke. Choose a spoke blur with sharply defined edges and use the protractor to measure the included angle (the angle formed by the edges of a single spoke blur). Draw lines that intersect to define a center point. This is necessary since bicycle spokes do not point at the center of the wheel. Note which picture title (e.g. BLUR 1, BLUR 2, etc…) was used to get the blur angle.

1.3. Record all the blur angle measurements in an excel spreadsheet up front so all class members can obtain data for the entire group.

1.4. Use the formulas on the handout following the pictures, and a bicycle wheel diameter of 26" and speed of 15 mph to find a shutter speed (the time the shutter was open). You will use the values along with all the values from other teams for a statistical analysis.

<u>Task 2 - flash speed</u>
Flash Speed Analysis

Next we will directly measure the flash duration using the oscilloscope, a flashlight and light probe:

1.1 Disassembly of the Camera
To begin, we need access to the film advance mechanism internally:

a. It's possible to disassemble and re-assemble the camera if one uses a little care in taking it apart. The camera is held together with "snap fits", which are molded into the components. In order to take the camera apart without breaking it, you'll need to pry the snap fits apart, one at a time. This will require you to use a small tool, such as a bent paper clip or a very small screwdriver, and some patience! Follow the instructions provided below…

☠ …**and pay special attention to the safety guidelines!** ☠

b. First, peel the labeling off of the camera, so that you can see all of the snap fits.
c. Next, remove the back plate of the camera. There is a set of snap fits on either side of the camera, and one each on the top and bottom as well. Another small snap fit is located at the top right center of the back plate near the viewfinder and

the thumbwheel (see Figure 1). Loosen these and then gently pry the back off at the upper right and lower left corners, leaving the front cover in place.

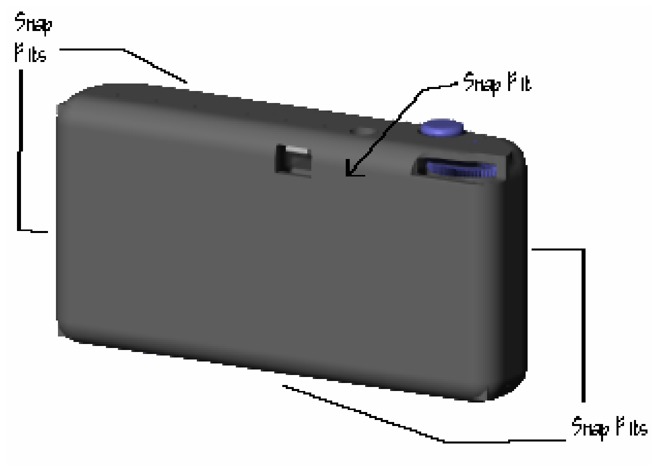


Figure 1

d. ***Remove the battery!*** This is very important to avoid accidental shock. The battery is located on the far left of the rear of the camera**. *Pay special attention to the orientation of the battery before you remove it***. To charge the flash circuit, you'll put the battery back in the circuit board, so it's important to note the polarity before you remove it.
e. Once the battery is removed, take out the empty spool in the left film cavity.
f. At the back of the camera, just above the exposure chamber, you'll see a small-toothed wheel that is attached to a part of the shutter mechanism (see Figure 2). This cogwheel engages the film when the camera is loaded. As the user advances the film between shots (using the large thumbwheel on the right), the small wheel rotates the cam to which it's attached, which causes several other actions to occur. . **Do not remove any other parts of the camera. Doing so will expose you to a 300V shock hazard.**

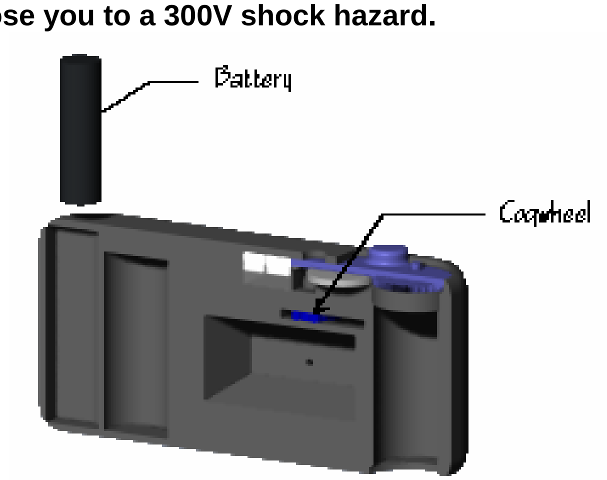


Figure 2

2.2 Connect one end of the BNC cable to the light probe. Connect the other end of the cable to the back of the computer on 'Ch 0'. (The rightmost of the three larger round connectors on the O-SCOPE card in the computer).

2.3 Setting up the Virtual Oscilloscope:

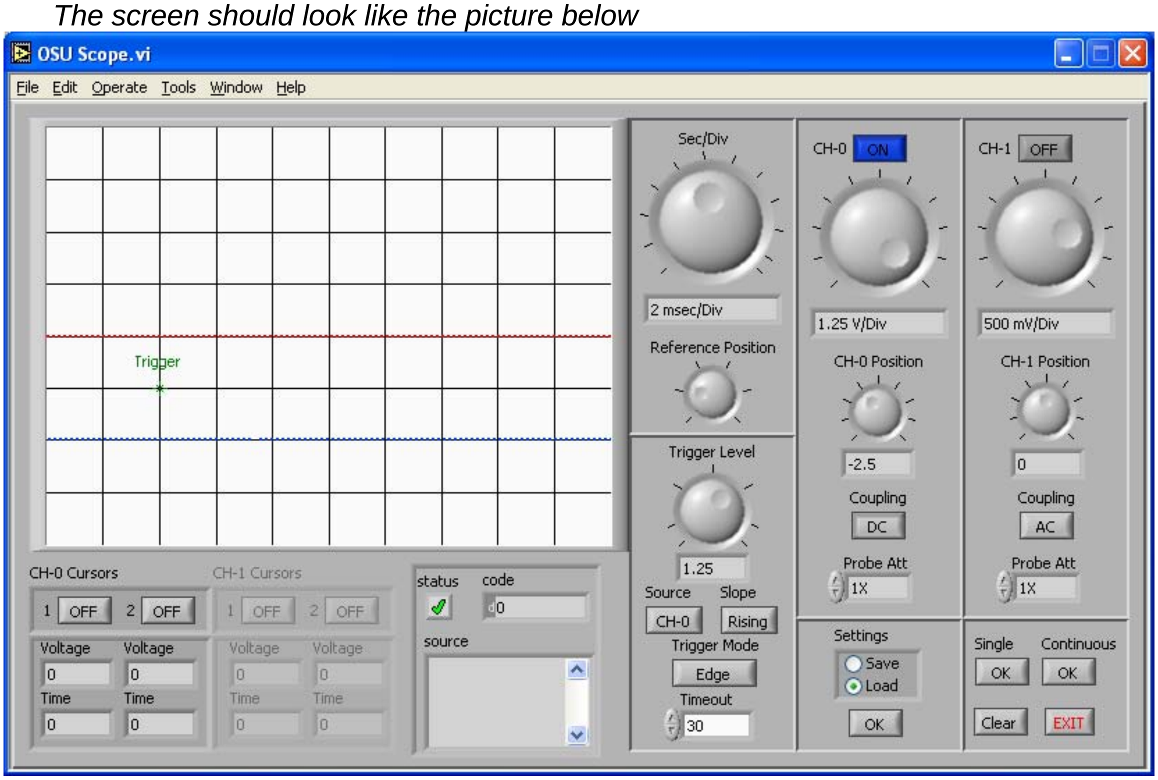
a. Double click on ‘OSU Scope’ icon on the desktop.
b. Load the Camera Lab A settings file to set up the oscilloscope as described below.

- In the ‘Settings section’, select the ‘Load’ radio button, click ‘OK’
- Select ‘C:\apps\scope\CameraA.sco’ in the file requestor

Check to see that you have the following settings

- CH-0 “ON”, Volts/Div = 1.25V, Position = -2.5V, Coupling “DC”, Probe Attenuation “1X”, CH-1 “OFF”
- Timebase = 2 msec/Div, Reference Position adjusted so trigger cursor is 2 major divisions from left edge of display
- Trigger Level = 1.25V, Source “CH-0”, Slope “Rising”, Trigger Mode “Edge”, Timeout 30

The screen should look like the picture below

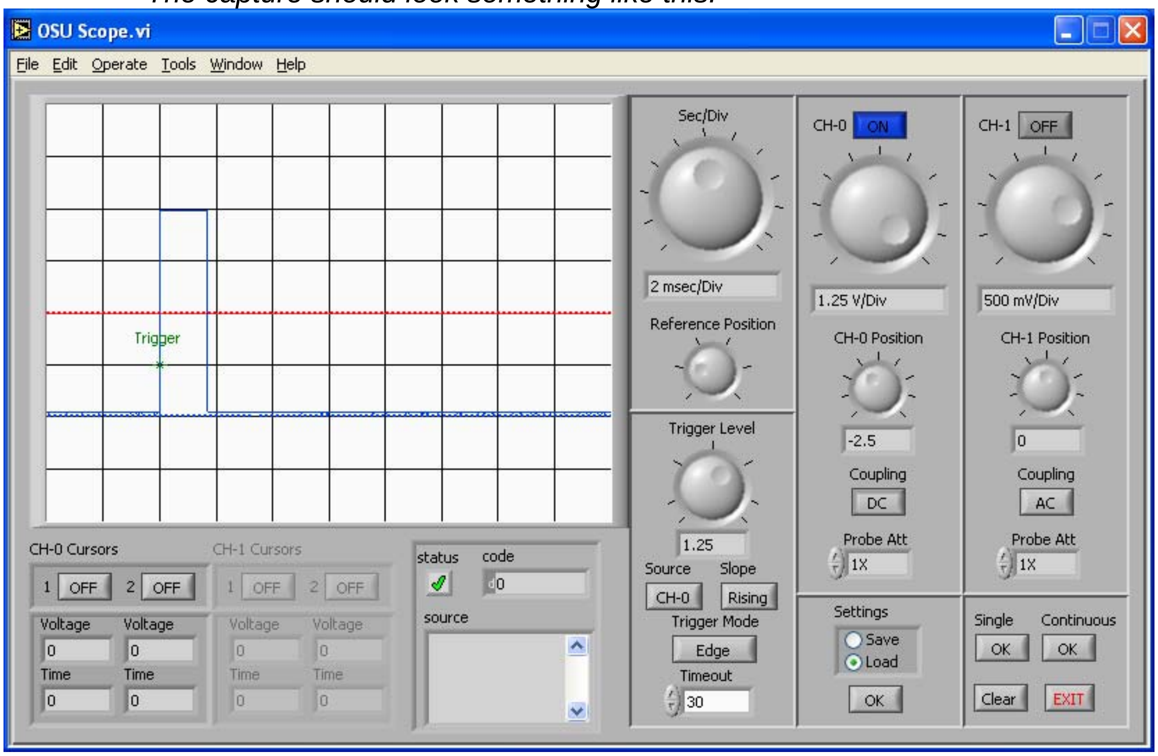


c. To verify the oscilloscope, we will test a signal from a flashlight. Press **and hold** the button on the probe. Click on the ‘Single’ button on the oscilloscope screen to enable the capture. With the flashlight on, wave the flashlight about an inch in front of the probe. On the oscilloscope, you should see a square wave that starts at the trigger mark. If the waveform extends beyond the screen’s width without completing the square wave, you probably did not wave the flashlight fast enough. If you want to, repeat the steps above, waving the flashlight faster. Do this until the square wave appears on the screen. Note: to clear the display or any possible error messages, use the ‘Clear’ button at the lower right.

2.4 Flash Speed Measurement

a. To begin the flash speed measurements, insert the battery if you have removed it and wind the camera shutter mechanism.
b. Position the camera and light probe **across the table** from one another, with the probe pointing at the camera. A distance of **at least 3’** is needed.
c. Once the flash ready light on the camera turns on, hold the light probe button down, click the ‘Single’ button then push the shutter release button to trigger the flash.
d. Release the light probe button.
e. You may need to do this a few times to get good results.

The capture should look something like this:



f. Record your results and repeat this for each camera in your group. You can capture the active window by pressing ‘Alt+Print Screen’ and pasting the image to Word. Be sure to label each plot. (Save your work!)

3.0 Shutter Speed Analysis

Next, we will measure the shutter speed using the oscilloscope, light probe and the flash light.

3.1. Disassembly of the Camera front:

For safety reasons we will remove the battery, and then discharge the large capacitor.

☠ …**Pay special attention to the safety guidelines!** ☠

a. ☠☠ **The capacitor is the only part of the camera that can bite you. When fully charged, shorting the capacitor leads will discharge about 300 volts. Accidentally shorting those leads with your fingers will definitely get your attention! So, in order to perform the rest of the lab safely, we must remove the battery and discharge the capacitor completely, as described below.**

b. **Remove the battery!**

c. Next, use your thumb to rotate the cogwheel to the right until it you hear a click sound. After you have rotated the wheel as far as it will go, press the shutter trigger (it's part of the top piece). This will trigger the flash and dissipate a large portion of the capacitor energy —**provided the battery is already removed**.

d. Now, remove the front cover. Hold the camera near the center of the film cavities and gently pry the front cover off at the sides, as shown in Figure 3.

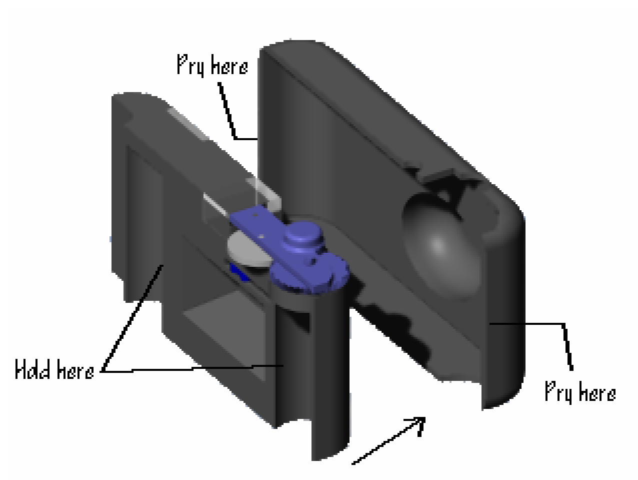


Figure 3

e. Removing the front cover exposes the circuit board. The capacitor is the cylinder located next to the circuit board, just beneath the shutter and lens. ***Do not touch any metal parts, especially the two leads coming from the capacitor!*** Give the camera to your TA to safely discharge the capacitor.

f. This camera is designed to automatically recharge the capacitor after each shot, but with the battery removed, that can't happen. Once the capacitor has been fully discharged, there is no further danger of being shocked. In Camera Lab B, next week, you will learn how the Kodak engineers can get such high voltage out of a somewhat puny 1.5 V battery.

3.2. *Setting up the Virtual Oscilloscope:* Now that the camera is safe, you will load the setting for the oscilloscope to measure the shutter speed and compare it with the flash speed:

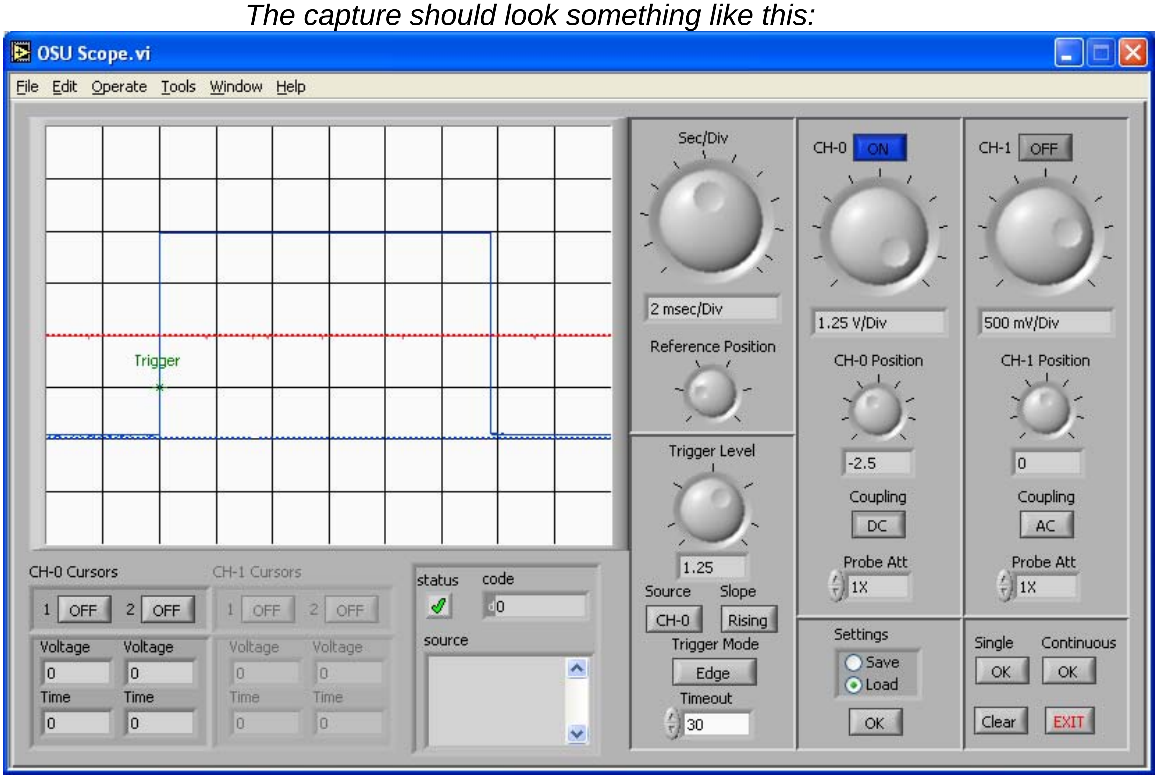
a. Press the ‘Clear’ button to clear the display, and if necessary, reload the flash measurement settings file to set up the oscilloscope.
   - In the ‘Settings section’, select the ‘Load’ radio button
   - Select ‘C:\apps\scope\CameraA.sco’ in the file requestor

   Recheck to see that you have the following setting
   - CH-0 “ON”, Volts/Div = 1.25V, Position = -2.5V, Coupling “DC”, Probe Attenuation “1X”, CH-1 “OFF”
   - Timebase = 2 msec/Div, Reference Position adjusted so trigger cursor is 2 major divisions from left edge of display
   - Trigger Level = 1.25V, Source “CH-0”, Slope “Rising”, Trigger Mode “Edge”, Timeout 30

b. You should now be ready to capture the shutter speed.
   - First, wind the camera shutter mechanism.
   - Shine the flashlight through the back of the camera.
   - Hold the light probe in front of the camera carefully lining it up with the lens. Make sure the small light sensor is at the center of the lens and lined up along the axis of the lens. This may involve holding the handle at a significant angle.
   - While holding the light probe button down, click the ‘Single’ button, then push the shutter release button.
   - Release the light probe button and remove the light probe from the camera.
   - You may need to do this a few times to get good results.

The capture should look something like this:

:



c. Record your results and repeat this for each camera in your group. You can capture the active window by pressing ‘Alt+Print Screen’ and pasting the image to Word. Be sure to label each plot. (Save your work!)

4.0 ***Data Collection:*** Make sure that someone from your group records all twelve data points for each set of measurements from your super-group! Before you leave the lab, your group should have twelve independent measurements for:

a. Shutter speed (photo estimate)
b. Shutter speed (light sensor/oscilloscope)
c. Flash duration (light sensor/oscilloscope)

Camera Lab A (Shutter Mechanism and Camera Systems) Memo Guidelines:

This is an **Team Lab Memo**.

Contents	Points Worth	Point Value
Header Information	**5 pts** (for header and memo format)	
Introductory Paragraph (3-5 lines)	**10 pts**	
1. Brief Introduction of objectives/goals of the lab.	8	
2. Brief introduction to contents of the memo.	2	
Results	**45 pts**	
1. Blur Angle values obtained	15	
2. Statistical Analysis (calculate Mean, Std-dev, etc) for your super group using Excel spreadsheet	20	
3. Sample Calculations (Written Out): Shutter speed using blur angle Mean for values of Task 3 Standard deviation for six values of Task 3	 3 3 4	
Discussion Questions	**30 pts**	
Two different methods were used to measure the shutter speed. Which method is better and why?	15	
Explain why the standard deviation differs for the different measurement methods. What does this tell you?	15	
Problems encountered (Conclusion) (3-5 lines)	**5 pts**	
Problems encountered during the lab.	3	
Change you might make (if any) & Conclusion.	2	
Lab Participation Agreement	**5 pts**	

Measuring the Blur Angle & Estimating Shutter Speed Formula Sheet (Accompanies Task 1 in Lab Procedure) Information from Lab Presentation, Slides 6-10

- Measure the blur angle (θ) with a protractor
- The radius of the wheel is r
- The bicycle traveled at 15 mph. Convert this to in/sec.

$$v = 15\ mph = \left(15\frac{miles}{hr}5280\frac{ft}{mile}12\frac{in}{ft}\right)\Big/\left(3600\frac{\boldsymbol{sec}}{hr}\right) = 264\ \frac{in}{\boldsymbol{sec}}$$

The amount of travel per revolution is: $c = 2\pi r\frac{in}{rev}$

The angular speed is given by: $\omega = v/c = \frac{v}{2\pi r}\frac{in}{\boldsymbol{sec}}\frac{rev}{in} = \frac{264}{2\pi r}\frac{rev}{\boldsymbol{sec}} = \frac{42.0}{r}\frac{rev}{\boldsymbol{sec}}$

If θ is the blur angle in degrees, the fraction (f) of a revolution is:

$$f = \theta\ \boldsymbol{deg}\frac{rev}{360\,\boldsymbol{deg}} = \frac{\theta}{360}rev$$

The time (t) for the wheel to move the fraction (f) of a revolution for a constant angular speed is related to f by: **f = wt**

The time (t) is expressed in the formula:

$$t = \frac{f}{\omega} = \left(\frac{\theta}{360}rev\right)\Big/\left(\frac{42}{r}\frac{rev}{\boldsymbol{sec}}\right) = \frac{\theta r}{360\boldsymbol{(}42.0\boldsymbol{)}}\boldsymbol{sec} = \frac{\theta r}{15,100}\boldsymbol{sec}$$

The speedometer actually measures the angular velocity of the wheel axis. It assumes a wheel diameter of 26” to convert to ground speed. Therefore, use r = 13 in and assume θ = 12 deg;

$$t = \frac{12(13)}{15,100}sec = 0.010\ sec\ = 10\ \boldsymbol{milli}\ \mathrm{sec}$$

Camera Lab A
The Shutter Mechanism
An Introduction to Experimental Error

The concept of error is inherent to any experimental process. In fact, it is a part of nature. This brief introduction will present the concept of experimental error, explain why it is important to us as engineers, and illustrate some of the ways that we deal with error as we encounter it.

- ***So what is error?***
  Most of us have grown up with the idea that the word "error" invariably means that someone made a mistake, got a wrong answer on an exam, etc. When scientists, engineers, and statisticians speak of experimental error, however, they are not referring to a mistake of any kind. Errors in scientific measurements are simply ***unavoidable uncertainties***. As technically sophisticated people, we recognize that perfect measurements are simply not attainable, and we find methods of dealing with this fact.

  There can be many sources of error. For example, if you use a stopwatch to time a worker performing a task, you introduce an error in the time measurement because it takes a fraction of a second for you to hit the start and stop buttons. There is no way to ***exactly*** account for that small deviation from the "true" elapsed time, and so an error is present in the reading. The same applies for the experiments we are doing in the labs.

- ***If error is inherent to all measurements, why do we care about it?***
  It's true that the presence of error is a given. What becomes important, then, is to try to ***quantify*** that error. That is, we need to know ***how large*** the error in our measurement is so that we can use the measurement with some degree of confidence. Another reason for estimating our "normal error" is that when a mistake *does* occur, we can spot it much easier, because it will lie outside the range of errors we expect to see.

- ***How can we get a handle on error?***
  Simply measuring a quantity once tells us little about the error associated with that measurement. The best way to get a handle on error is to take a series of measurements (a ***sample***) and then calculate a ***mean*** and a ***standard deviation*** based on that sample.

- ***What is the mean and standard deviation?***

  The ***mean,*** represented by the Greek letter μ, or mu**,** is our "best guess" of the true value of the quantity we're measuring. It's just the arithmetic ***average*** of all the measurements:

$$\mu = \frac{1}{N}\sum_{i=1}^{N} x_i$$

  where **N** is the total number of measurements.

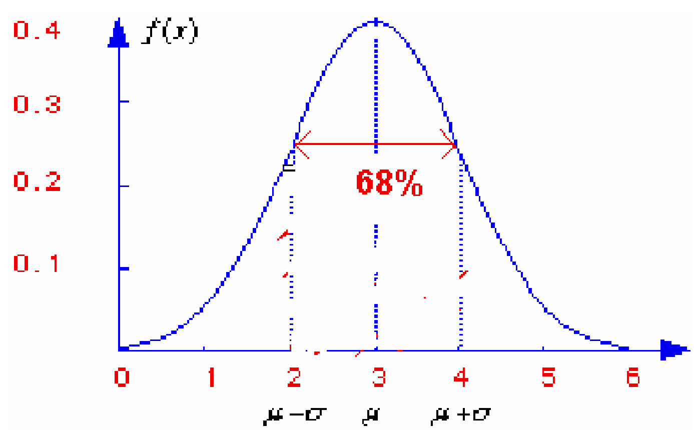
The sample ***standard deviation***, represented by the Greek letter σ, or ***sigma***, is the actual estimate of the error. It measures the average difference between our observed values and our best guess of the mean. The standard deviation is calculated from the sample using the formula:

$$\sigma_x = \sqrt{\frac{1}{N-1}\sum\left(x_i - \bar{x}\right)^2}$$

It can be shown that, in most cases, measurements subject to random errors have a ***normal distribution.***

- ***What is the normal distribution?***
The normal, or Gaussian, distribution is represented by a bell-shaped curve as shown below. The value of the quantity of interest is shown on the x-axis, and the probability of observing that value in a measurement situation is shown on the y-axis. Note that the highest probability corresponds to the mean and that the probabilities are symmetric about this mean value.

The normal distribution occurs very often in nature – in fact, your grades in this class will likely be normally distributed! It also has some interesting characteristics. Regardless of the value of N, μ, or σ, about 68% of your observations will fall within one standard deviation of the mean, as shown on the graph below. Ninety-five percent will fall within two standard deviations, and 99.7% will fall within 3 standard deviations.



We only have time to examine the normal distribution very briefly here. To learn more, check out the following website, courtesy of Stanford University:

http://www-stat.stanford.edu/~naras/jsm/NormalDensity/NormalDensity.html

Camera Lab A
The Shutter Mechanism
Introduction to the Oscilloscope

An Oscilloscope is an instrument that is typically used to measure and record voltage as a function of time. The oscilloscope you will be using is a virtual digital oscilloscope that has two "channels." The actual hardware resides inside the computer plugged into the PCI bus. The probes are connected to the inputs on the back of the PC. Since there are two inputs you will be able to display the voltage at two different points in your circuit as a function of time. An image of the main graphical user interface of the OSU Scope is shown in Figure 1. You will note in this figure that there are buttons to toggle on/off states as well as knobs and selection windows to adjust other parameters. You can pre-load values into the Scope to control the way data is displayed. We will discuss the details of some of these here and in the lab procedure.

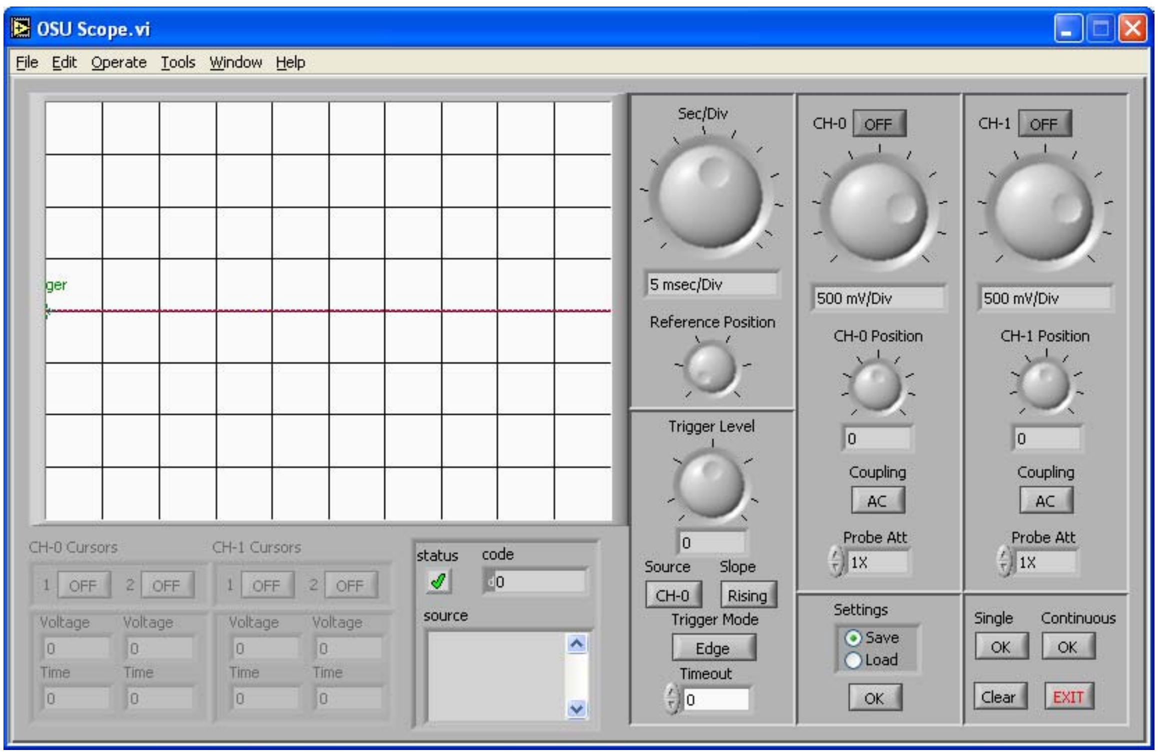


Figure 1: The main window of the OSU Scope

<u>Display Screen:</u> The front panel of the oscilloscope is divided into sections by function. The largest section is the display. The results of the measurements will be plotted on a graph on the display. The horizontal axis will be time, and the vertical axis will be voltage. You should note that the Voltage per division for the vertical axis is shown in the display beneath the V/Div knob for each channel. Also, the time base for the horizontal axis is displayed beneath the Sec/Div knob.

Vertical (Voltage) Scales: Located in the upper right of the OSU Scope window, they are labeled CH-0 & CH-1. The buttons at the top of this section toggle the displayed signal sources (Channel 0 and Channel 1) on or off, with the color of the button in the ON state corresponding to the color of the associated trace on the display. CH-0 is blue and CH-1 is red.

The V/Div knob adjusts the voltage per major scale division on the display. Note that the two channels can be set independently. The value can be read in the text display beneath each knob.

The CH-0 & CH-1 knobs control the position on the display of the zero level reference for each channel. These are marked by a thin horizontal bar of the appropriate color. The position is measured with respect to the center of the display, and is shown numerically beneath the position knob. Note that because of machine precision, 0V will be displayed as some very small number such as 207E-18.

The Coupling buttons control the display of any DC offset present in the incoming signal. DC coupling displays any such offset, while AC coupling ignores it, allowing the display of small signals with a large DC component.

Probe Attenuation takes into account the type of probe used. For example a BNC cable has no built in attenuation, and the scope is limited to the maximum 5V range, so it uses the 1X attenuation setting. A 10X probe, has a built in divide by 10 factor, so the scope can be used with a 50V signal, and it uses the 10X attenuation setting.

Horizontal (Time) Scale: Commonly referred to as the timebase, these controls are located between the vertical controls and the graphical display. The Sec/Div knob lets you adjust the timebase for the horizontal axis of the display. The time base is the same for all signals plotted on the display.

The Reference Position knob controls the horizontal position of the trigger point, marked by a green cursor labeled “Trigger”.

Trigger: While the oscilloscope can be set to continuously display the voltages being measured, that will usually result in a jumble on the screen. In our labs we will typically want to trigger the display at some point in time, so that the signal we want to observe gets displayed. You will use the controls in this section to define when the oscilloscope will start to display the voltages (the $t = 0$ point of the measurements). You will do this by setting a trigger level voltage, the position in the timeline, the trigger mode, the trigger source and the trigger slope. The trigger level will tell the oscilloscope to define $t = 0$ at the point the voltage crosses some value you set for the trigger level. The trigger mode can tell the oscilloscope to plot the voltage once and then stop. The source tells the oscilloscope which channel to use for the trigger. The trigger slope will tell the oscilloscope to trigger when the voltage crosses the trigger level with either a positive slope or a negative slope (and not to trigger if the voltage crosses the trigger level with the wrong slope.) The trigger level and its position in the time line is set by a ‘+’ cursor in green, which can be moved on the display panel.

Operational Controls: These are located in the lower right hand corner of the OSU Scope window.

The Single button activates the once, acquiring and displaying one set of traces, and returning the scope to an inactive state. This is normally used for non-periodic signals.

The Continuous button activates the scope, acquiring and displaying traces until the button is pressed again, then returning the scope to an inactive state This mode is normally used for periodic signals.

The Clear button will clear the display, and clear any error messages as well.

The Exit button will stop all data acquisition and exit the OSU Scope program.

Settings: The settings controls allow presets for the front panel controls to be loaded and saved. Presets will generally be provided for labs.

Error Status: This is below the waveform display and next to the trigger controls. It contains error codes and descriptions of any errors. Common errors you might see include timeout (no trigger after waiting a predetermined amount of time) and no channel enabled (trying to acquire a signal without enabling CH-0 or CH-1) Most errors are not serious, and can be cleared by pressing the Clear button in the Operational Controls.

Cursors: The cursor controls are located at the lower left of the OSU scope window. They only become available for a channel that is active, and match the color of the channel. Each channel has two cursors, and a numerical display of voltage and time. The cursors are locked to the waveform, and can be dragged left or right by the vertical line to take measurements at a specific point of the waveform.

ENG 181 Camera Lab A Worksheet

Quarter/Section: ____________________
Instructor: ____________________
TA/PM: ____________________

Team	Blur Picture Number	TASK 1: BLUR ANGLE (Degree)	TASK 1 : Shutter Speed (*1) from BLUR ANGLE (ms)	TASK 2: Flash Duration from O_SCOPE (ms)	TASK 3: Shutter Speed from O_SCOPE (ms)	Team	Blur Picture Number	TASK 1: Blur Angle (Degree)	TASK 1 : Shutter Speed (*1) from BLUR ANGLE (ms)	TASK 2: Flash Duration from O_SCOPE (ms)	TASK 3: Shutter Speed from O_SCOPE (ms)	Team	Blur Picture Number	TASK 1: Blur Angle (Degree)	TASK 1 : Shutter Speed (*1) from BLUR ANGLE (ms)	TASK 2: Flash Duration from O_SCOPE (ms)	TASK 3: Shutter Speed from O_SCOPE (ms)
A						D						G					
B						E						H					
C						F						I					
		Mean >>						Mean >>						Mean >>			
		SD >>						SD >>						SD >>			

NOTE:
***1 With the Blur Angle measurement, use the formula given in the presentation slides/handout, to compute the Shutter Shutter**

Show your sample Calculation for Mean:

Show your sample Calculation for Standard Deviation:

BLUR ANGLE 1

BLUR ANGLE 2 -

BLUR ANGLE 3 –

BLUR ANGLE 4 -

WITH FLASH

Fundamentals of Engineering
Engineering 181

Pre-lab Assignment for Lab 8, Camera Lab B: Camera Circuitry

What You Have To Do Before Lab 8

1. Carefully read all the material for Lab 8. If you like, you can even visit a library or use the web to find out more about these things.
2. Perform the pre-lab assignment at the end of this document. The pre-lab tasks are to be performed and turned in by each person at the beginning of lab 8. You will **NOT** have time to do it at the beginning of Lab 8. The pre-lab is an **individual** assignment.
3. **Note**: The pre-lab assignment is not a lab memo. It does not have to follow the lab memo format.
4. The pre-lab assignments will be due at the beginning of Lab 8 and will count as 15% of your lab memo grade.

What You Have To Do After Lab 8

1. Analyze the results of the measurements you performed in Lab 8.
2. Prepare a **team lab memo** on Lab 8. You will be given a set of discussion questions that are specific to the Lab 8 memo. Include these questions in your lab memo.
3. Be sure to review the grading guidelines provided after the Lab 8 Procedure to be sure of memo requirements and distribution of points.

Fundamentals of Engineering
Engineering 181
Camera Lab B: Camera Circuitry

1 Objectives of Camera Lab B

The Kodak Max Flash camera contains a circuit for operating the flash. We do not expect you to become an instant expert on the operation of this circuit. We do expect you to:

- Develop an understanding of the distinction between the core functions and auxiliary functions of the flash circuit and acquire a "big picture" view of what the circuit must do to perform the core functions.
- Acquire experience in using a voltmeter and an oscilloscope to measure voltages in the circuit.
- Be able to calculate currents flowing in certain parts of the circuit using the measured voltages together with the values of some of the components.
- Develop an understanding of how and why the speeds of various parts of the flash circuit are related to the speeds of other parts of the camera.

The components and operation of some parts of the circuit are more complex than others are. Understanding the operation of the more complex sections requires more background than we will be able to give you in this quick touch on electronic circuits. These more complex parts of the circuit will receive only a cursory treatment in this laboratory.

2 Background

2.1 The Core and Auxiliary Functions of the Flash Circuit

2.1.1 <u>The Battery and the Flash Tube</u>

The overall objective that the flash circuit must meet is to provide a short flash of light that is synchronized with the shutter of the camera. This is basically a problem in synchronized energy conversion that engineers solved with the flash circuit. Before we can look at the core functions of the camera circuit we must take a brief look at the battery at the input end of the system and the flash lamp at the output.

The energy for the flash of light comes from the AA battery in the camera. The battery is basically an energy storage and conversion device. It stores energy in chemical form and converts it to electrical form.

In general, a battery makes its electrical energy available when the user "completes a circuit" between the battery's positive and negative terminals. In this case to "complete the circuit" means to provide a path for electrical current to flow out of the positive terminal of the battery, through the device that the battery is powering, and back to the negative terminal of the battery. The term "electrical current" refers to the motion of electrons through the wires and components of the circuit. More will be said about current in the **Basic Concepts** section of this document. Note that the current eventually comes back to where it started. This is the origin of the term "circuit." In general, current will not flow unless such a closed path exists.

The AA battery is a 1.5 volt battery. It has a voltage difference of 1.5 volts between its positive and negative terminals. The battery supplies current to the circuit at an electric potential, or voltage, of 1.5 volts. (For a discussion and definitions of voltage, electric potential and current see the **Basic Concepts** section.) The current that returns to the battery comes back at an electric potential that is 1.5 volts lower than when it left the battery. This difference is related to the energy delivered to the components that the current passed through in the circuit.

The flash lamp in the camera is also an energy conversion device. It converts electrical energy into optical energy. The flash lamp is very different than a typical incandescent light bulb since flash photography requires a very fast and bright light pulse.

The flash lamp has the form of a sealed glass tube with an electrode at each end. The flash tube requires a voltage difference of several hundred volts across the two electrodes for it to operate. However, it is not sufficient to merely apply this voltage. Unlike an incandescent light bulb, the flash tube does not have a wire inside it between the two electrodes. Rather, the tube is filled with a gas. Under normal conditions the gas does not provide a path for current flow from one electrode to the other. That is, under normal conditions the gas is an "open circuit" and has a resistance to current flow that is so large we can consider it to be infinite for most practical purposes. It is not our purpose to study the physics of what happens inside the flash tube during a flash. It will suffice to say that under the right conditions the gas in the tube can be made to *break down* and form a *glow discharge*. In the glow discharge some of the atoms have one electron removed. The atoms that are short one electron have a positive charge and are known as ions. The voltage applied between the electrodes of the lamp cause the negative electrons and positive ions to move (in opposite directions), and moving charge is current. As a result the glow discharge has a relatively small resistance to current flow. Light is emitted as the electrons relax back to their normal locations on the atoms.

The right condition to trigger the flash is a voltage pulse applied to a third electrode (a trigger electrode) placed very close to the side of the flash tube. The metal mirror, or reflector, behind the flash tube has double duty. In addition to reflecting the light that comes out of the back of the lamp toward the front of the camera, it serves as the trigger electrode. The required trigger voltage pulse is more than a thousand volts and causes the gas in the flash tube to break down. Once the flash tube is triggered the glow discharge in the tube provides a low resistance path for current to flow between the electrodes at the two ends of the tube.

The trigger voltage is only needed to start the discharge. Once the glow discharge is started the voltage applied across the tube will maintain the glow discharge. The current flow will persist as long as the voltage across the two electrodes is above some minimum value (typically a few tens of volts).

2.1.2 The Core Functions

It should now be apparent that there is a mismatch between the battery and the flash tube. The battery provides a voltage of 1.5 volts, but the flash tube needs much larger voltages. The flash circuit provides the interface between the battery and the flash tube. It must take what the battery supplies and convert it into something that is useable by the flash tube.

While it may be possible in principle to design a circuit that will directly match the battery to the flash tube as soon as the shutter is triggered, such a circuit would definitely be expensive compared to the low cost of the camera. It would probably also be too large to fit inside the existing camera box. A circuit that can accomplish the required goals can be made economical and small enough to fit in the camera by breaking the overall process into two parts. These two parts are the core functions of the flash circuit.

The first core function (charging) starts when the user presses the charging button on the front of the camera. As a result, chemical potential energy stored in the battery is delivered to the circuit at only 1.5 volts. The circuit increases the voltage up to a much larger value. The small current is delivered to a large capacitor in the circuit. As a result of the small current the capacitor slowly "charges up" to close to 350 volts. This takes several seconds, much longer than the time the shutter is opened, so it must be done before the picture is actually taken (In Lab 8 you will measure how long this takes). The capacitor is used to temporarily store the electrical energy delivered from the battery through the circuit, but now the energy is at a large enough voltage to be useful for the flash lamp. The flash tube is connected directly across the capacitor so the voltage on the capacitor also appears across the flash tube. However, since the flash tube normally has very high resistance, it does not flash yet.

The second core function (trigger) starts when the shutter is opened in the process of taking a picture. The circuit uses a small fraction of the stored electrical energy to generate a very quick flash trigger pulse to initiate the glow discharge in the flash tube. Once the glow discharge is started the flash tube temporarily has a very low resistance, allowing the energy stored in the capacitor to quickly discharge through the flash tube, where much of it is converted from electrical energy into optical energy. (The remainder is converted into waste heat.) This happens very quickly, while the shutter is open (In Lab 8 you will measure just how fast these processes are).

2.1.3 Auxiliary Functions

The circuit performs a few convenience functions in addition to the two core functions. One is to illuminate a pilot light to let the user know when the circuit is charged and ready for flash photography. The charge stored on the capacitor slowly leaks off. If the amount of stored charge becomes too low, the flash will be too weak or may not happen at all. The neon light goes out if the voltage across the flash lamp becomes too small. This lets the user know they need to restart the charging circuit before taking a flash picture.

The two core functions and the pilot light were the only functions performed by the flash circuit in the first generation of the Max Flash camera. The user of the first generation camera had to press <u>and hold</u> the charging button until the pilot light turned on. A flash photograph could then be taken within a few minutes (before the pilot light went out). In order to take another flash photograph the user had to press and hold the charging button until the pilot light came on again.

The flash circuit in the current generation of the MAX Flash camera has a few additional functions. First, the user only has to momentarily push the charge button to start the charging cycle. The circuit **latches** into an "on state" and keeps charging the capacitor until the flash capacitor is fully charged. Since the charging circuit is latched on, additional modifications had to be added to automatically unlatch it after the capacitor is fully charged. Otherwise the battery would be quickly drained.

Another convenience feature that was added causes the flash circuit to automatically recharge after a flash photograph has been taken. In this way the user doesn't have to remember to press the charge switch between taking flash photographs.

2.2 A Few Basic Concepts for Electronic Circuits

2.2.1 <u>Objective</u>

The objective of this section is to provide you with an introduction to some aspects of electronic circuits enabling you to perform and understand measurements characterizing the camera flash circuit. Some terms are defined, the electrical characteristics of some components of the flash circuit are discussed and an overview of some aspects of circuits is presented.

2.2.2 <u>Electric Current</u>

You may have an intuitive grasp that when we speak of an electric current we are referring to the motion of electronic charges. In this discussion we will confine ourselves to currents flowing through wires or electronic components. Charge is measured in units of *coulombs*. The *current* is the amount of charge that moves past a location on the wire per unit time (coulomb/second = ampere). (Or the charge that moves into or out of a lead of a component per unit time.)

We can conceive of moving positive or negative charges. Historically, the existence of electronic current was known before it was known what physical object was actually moving. A convention was established in which positive current flowed from point of higher electric potential to points of lower electric potential. However, they got the convention backward! It was eventually discovered that the particle moving in metal wires was the electron and that it moved in a direction opposite to the established convention. The convention was so well established that it wasn't changed. Therefore a positive current flowing in a wire actually corresponds to the motion of negatively charged electrons moving in the opposite direction. By the way, an electron has a charge of -1.6×10^{-19} coulomb. A current of 1 Amp = 1 coulomb/sec therefore corresponds to a very large number (~ 6,250,000,000,000,000,000) electrons moving past a location on the wire each second.

2.2.3 <u>Voltage</u>

Voltage is related to the force that causes current to flow. (Important: pay attention to the wording in the previous sentence, in particular to "related to." While voltage is related to the force that causes charges to move, it is not the force itself.) An analogy that you may find useful is water flowing in a garden hose. (It's not a perfect analogy but ignore that for now.) The current of water is analogous to the electric current in a wire and the pressure that causes the water to flow is analogous to the voltage.

When someone quotes a number for pressure in a hose or air pressure in a tire, that pressure is always stated relative to some reference. The pressure quoted is actually the pressure difference between the thing being measured and the reference. A common reference is the atmospheric pressure of the surrounding air, in which case the pressure is known as gage pressure (in units of psig - pounds per square inch gage - for example). Another reference that is sometimes used is vacuum, in which case the pressure is known as the absolute pressure (psia).

In a similar fashion, when a number for a voltage is stated, it is actually the difference in voltage (or difference in electric potential) between two different points. Voltages are always stated relative to some reference. A common reference that is often used is earth ground. That is the reference used by electrical utilities for electric power generation and distribution to homes and industry. The 120 V supplied to your residence by the electric company is measured relative to earth ground. Some circuits are isolated from earth ground, and in those cases a reference point in that circuit may be picked. This is often also called the "ground" for that circuit, although it may not actually be connected to earth ground in any way.

Another way in which voltage is used is to describe the difference in electric potential <u>across</u> an electronic component. When we speak of the voltage <u>across</u> a component we are measuring the voltage on one lead (wire) of the component while using another lead of the same component as the reference point. (In the water hose analogy we could talk about the pressure difference across a device, such as a filter, through which the water is flowing.)

2.2.4 <u>Resistors</u>

A resistor is an electronic device that resists the flow of current and obeys Ohm's law. Ohm's law states that the voltage <u>across</u> a resistance is proportional to the current <u>through</u> it. (Note the emphasis on the words "across" for voltage and "through" for current.)

Ohm's law can be stated mathematically as

$$V = IR \qquad \text{(Ohm's law)} \qquad \text{(Equation 1)}$$

or in words:

(voltage across resistor) = (current through resistor) × (value of resistance)

where *V* stands for the voltage across the resistor, *R* stands for the resistance of the resistor, and *I* stands for the current through the resistor. The unit of resistance is the ohm (from, ohm = volt/ampere, which agrees with the equation). The symbol for a resistor is shown in Figure 1. Also shown is the polarity of the voltage drop across the resistor if the current is flowing in the direction indicated by the arrow.

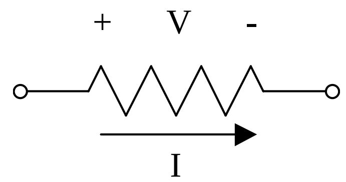


Figure 1: Symbol of the resistor.

<u>EXAMPLE:</u> A 10 kΩ resistor that has 10 volts across it will have a current of ***I*** = 10 V/10 kΩ = (10 V)/ (10,000 Ω) = 0.001 A = 1 mA flowing through it.

<u>EXAMPLE:</u> If the same resistor had 0.5 mA flowing through it the voltage across it would be V = (0.5 mA) (10 kΩ) = (0.0005 A) (10,000 Ω) = 5 volts.

2.2.5 <u>Capacitors</u>

A capacitor is an electronic device that stores a charge and can be discharged very quickly when the electricity is needed; for example, to set off a flash for a camera. The more charge you want to store, the bigger the capacitor you need. Capacitors come in standard sizes, and when you buy one, you specify the size you want by giving the <u>capacitance</u>. The unit of capacitance is farads (F). A more convenient size capacitor would be sized in microfarads (μF). ($\mu = 10^{-6}$) See tables 1 and 2 (following the pre-lab assignment) for details about units.

A capacitor consists of two metal plates separated from each other by a thin insulator. Since an insulator separates the two plates a steady state DC current cannot flow through a capacitor. On the other hand, if a positive current is applied to one plate of the capacitor a positive charge will build up on that plate. Since like charges repel each other and opposite charges attract, this positive charge will force an equal amount of positive charge off of the other plate, inducing a net negative charge of equal magnitude on it. There will be an electric field between the positive and negative charges, and a voltage difference between the two plates, and hence across the capacitor. The voltage difference across the capacitor is proportional to the charge on the capacitor.

In equation form:

$$V = \frac{Q}{C} \quad \text{or} \quad Q = CV \qquad \text{(Equation 2)}$$

where *V* is the voltage (volts) across the capacitor, *Q* is the charge (coulombs) on the capacitor, and *C* is the capacitance (farads) of the capacitor. Restating this with words

(voltage across capacitor) = (charge on capacitor) / (value of capacitor)

or

(charge on capacitor) = (value of capacitor) × (voltage across capacitor).

Capacitance is measured in farads (farad = coulomb/volt). The symbol for a capacitor is shown in Figure 2.

EXAMPLE: In order to charge the 120 μF capacitor in the flash circuit up to 300 V we would have to add a charge of 0.036 coulombs [= (120 μF) × (300 V)] to the positive plate of the capacitor.

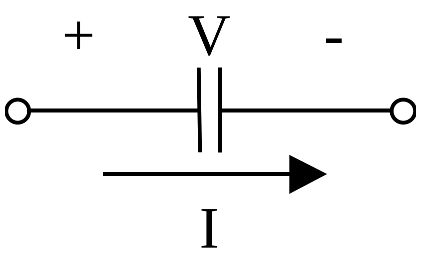


Figure 2: Symbol of the capacitor.

If a current (I) is flowing into a capacitor the charge on the capacitor has to be changing. Mathematically

$$I = \frac{dQ}{dt} = \frac{CdV}{dt}. \qquad \text{(Equation 3)}$$

Note: dt means "change in t, time." It is similar to Δt.

Since $Q = CV$ where *C* is a constant, d*Q*=*C*d*V*.

So $I = \frac{CdV}{dt}$ or $\frac{I}{C} = \frac{dV}{dt}$

In words:

(current entering capacitor)
= (time rate of change of charge on capacitor)
= (value of capacitance) × (time rate of change of voltage across capacitor)

$\frac{dQ}{dt}$ is the time rate of change of the charge. $\frac{dV}{dt}$ is the time rate of change of voltage.

For example, if you force a constant current of 1 mA onto the discharged 120 μF capacitor the voltage across the capacitor will change at a rate of

$$\frac{dV}{dt} = \frac{I}{C} = \frac{1\,\text{mA}}{120\,\mu\text{F}} = \frac{10^{-3}\text{ coulomb/sec}}{120 \times 10^{-6}\text{ coulomb/volt}} = 8.33\,\text{volt/sec}$$

The current flowing into a capacitor is proportional to the time rate of change of the voltage across the capacitor. If the voltage is not changing, the rate of change (derivative) with respect to time will be zero, and the current will therefore be zero. Conversely, if a current is flowing in or out from the capacitor, the voltage across it must be changing.

A charged capacitor stores electrical potential energy via the electric field inside it. The amount of electrical potential energy stored in a charged capacitor can be expressed as

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2. \qquad \text{(Equation 4)}$$

In words:

(electric potential energy)

$$= (1/2) \times (\text{charge on capacitor})^2 / (\text{value of capacitor})$$
$$= (1/2) \times (\text{value of capacitor}) \times (\text{voltage across capacitor})^2$$

The stored electrical energy can be released by allowing the capacitor to discharge through a circuit attached across it. The energy stored on a 120 μF capacitor charged to 300 V is $(1/2) \times (120\ \mu F) \times (300\ V)^2 = 5.4$ Joules. In Lab 7 you measured the speed of the flash. You probably saw that it was on the order of a few milliseconds long. If we could completely discharge that capacitor in 1 ms, the average power leaving the capacitor during that 1 ms would be 5.4 J/ 1 ms = 5,400 watts! The reason I stated this is the average power is that the energy does not leave the capacitor at a uniform rate during the flash discharge. The energy leaves the capacitor faster at the beginning of the discharge so the peak power is even larger! The flash capacitor delivers power on the order of kilowatts to the flash lamp (But fortunately only for a very short time, otherwise components of the flash circuit would probably melt!).

3 The Circuit Board and Circuit Schematic

The flash circuit for the camera is made on a printed circuit board. The body of the board is made of an electrically insulating material. Much of the "wiring" in a printed circuit board takes the form of thin metal traces printed on the board, rather than actual wires. That's why it's called a "printed" circuit board.

Holes are drilled through the board in appropriate locations. When the circuit is being manufactured components are connected to the metal traces on the board by inserting the wire leads of the components into the holes and joining them to the metal traces with solder. In the original versions of the flash circuit board all of the components were attached to the board this way. In some more recent versions of the flash circuit board some of the components are attached by a technique known as "surface mount." Components that are attached by surface mount do not have wire leads designed to go through holes. Rather, they have metal tabs that are directly soldered to the metal traces on the board, without holes. Since the cameras are recycled, some of you will have boards with surface mount components and some of you will not.

A circuit schematic is a symbolic representation of an electronic circuit. Each symbol on the schematic represents a component in the circuit. The lines in the schematic represent the wires or metal traces on the circuit board used to connect the components together.

A partial schematic of the 5C3406 generation of flash circuit is shown in Figure 7. In both circuits, the more complex circuitry that we will not study in this lab is not explicitly shown. It is represented by the box labeled "More complex circuitry for converting DC to AC." Most of the differences between the two generations of camera occur inside this box. There are a few other differences that are important for this lab, and they will be discussed below.

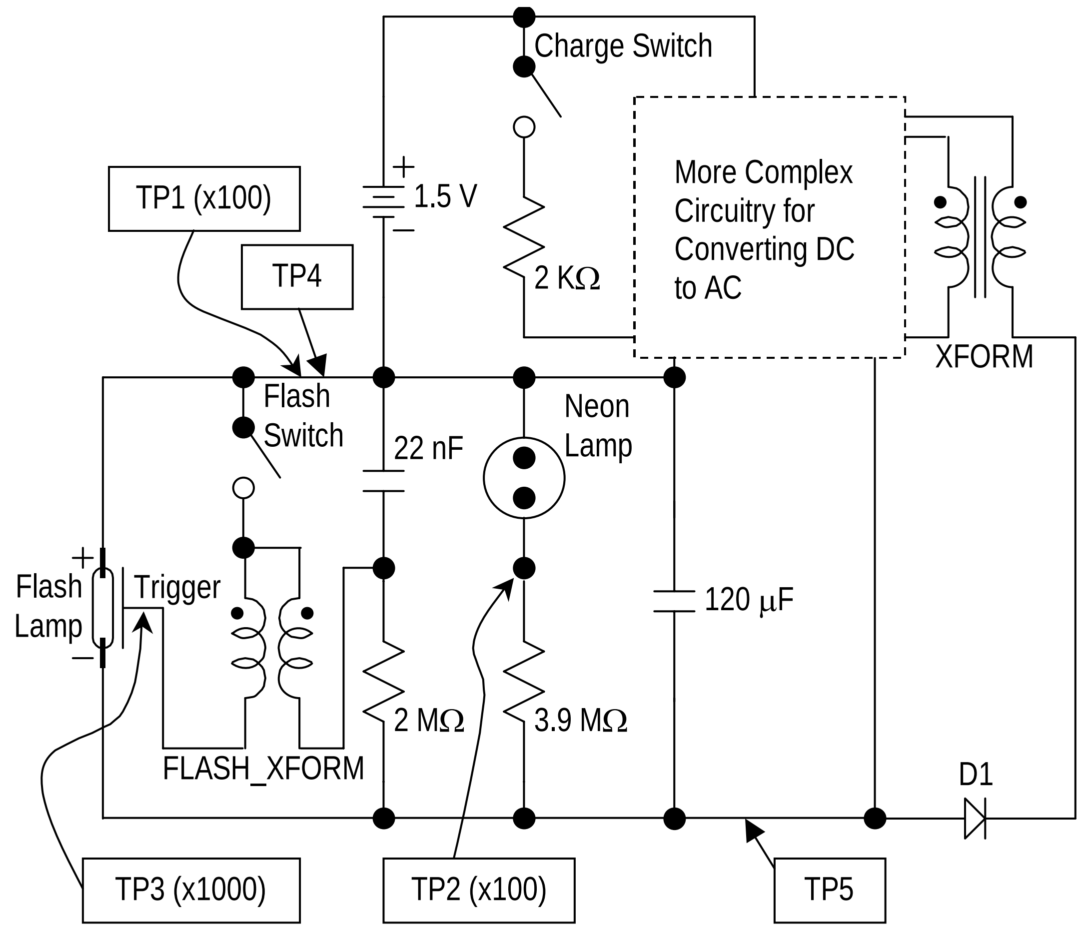


Figure 7: Schematic of the 5C3406 generation of flash circuit.

A few general features about some conventions used in these schematics should be understood. Wires connecting the various components are represented by lines. A connection between two devices is known as a "node." Wire intersections that are marked with a dot represent a connection between the wires. Wires that are connected together will have the same voltage. They form a single node and will have the same "node voltage." The term "node" does not mean the dot at the intersections; all of the wires that are connected make up the node and have the same voltage. Wires that cross without a dot are not connected together - one wire bridges over the other. They are not the same node.

Note: There is an alternate convention for drawing wires in schematics. In this second convention any wires that intersect as straight lines are connected (no dots). To draw wires that cross without a connection one uses a small "loop," typically drawn as a half-circle, in one of the wires to show it "bridging" over the other. This second convention is not used in these instructions.

The layout of the components in the schematic does not reflect the physical position of the components on the circuit board. Rather, it shows the electrical connections between the components. In the schematic the components are frequently grouped according to the function of various parts of the circuit. On the circuit board the layout of the components might be chosen for a variety of different reasons. Some of these might be ease of manufacture, minimization of distance between components for speed of operation, or fitting the circuit board inside its housing. Can you think of others?

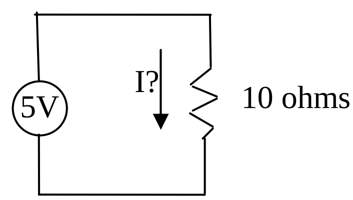
4 Lab 8: Camera Lab B Pre-lab Assignment

This section describes tasks that you should perform before coming to Lab 8. The Pre-lab Tasks is to be done as an **individual** assignment. Guidance on performing this assignment can be found in various sections of the reading.

Pre-Lab Assignment 1:

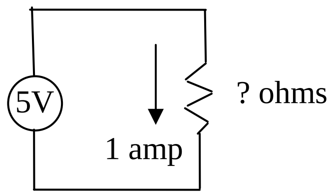
1. What are the core functions performed by the electronic circuitry of the Kodak disposable camera? Include a brief explanation of them (a few sentences). (4 pts)

2. For the circuit below, calculate the current through the resistor. (3pts)



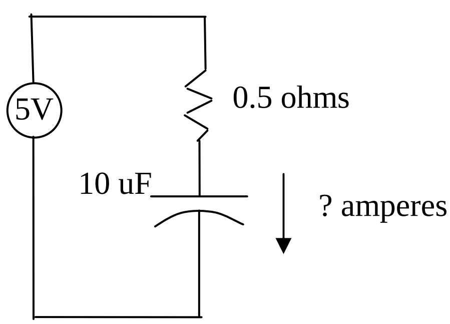
Show your calculations.

3. For circuit below, determine the value of the resistor which would cause a current of 1 ampere to flow. (3pts)



Show calculations.

4. For the circuit below, the voltage across the capacitor is measured over a duration of 1 millisecond while it is charging. The voltage changes 0.2 volts during that interval. What is the average current that is flowing through the capacitor during that time? Show calculations. (5pts)



Camera Lab B (Flash Speed using Virtual Oscilloscope)

Introduction

In this lab, you will perform measurements on various parts of the camera flash circuit while each of the core functions is being executed. You will be using a digital multi-meter (DMM) and a **virtual oscilloscope (VO**) to measure voltages. The digital multi-meter will allow you to measure steady DC voltages and monitor voltages that are slowly changing with time. With the **VO** you will be able to display time histories of voltages that are changing rapidly with time.

Parts List / table

Item #	Item Description	Part Placement
1	Camera Circuit Test Box	
1	Digital Multi-meter	
2	BNC-BNC cables	
2	Banana-Banana cables (1 red/ 1 black)	

Setup Procedures

Special notes

- Check that 10 sets of BNC-BNC cables and banana-banana cables are present. 1 set refers to two cables. So in total there should be 20 BNC-BNC cables and 20 banana-banana cables.
- In the case of the banana-banana set one cable should be red while the other should be black.
- A set of BNC cables and a set of Banana cables should be placed on each table.
- Test all camera circuits test boxes make sure they work. Batteries may have been discharged. Testing the flash can check the test boxes.
- Please check to see that the multi-meters are working. (Batteries checked)
- Boot up computers if not so already.
- Make sure all files for Virtual oscilloscopes are on the H-DIRVE.

Setup Pictures

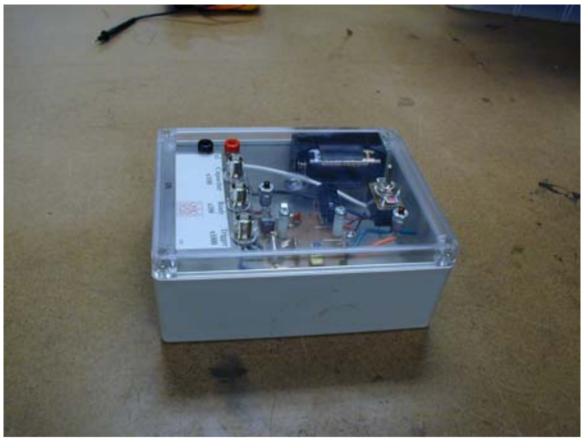


Figure. 1. Camera Circuit Test Box

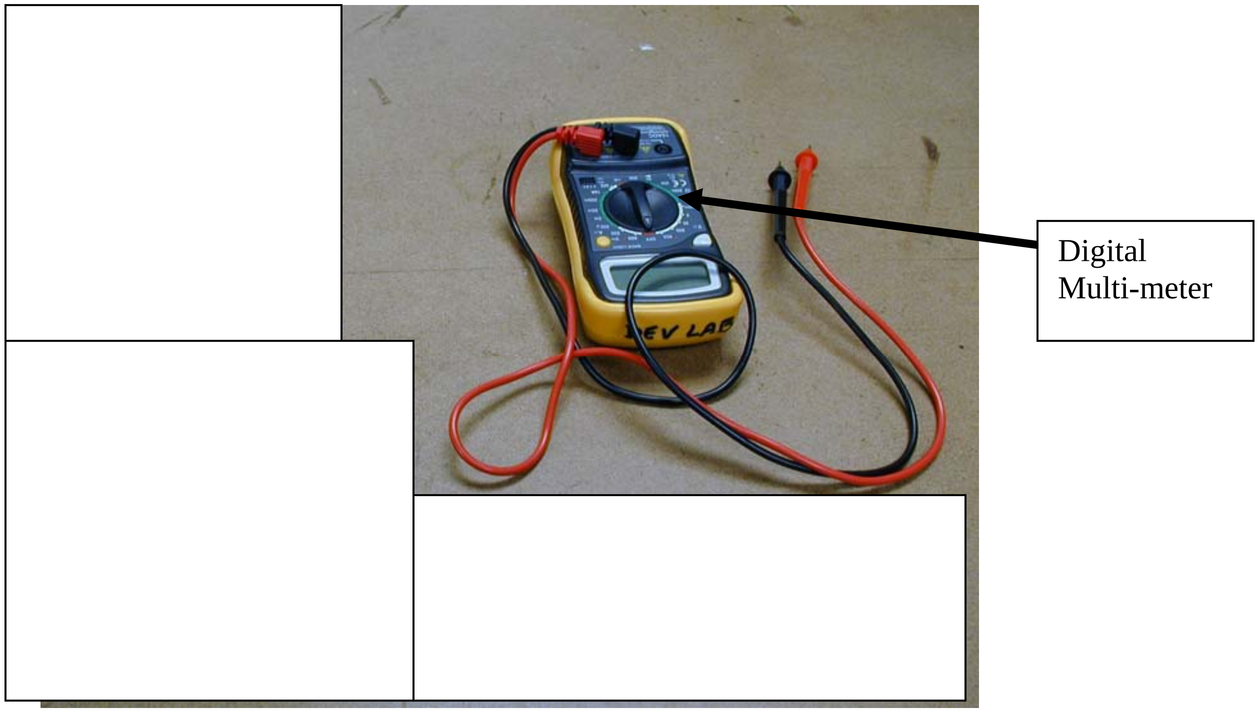


Figure. 2. Digital Multi-meter

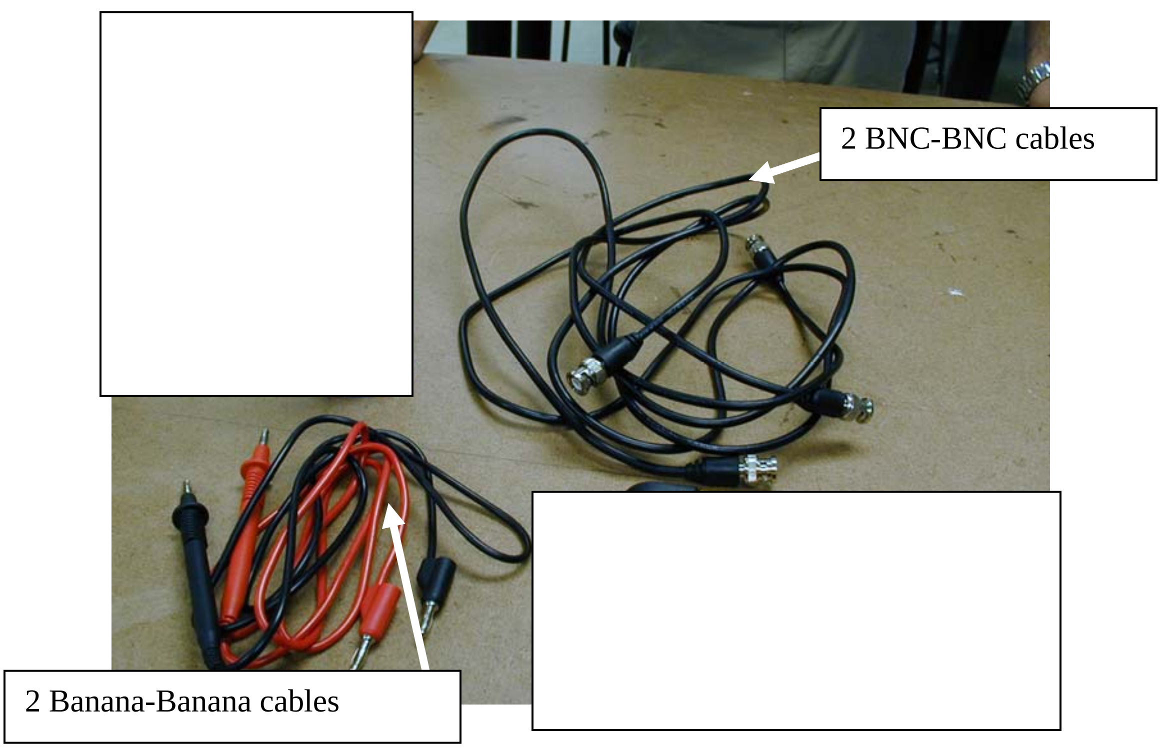


Figure. 2. BNC and Banana cables used

Teardown Procedures

- Collect all test boxes. Make sure none are damaged as far as outlets and probes are concerned.
- Count and collect all BNC cables and all banana cables.
- Note (write down) any unusual occurrences in or after lab, notify the appropriate people (usually the Lab Supervisors) and revise the setup procedures accordingly
- For tear down make sure all the wires and equipment are stowed back into the appropriate place.

Lab 8: Camera Lab B – Circuitry

Goals

In Lab 8 your group will perform measurements on various parts of the camera flash circuit while each of the core functions is being executed. You will be using a digital multimeter (DMM) and a virtual oscilloscope (O-Scope) to measure voltages. The digital multimeter will allow you to measure steady DC voltages and monitor voltages that are slowly changing with time. With the O-Scope you will be able to display time histories of voltages that are changing rapidly with time. In this lab, you will learn the following objectives:

- Learn what the core and auxiliary functions of the flash circuit are and what the circuit must do to perform them.
- Be able to calculate currents flowing in certain parts of the circuit using the measured voltages together with the values of parameters of some of the components.
- Acquire experience in using a voltmeter and an oscilloscope to measure voltages in the circuit.

Background

In many cases we would like to know currents flowing in the circuit, however, it is difficult to measure currents directly. To directly measure current we would have to break the circuit and insert the measuring instrument in series with the component whose current we wish to measure. That would require us to unsolder one end of the component from the circuit board and clip or solder the current meter between that end of the component and the point on the circuit board to which it was originally attached. That is not practical in many cases, and the limited time for the Lab does not allow us to do that. In addition, while the digital multimeter has a current measuring capability, the O-Scope is not designed to directly measure currents.

To extract information about currents flowing in the circuit you will therefore need to use voltage measurements along with the equations presented in this document.

In addition to the digital multimeter and O-Scope, you will be using a test box that will simplify some of your connections. These connections are made via BNC (Bayonet Neill Concelman) connectors, and are labeled on the test box.

Warning: To minimize the chance of accidentally contacting high voltage, only one team member at a time should be handling the test box or connecting wires. We suggest that while one member of a team is making the connections the others carefully watch to make sure that the correct connections are made in a <u>safe</u> manner. The connectors on the box are designed to be safe, but attached wires can expose you to hazardous voltages. Connect wires ONLY as instructed. To minimize your risk of electrical shock, DO NOT remove wires from any test instruments during the actual experimentation.

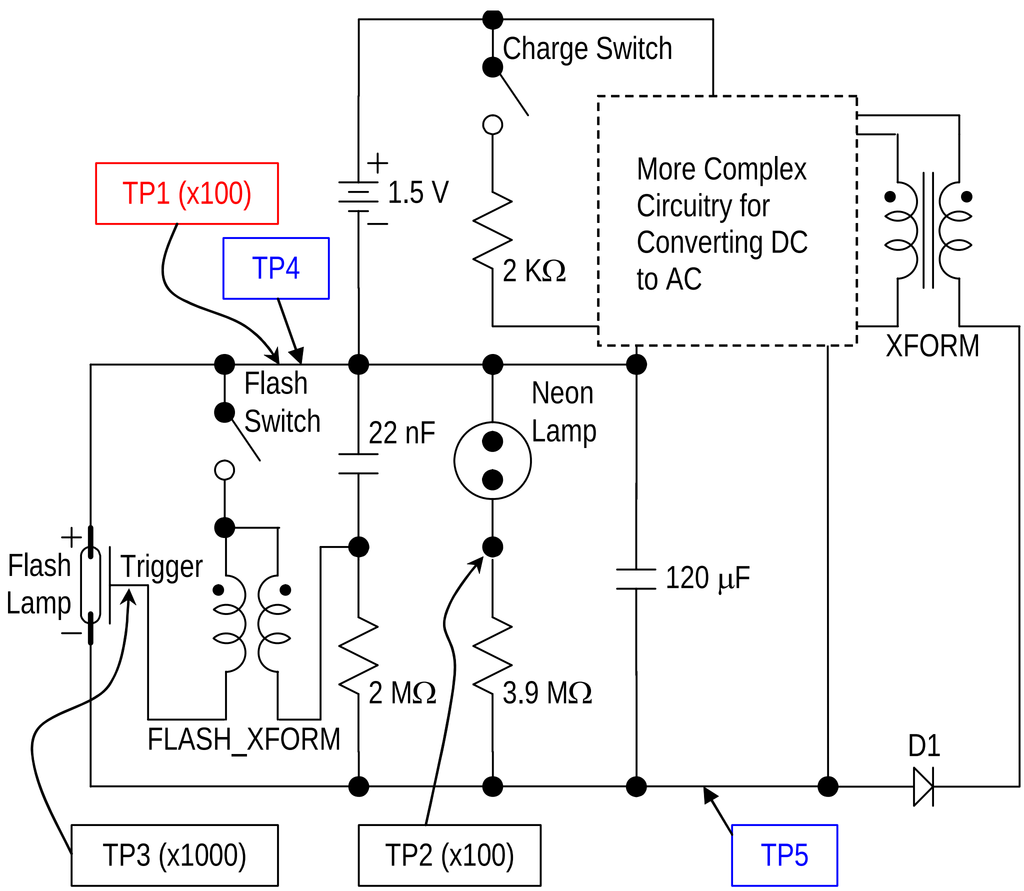
Warning: Always connect the test leads to the measuring instrument first. Then connect to the appropriate test point on the test box. Handle the test leads by holding only the <u>insulated</u> portions. Remove all test leads from the test box before disconnecting the lead from the test instrument.

Materials/Equipment

- two black cables with BNC connectors at each end,
- a test box,
- a digital multimeter (DMM),
- a set of two wires with banana plugs at each end, and,
- a wristwatch with seconds reading.
- Worksheet A (at the end of this procedure)

Camera's Circuit Schematic

Below is a schematic diagram of the circuit inside the camera. A test box has been constructed containing this circuit with access to the test points shown on the schematic. Note that additional circuitry has been added to reduce the voltage to a safe level for use by the oscilloscope. Therefore you will need to apply multipliers indicated in the procedure to obtain the true voltages.

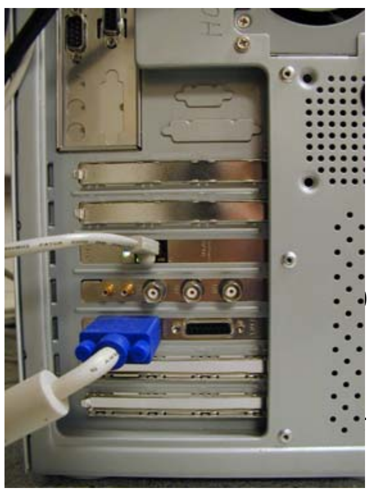


Procedure

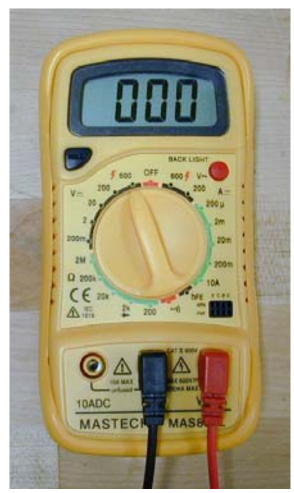
1.0 ***Set-up Oscilloscope, multimeter and test box.***

1.1 Now, on the PC at your work table, start up the program called 'OSU Scope'. (Double click the icon on the Desktop). It is the program that controls the actual O-Scope card in the computer.

1.2 Connect the BNC test leads to the O-Scope. The O-Scope card and its connectors are accessed at the back of the computer (see photo below). Channel 0 (CH 0) is the connector farthest to the right as you look at the back of the computer. Channel 1 (CH 1) connector is immediately to the left of CH 0 connector. BNC connectors must be slid onto the O-Scope mating connector and given a quarter-twist clockwise to fasten. A quarter-twist counter-clockwise will release the connector. Note the alignment pin on the scope portion of the connector, and the swiveling action of the test lead connector. To properly connect the test leads, always hold the connector by the metal portion with the small grooves in it, and always line up the alignment pins with the 'slots'. This method will allow easier connection and disconnection.



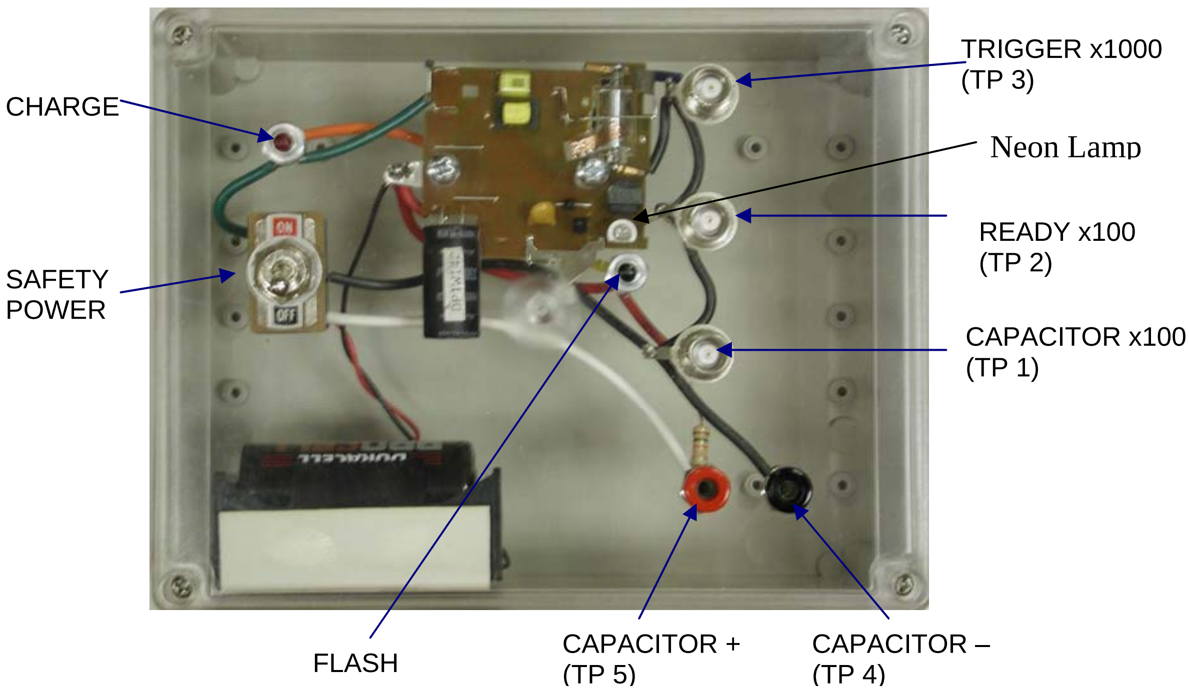
REAR VIEW OF LAB PC



DIGITAL MULTIMETER (DMM)

1.3 A DMM is shown above. Remove the regular test leads from the DMM at your table and attach the banana plug leads to the DMM with the BLACK LEAD plugged into the 'COM' hole and the RED LEAD plugged into the 'VΩmA' hole. Turn the large knob on the DMM <u>'one click' counter-clockwise</u> from the OFF position. This action will put the DMM on a 600 volt DC scale.

1.4 The test box is shown below. Note the location of the various test points (BNCs or “banana jacks” labeled ‘TP x’ below). Reference to the test points is made throughout the rest of the procedure. Note also the location of the SAFETY POWER switch and the CHARGE and FLASH push buttons.



1.5 Insure the test box POWER switch is in the OFF position. IF YOU ARE EVER IN DOUBT ABOUT THE ELECTRICAL STATUS OF THE TEST BOX, FLIP THE POWER SWITCH TO ‘OFF’ AND ASK FOR HELP !!!

1.6 Connect the BLACK LEAD of the DMM to the test box TP 4 ‘CAPACITOR–’ BLACK banana jack (towards the bottom of the of test box panel). Connect the RED LEAD of the DMM to the test box TP 5 ‘CAPACITOR +’ RED banana jack.

1.7 Connect Channel 0 (CH 0) BNC test cable of the oscilloscope to the TP 1 ‘CAPACITOR x100’ test point. Connect Channel 1 (CH 1) test lead to the TP 2 ‘READY x100’ test point.

1.8 Load the settings from file ‘C:\apps\scope\CameraB_Task1.sco’. Do this by clicking the ‘Load’ radio button in the settings section and pressing ‘OK’ to open the file requestor window. Now check the O-Scope settings against Figure 1 below:

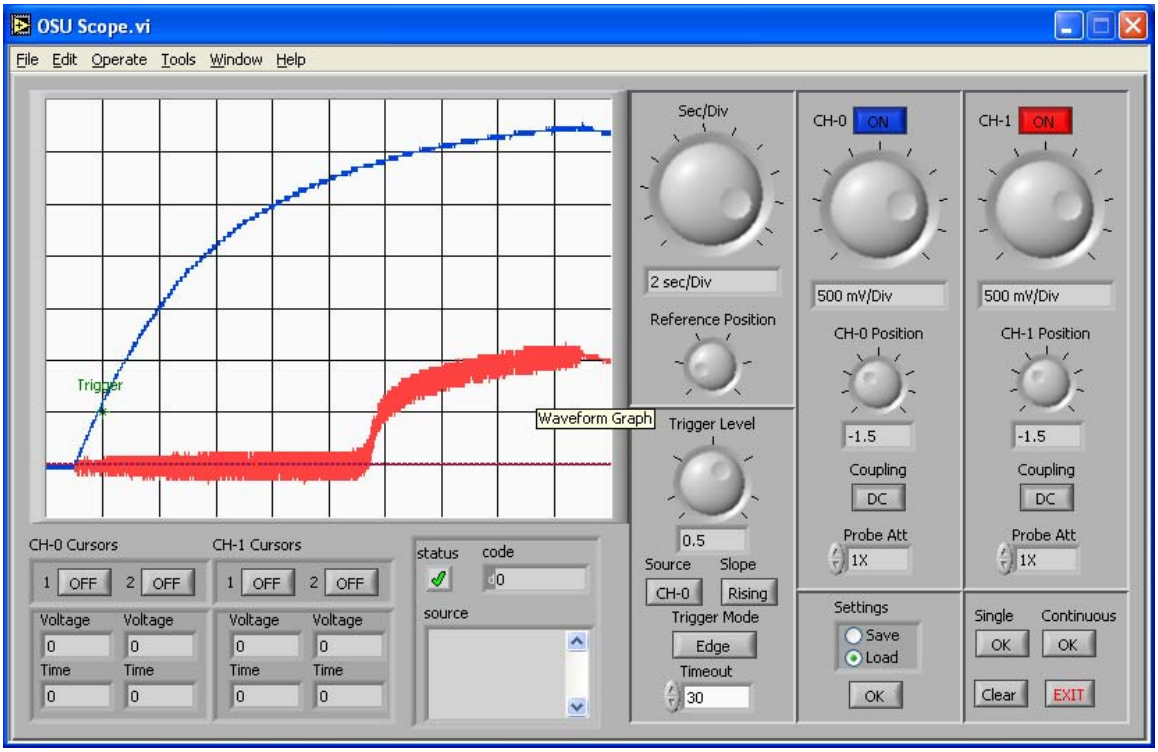


Figure 1. Task 1 settings and results.

2.0 Task 1 - Transient Measurement: Capacitor Charging Function

2.1 Turn the test box SAFETY POWER button ‘ON’.

2.2 Prepare your wristwatch for timing. You are to have one team member use it to time the seconds from pressing the CHARGE button until the indicator light comes on. Also, have another team member watch the DMM reading and note the reading when the indicator light comes on. A third team member should call out when the CHARGE button is pushed and when the indicator light comes on. This allows the other two members to just listen for the time ‘mark’ at which to record a value. (The person doing the callouts should be the person to press the button and watch for the light).

2.3 Click on the ‘Single’ button in the lower right portion of the display. The scope is now ready to record voltages from the capacitor charging cycle.

2.4 Press and release the red CHARGE button (directly above the POWER switch). Manually record the time for the light to come one and the corresponding voltage on the DMM. Record these values on Worksheet A, Results Table 1.

2.5 The ***O-Scope will appear to do nothing for about 20 seconds***!! After about 20 seconds, two data traces should appear on the display, one for the capacitor voltage and one for the ready light voltage (ready light voltage this is actually the voltage of the resistor connected in series with the neon lamp. The trace should look very similar to the graph of Figure 1.

(**If no traces show after 30 seconds**, and you get a timeout error message, turn the test box toggle switch to OFF, wait until the DMM reads 0V, and try again. If there still are no traces, ask one of the instructional staff for help).

2.6 Turn the safety power switch to "OFF" and press the black Flash button to discharge the capacitor.

2.7 Cursors are lines that can be used to pick values from the display screen. There are two cursor lines per channel, clearly labeled, and matching the color of the associated trace. The mouse is used to drag a particular cursor by the vertical line to a position on the display. The "x" at the intersection of the horizontal and vertical lines marks the measurement point, and is locked to the associated trace.

a. Turn on the CH-0 cursors by pressing the associated buttons. 2 pairs of blue crossed lines labeled CH-0 #1 and CH-0 #2 will appear
b. Drag the #2 cursor line to where the CH 0 trace ***just begins*** to change.
c. Drag the #1 cursor line to where the CH 1 trace ***begins a rapid 'jump'***.
d. Mark both times (times are displayed in seconds) and subtract the time associated with #1 from #2 cursors to get the time difference (dT) between the two points
e. Read and note the voltage reading for the #1 cursor. NOTE: the test box has a multiplier factor of 100. You must apply the multiplier factor to get the real voltage value.
f. Record the time and voltage results on Worksheet A, Results Table 1.

2.8 Use the cursors line to pick the *overall maximum capacitor voltage and the corresponding CH 1 voltage*.

a. Note the maximum voltage values for CH 0 using the CH-0 #1 cursor
b. Turn on the CH-1 #1 cursor (red) and note the corresponding CH 1 voltage. Overlap the vertical cursor lines to make sure they you are measuring the same point.
c. Record the results on Worksheet A, Results Table 2.

d. Note the CH 0 and CH 1 voltages just before and just after the ‘jump’ in CH 1:

e. Record these values on Worksheet A, Results Table 2.

   (Note: If CH 1 trace is *relatively gradual*, use start of change for “before ‘jump’” and move *right one-half division* for “after the ‘jump’”).

f. Capture the screen (Alt-PrintScreen). Paste it to a Word document. It may be beneficial to minimize the window before capturing it.

3.0 *Task 2 - Transient Measurement: Capacitor Discharge and Flash*

This task will involve triggering the flash tube so DO NOT LOOK DIRECTLY INTO THE TEST BOX WHEN PUSHING THE FLASH BUTTON!!! YOUR EYES CAN BE DAMAGED IF THEY ARE EXPOSED TO SUCH BRIGHT LIGHT!!!

3.1 For the remainder of the measurements we will only use CH 0. (You may disconnect the CH 1 test lead from the test box but that action is not absolutely necessary).

3.2 Load the settings file called 'CameraB_Task2.sco'. Verify the settings are accurate compared to Figure 2.

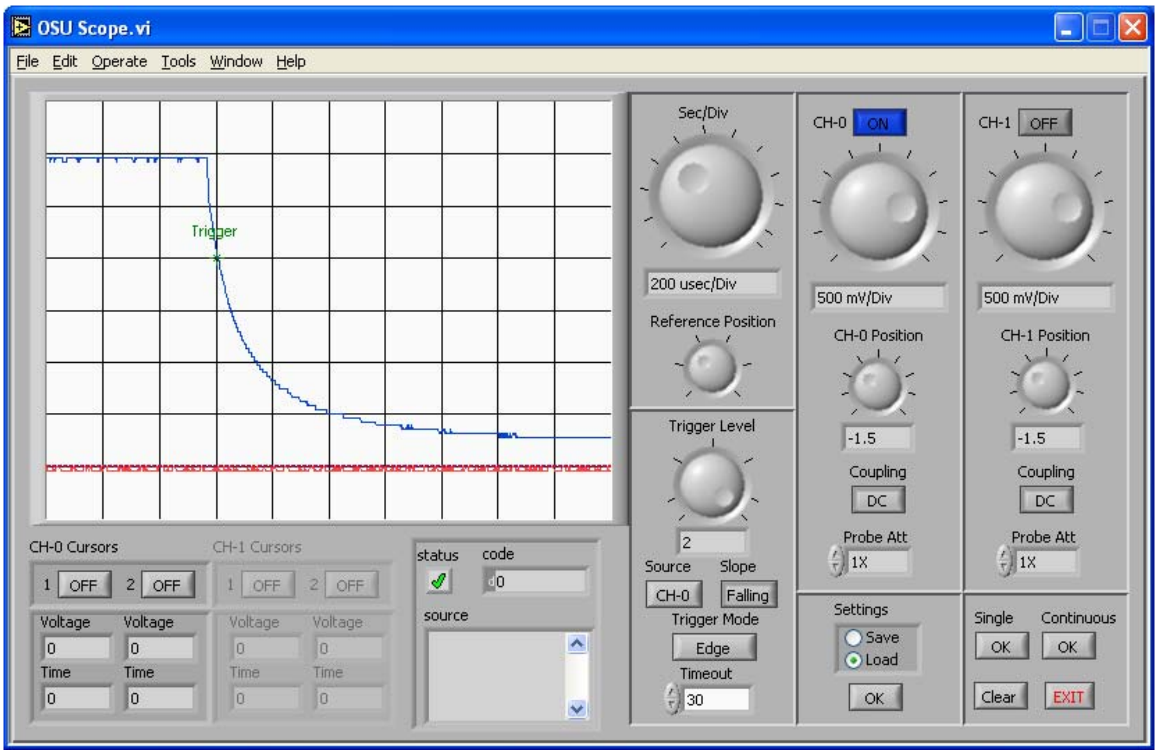


Figure 2. Transient Decay Graph.

3.3 Turn on the safety power switch and press the red charge button. By viewing the DMM, make sure the capacitor has a full charge (greater than 300 volts).

3.4 Press the 'Single' button on the O-Scope, then press the black FLASH button. A trace similar to that of Figure 2 should immediately appear on the display screen.

3.5 Turn the test box SAFETY POWER switch to 'OFF'.

3.6 Turn on the CH-0 cursors and use them to get values for the voltage column in the following table. Also record the "smallest" capacitor voltage as measured at the end of the discharge trace. Calculate the values for the other columns in the table. (Remember: Time = 0 is when the trace begins its rapid decrease; not when the trace begins on the display screen).

3.7 Record the results on Worksheet A, RESULTS TABLE 3. Use the following formula to analyze for the current.

CALCULATION FOR CURRENT (can be done after lab)

a. The capacitor current is given by $I = C\frac{dV}{dt}$.

We can approximate the derivative in this equation to give $I \approx C\frac{\Delta V}{\Delta t}$ or in words (current) ≈ (value of capacitor) × (change in voltage) / (time interval). The approximation is reasonable provided the time interval Δt is small when compared to the overall time of the event. Since time in the table is in *micro*seconds, use 120 for the value of the capacitor 'C' in the expression above (the value of the flash capacitor in the test box is 120 *micro*farads).

b. Repeat the calculation for each of the time intervals in the table.

3.8 Capture the screen (Alt-PrintScreen) and paste to a Word document

3.9 Turn the test box POWER switch to 'OFF'.

4.0 Task 3 - (Optional) Flash Trigger Measurement

This task is optional. If completed and included in the lab memo, additional points will be awarded.

The flash tube in the camera contains Xenon gas—a good insulator of electricity unless the gas is ionized; it then becomes a good conductor of electricity and the high voltage you measured (and stored in the flash capacitor as power) is quickly "dumped" through the flash tube, resulting in a brilliant white flash. In order to ionize the gas within the flash tube a second trigger transformer is used. This transformer takes the electrical connection made by the shutter to create a momentary high-voltage (around 5000 volts) across the Xenon gas in the flash tube. This high-voltage flash trigger is used to 'fire' the flash tube. In this exercise you will measure the high-voltage flash trigger across the strobe tube.

4.1 Ensure that the POWER switch is 'OFF'.

4.2 Remove the scope test leads from all test points on the test box.

4.3 Connect the CH 0 test lead to the TP 3 'Trigger x1000' test point

4.4 Load the "CameraB_Task3.sco' settings file, and verify the settings match those in Figure 3.

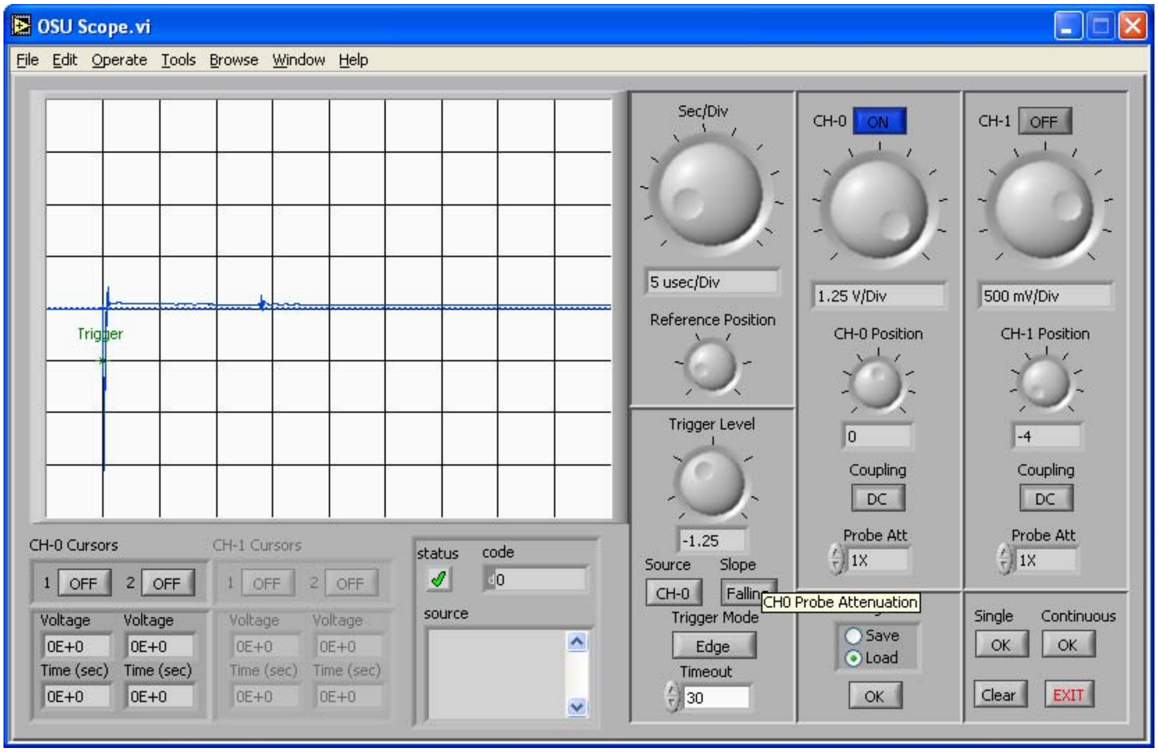


Figure 3. Flash trigger graph.

4.5 Turn the test box POWER switch 'ON' and PRESS the CHARGE button. Make sure the capacitor has a full charge (voltage reading on DMM greater than 300 volts).

4.6 Press the 'Single' button in the O-Scope display, then press the FLASH button. A trace should immediately appear on the display screen. The trace may look similar to Figure 3. The trace could also appear as a decaying sine wave, with well defined peaks and valleys, and a definite frequency. Often there is still a trigger signal before the oscillation. Use the cursors to check. If you do not see the trigger signal, try again. it does not appear like Figure 3, try again. If you cannot get a trigger signal, continue with step 4.7.

4.7 TURN THE TEST BOX SAFETY POWER TO 'OFF'

4.8 Capture the screen display

4.9 Use the measurement cursors to record the duration and voltage of the trigger pulse. If the waveform does not appear similar to Figure 3, measure the voltage and time of the first 3 peaks and first 3 valleys of the waveform, and record in Results Table 4. Adjust the scope voltages you recorded by using the multiplier factor (x1000) to get a Corrected Voltage. The Corrected Voltage will be the actual trigger voltage that existed in the circuit. Include these data in your memo.

5.0 Ensure that the test box POWER switch is 'OFF'. Disconnect all leads, first from the test box and then from the test instruments.

GENERAL INFORMATION:

Finish the hands-on part of the lab by turning off (exiting) the O-Scope program, turning OFF the DMM, and cleaning-up the work area.

Remember to apply signal multiplier factors for each channel of O-Scope data. The O-Scope card maximum input allowed is 5 volts. The test box signals are divided by 100 or 1000 in order to keep the input values to the card below 5 volts. ***You must apply the multiplier factors to get the real voltage value.*** The multiplier factors are indicated on each test box opposite respective connection points.

Lab Reporting Requirement for Camera Lab B

For this lab exercise, each team should turn in a lab memo. See Memo Guidelines.

Worksheet A

RESULTS TABLE 1

METHOD	TIME	VOLTAGE
Manual recording		
Oscilloscope reading		

RESULTS TABLE 2

	VOLTAGE CH 0	VOLTAGE CH 1
Maximum capacitor voltage		
Voltage value before “jump”		
Voltage value after “jump”		

RESULTS TABLE 3

Smallest Voltage Value is __________ volts.

Time (μs)	Capacitor Voltage (volts)	Δt (μs)	ΔV (volts)	I (amps) - see below
0				
		100		
100				
		100		
200				
		100		
300				
		100		
400				
		100		
500				
		100		
600				
		100		
700				

RESULTS TABLE 4

Trigger width ____________ peak voltage _________________.

Valleys		Peaks	
Time	Voltage	Time	Voltage

Camera Lab B (Camera Circuitry) Memo Guidelines:

This is a **TEAM MEMO**. Follow the memo format below –

Contents	Points Worth	Point Value
Header Information	**5 pts (for header and memo format)**	
Introduction	**10 pts**	
Results (Tasks #1 & #2; Task #3 extra credit)	**35 pts**	
Task 1: Charging Transient	**25 pts**	
• Include graph, Results Table 1and 2.	5	
• Compare the time and voltage values of the manual recording vs. the oscilloscope reading? What is the percentage difference?	5	
• Use Ohm's law to calculate the current flowing through the 3.9 MΩ resistor at the following times:	15	
o just before the jump in resistor voltage		
o just after the jump		
o when the capacitor voltage was at its maximum value.		
Task 2: Flash Discharge Transients	**10 pts**	
Include graph and Results Table 3. Explain the shape of the curve.		
Task 3: (Optional) Flash Trigger Transient (Extra Credit)	*5 pts.*	
• Include graph and Results table 4. Time is measured as the time between 2 peaks OR 2 valleys.		
Remember to correct the voltages for the attenuation caused by the voltage divider.		
Discussion (Tasks #1 & #2; Task #3 extra credit)	**20 pts**	
Task 1: Charging Transient	**15 pts**	
• What is happening to the capacitor during charging that causes the voltage to change?	5	
• What voltage is required across the capacitor to turn on the neon lamp?	5	
• What else happens when the neon lamp turns on - why does the neon lamp resistor voltage 'jump'?	5	
Task 2: Flash discharge Transients	**5 pts**	
How does the rate of discharging compare to the rate of charging for the capacitor?		
Task 3: (Optional) Flash Trigger Transient (Extra Credit)	*10 pts.*	
• Make a table of estimates of the duration of charging, flash discharge and trigger transients. **Charging transient**: The time it takes the voltage to go from zero to 90% of its peak value. For the **flash discharge transient** calculate V_{start} - (90%)(V_{start} - V_{end}). Use your graph to estimate the time at which this voltage is reached. For the **flash trigger transient** use one-half the time between the first peak and valley.		
• Compare the time scales for these three events with each other.		
Conclusion	**10 pts**	
Lab Participation Agreement	**5 pts**	

The Camera Lab B lab memo is worth 85 pts and is a team assignment. The pre-lab is worth 15 pts and is an individual assignment. Together the pre-lab and memo are worth 100 points total.

LAB 9: Camera Lab C - Assembly Operations

Introduction

Manufacturing operations are often divided into many different categories for processing and assembly operations. Within an operation, the different approaches are practiced to effectively and efficiently make the final product in the most time and cost effective method possible.

This lab demonstration will examine two common approaches of the Sequential assembly line:

1. "Push" system
2. "Pull" system

In this lab, you will learn about these approaches and have a general understanding of the applications of each approach to manufacturing the disposable cameras, including quality testing.

Background

Assembly can be accomplished is a variety of ways. If large, bulky products (aircrafts, building air conditioning units) are being assembled; the assembler(s), materials and assembly fixtures are transported to one location where the entire product is built without moving. This approach is called a fixed material location assembly operation. Using this approach the assembler(s) are often very knowledgeable, to the degree that they could assembly the entire product alone.

For smaller, more portable products, another method is the assembly line where the product moves sequentially from one assembler to the next, and the assemblers remain stationary. In the assembly line approach, the concept of division of labor is used - every assembler becomes an expert at his/her particular sub-assembly operation. Since not all assembly operations require exactly the same amount of time, sequential assembly lines will have bottleneck operations – activities that take longer than any of the other operations. Identifying and eliminating bottleneck operations in assembly lines are common problem assigned to Industrial and Systems Engineers.

One practice for product flow in some manufacturing plants is known as the "push" system. This system allows the operator to create parts when material is available & schedule permits. Mainly, in the push system, material and information are "pushed" through the manufacturing processes. Information encompasses many factors such as order quantity, specification, design, etc. When material is available, it prompts the stations to begin the assembly process. Some of the characteristics of the push system include large batches, long run, high work-in-progress and finished goods inventory.

Another theory in production is known as the "pull" system. In the Pull system, the product is "pulled" through the line by the "customer". A customer can be defined as the final customer or any subsequent operation in the line.

When the customer has used up their available stock (to the minimum level), they would retrieve another "batch" form the previous operation. This prompts the previous operation to replenish their stock by going to their "supplier(s)" and retrieving the appropriate parts. Thus, the flow of the material and information "move" in the opposite direction. Some the key characteristics of this operation are small batches, low work-in-process and finished good inventory.

Within the assembly lines, many factors determine the business success. Such factors are inventory, approved/scrap product and machine utilization. In order to please the customer, companies want to have enough stock to supply the customer, especially in emergencies. However, holding large stocks of inventory is very expensive due to floor space, money held up in the material, labor cost, and taxes. Likewise, with the cost of equipment and overhead, any associated downtime of machines is potential loss income for the manufacturer. Finally, quality is essential to reduce cost due to wasted material and labor as well as maintaining customer satisfaction. The challenge for many companies is to balance these critical factors to create the best manufacturing operation that are profitable for their business.

Materials/Equipment

- Worksheet A

Procedure

In this demonstration, we will set up and concurrently operate a sequential 'PUSH' assembly line and a sequential 'PULL' assembly line operation. The class will divide into two groups, Group A and Group B, to run the respective lines. TA's and PM's will be keeping time and tabulating results.

1.0 Assembly of the Camera

1.1 The class will divide into two groups: a) 16 students in each group would be working on 16 workstations b) the remainder of the students will be working as ' Truckers' for each team. Approx. 2 truckers per team

1.2 Each student will find a workstation to learn the assembly process.

1.3 The instructional team will demonstrate the assembly of the camera to the class with a video clip (use supplemental directions also) – Per the Camera Assembly Handout.

2.0 Task 1 – Sequential 'PULL' Assembly vs. Sequential 'PUSH' Assembly

2.1 In the first exercise, each line will have 10 minutes to assemble your cameras. Students are not allowed to "pre-assemble" parts ahead of the start. When the signal is given, each student can begin to assemble for the parts that are available to him/her.

2.2 Guidelines for the 'PUSH' System:

2.2.1 In this operation, the first student (first station) will perform the first sub-assembly operation and immediately pass the cameral to the second operation – and so on – until the camera is completely assembled and tested.

2.2.2 Students should work as quickly and accurately as possible. Do not worry about accumulating cameras at the next station. – KEEP WORKING.

2.2.3 At the end of the 10 minutes, all work must stop and parts must remain at their current workstation.

2.3 Guidelines for the 'PULL' System:

2.3.1 In this operation, every station will have only one camera completed up to his/her station. This is your minimum inventory level.

2.3.2 You can assemble another part only the stock inventory level has been used by the station after yours.

2.3.3 The last station starts this operation and asking the previous station for the part.

2.3.4 The next station then prompts the previous station for a part – and so on.

2.4 TA's and PM's will collect the count for the finished approved and scrapped cameras. They will also count the number of remaining "in process" parts at their station. "In-process" parts are parts that have begun some operation of assembly but have not had been completed.

2.5 The students will begin to disassemble the cameras after the count is collected.

2.6 On a spreadsheet, the TA's will record the number of approved cameras, the number of scrapped cameras, the number of "in-process" parts.

2.7 Record the data in Worksheet A, Table 1.

3.0 Task 2 – Brainstorm ideas for Optimization of both processes.

3.1 The students will brainstorm to determine bottleneck areas and solutions. The groups will have 10 minutes to brainstorm together. What operations were most idle? What operation held up the other operations? What can you do to address these issues?

3.2 Make the appropriate changes to the assembly lines including moving people if appropriate.

4.0 Task 3 –Optimized Sequential 'PULL' Assembly vs. Optimized Sequential 'PUSH' Assembly

4.1 In this exercise, each line will have 10 minutes to assemble your cameras with the optimized changes. All cameras should be disassembled from previous run. Students are not allowed to "pre-assemble" parts ahead of the start. When the signal is given, each student can begin to assemble for the parts that are available to him/her

4.2 TA's and PM's will collect the count for the finished approved and scrapped cameras. They will also count the number of remaining "in process" parts at their station. "In-process" parts are parts that have begun some operation of assembly but have not had been completed.

4.3 The student's will begin to disassemble the cameras after the count is collected.

4.4 On a spreadsheet, the TA's will record the number of approved cameras, the number of scrapped cameras, the number of "in-process" parts.
4.5 Record the data in Worksheet A, Table 1.

5.0 Disassemble all the cameras and return them into the appropriate boxes and bags.

6.0 For this lab, use the following numbers for the calculations.

The associated prices for manufacturing and sales are as follows:

- Man-hour cost - $15.00
- In-process - $3/(in-process assembled part)
- Scrap – $15.00/piece
- Selling price + $10.00/approved camera

The associated formulas you will need are as follows:

- Labor Cost = [(Assembly time in minutes) x (# of workers) x (labor cost)] / (60)
- When comparing the percent change in profitability:
  - % change = (Profit in 2nd run – Profit in 1st run)*100/(Profit in 1st run)
  - This value can be GREATER THAN 100%

Definitions:

- *Profitability* ~ Money from cameras sold – cost to make camera (labor time, WIP and scrap)
- *Productivity* ~ # assembled cameras/(time * #assemblers)
- *Throughput* is (units produced/time)

NOTE**: calculations include only approved cameras**

Camera Lab C Memo Guidelines

For this lab exercise, an INDIVIDUAL Lab Memo should be submitted.

Contents	Points Worth	Point Value
Header Information	**5 pts (for header and memo format)**	
Acknowledgement	**5 pts**	
Introductory Paragraph (3-5 lines)	**10 pts**	
Brief introduction of objectives/ goals of the lab.	8	
Brief introduction to contents of the report.	2	
Results	**35 pts**	
Complete spreadsheet provided by instructional staff	20	
Comparison of the 2 *(push vs. pull)* operations for profitability.	15	-
Discussion	**30 pts**	
For Task 1 and 3 of the push and pull operations which was the most productive , and why?	10	
Show calculations for the percentage increase in productivity between Task 1 and Task 3 for the push operation. Repeat for the pull operation.	10	
Description of the changes made from the Task 2 discussion for your operation (push or pull).	10	
Conclusion	**15 pts**	
Conclusions about the best operation (push or pull), and why.	10	-
Further improvements that can be made to improve the operation you were working with.	4	
Improvements to the Lab set up, if any.	1	

Camera Lab C - W ORKSHEET A

Table 1 Group A

	Approved Cameras	Rejected Cameras	In-process Cameras
Task 1			
Task 3			

Table 2 Group B

	Approved Cameras	Rejected Cameras	In-process Cameras
Task 1			
Task 3			

ENG 181 Camera Lab C Worksheet

Quarter/Section: ____________
Instructor: ____________
TA/PM: ____________

Selling Price ($) 10
Labor cost ($/person/hour) 15
WIP Cost ($/in-process piece) 3
Scrap cost ($/rejected piece) 15

SEQUENTIAL ASSEMBLY - PUSH SYSTEM

	TIME (min)	PEOPLE	APPROVED	REJECTED	WORK INPROCESS (WIP)	Selling Price ($)	Labor Cost ($)	WIP Cost ($)	Scrap cost ($)	Profit ($)	Productivity (#cameras/assembler-hour)
TASK 1						0	0	0	0	0	#DIV/0!
TASK 3 (optimized)						0	0	0	0	0	#DIV/0!

SEQUENTIAL ASSEMBLY - PULL SYSTEM

	TIME (min)	PEOPLE	APPROVED	REJECTED	WORK INPROCESS (WIP)	Selling Price ($)	Labor Cost ($)	WIP Cost ($)	Scrap cost($)	Profit ($)	Productivity (#cameras/assembler-hour)
TASK 1						0	0	0	0	0	#DIV/0!
TASK 3 (optimized)						0	0	0	0	0	#DIV/0!

Oral Presentation: Engineering Disciplines Project

In order to provide a better understanding of the different engineering disciplines offered at The Ohio State University, each team will prepare an *oral presentation* on an Engineering discipline to be given in Lab session 10. This presentation serves as a means to learn about the various majors offered at OSU.

Objective: Using a variety of resources, your team is required to create a ten-minute presentation (**eight minutes to present plus two minutes for questions and answers**) and accompanying handout describing the engineering discipline.

Assignments (Overall - 10% of final grade) and Grade breakdown -

1. Research Review Meeting (10 pts.)
2. Interview Follow-up (5 pts.)
3. Outline of Oral Presentation (25 pts.)
4. Draft of Oral Presentation (25 pts.)
5. Final Handout (50 pts.)
6. Give Oral Presentation (100 pts.)
    a. Actual Presentation (90/100 pts.)
    b. Final Presentation Slides (5/100 pts.)
    c. Final List of References – to be included in the handout (5/100 pts.)

Working Timeline (Check Syllabus for actual due dates)
- **Week 2**: Oral Presentation described in class; disciplines assigned to teams
- **Weeks 3-5:** Research your discipline; **Research Meeting with GTA**; conduct interviews; create preliminary reference list; summarize your research into key content areas.
- **Week 5:** By the last class meeting of the week, complete the interview.
- **Week 6: Interview Follow-up** due - Turn in the Interview Evaluation Sheet.
- **Lab 6:** Outline of oral presentation is due.
- **Lab 8:** Draft of Oral Presentation due
- **Lab 10:** Give oral presentation; provide copy of FINAL slides of presentation and handout with reference.

Assignment Detail

Please note that there is no formal written requirement, such as a lab memo, for this assignment. The only things you will have to turn in **on the day** of your presentation are a Final copy of your presentation slides and your handout with your list of references. A detailed layout of the process leading up to the oral presentation and the work involved follows.

1. Choosing a Discipline (5 pts.)

Students are required to choose an Engineering discipline that is of interest to all the members of your group. Keep in mind that your team members may have a major different from your own. The presentation is a chance for you to research and find out more on your interest area or an area that you may know little or nothing about, and then share this information with the entire class for their benefit.

Think about disciplines your group would like to research from the following list. Decide on the three disciplines you would be most interested in and email those choices to your TA. The TA will then assign disciplines based on your choices, and the order in which they are received.

List of Departments – Given below is a list of Departments that offer Engineering program at the Ohio State University. The secondary bullets indicate the Engineering majors offered by the respective departments. 'U' implies a degree in Bachelor of Science. 'G' implies a Masters or a Doctoral program. Note – Certain departments offer minor for undergraduates.

- Aerospace Engineering & Aviation
  - Aeronautical and Astronautical Engineering (UG)
  - Aviation (U)
- Austin E. Knowlton School of Architecture
  - Architecture (UG)
  - Landscape Architecture (UG)
  - City & Regional Planning (G)
- Biomedical Engineering (U – minor, G)
- Chemical & Biomolecular Engineering (UG)
- Civil and Environmental Engineering & Geodetic Science
  - Civil Engineering (UG)
  - Environmental Engineering (UG)
  - Geomatics Engineering (UG)
  - Geodetic Science (G)
- Computer Science and Engineering
  - Computer Science and Engineering (U)
  - Computer and Information Science (U – BS and minor)
- Electrical and Computer Engineering
  - Electrical and Computer Engineering (U)
  - Electrical Engineering (G)
  - Computer Engineering (G)
- College of Mathematical and Physical Sciences - Department of Physics
  - Engineering Physics (U)
- College of Food, Agricultural and Environmental Sciences
  - Food Agricultural and Biological Engineering (UG)
- Industrial Welding & Systems Engineering
  - Industrial and Systems Engineering (UG)
  - Welding Engineering (UG)
- Material Science & Engineering
  - Material Science and Engineering (UG)
  - Ceramics (G)
  - Metallurgy (G)
- Mechanical Engineering
  - Mechanical Engineering (UG)
  - Nuclear Engineering (G)

Source: http://www.osu.edu/academics/index.php
http://www.eng.ohio-state.edu/#

2. Research Review Meeting (10 pts.)

This is a three-step process:

1. **Research Meeting** – This meeting is to take place within a week after your GTA assigns you an engineering discipline. Your GTA will furnish you with information like faculty contact list, **Interview Evaluation Sheet** and homework that you need to do before your meeting. It is recommended that you schedule a time where all the four group members can be present; **at least two members must be present**.
2. **Interview** – You are required to schedule an appointment between Week 3 and Week 5. Be punctual for your appointment. Let the interviewee know about the "Interview Evaluation Sheet" at the beginning of the meeting.
3. **Interview Follow-up** – Before the end of Week 6 report back to your GTA and submit the "Interview Evaluation Sheet" or let him/her know that the sheet will be e-mailed.

Refer to step #6 -"Oral Presentation" for the materials to be included in the presentation

When conducting your research, keep in mind that a final reference list is due with your presentation and therefore your group should save information on all references you use in the final presentation and handout. Details on creating and formatting a reference list can be found on page 237 in the book A Guide to Writing as an Engineer by Beer and McMurrey. You must use at least five references for your presentation including the interview you conducted.

Chapter 8 in the Beer and McMurrey book also suggests many ways to research engineering information. Some places to start researching are listed below.

Interviews – You are required to schedule an interview with someone from one of the following groups -

- Department Faculty (check list of faculty on WebCT)
- Practicing Engineers
- Current Students (no list is provided; check with your GTA and peer mentor for helpful contacts)

Written Resources [Chapter 8, pp. 157 – 164 in Beer and McMurrey]

- Technical Journals
- Books
- Magazines

Information on the Internet

Some websites (College, Industry, Job Posting, etc.) are provided here:

- Engineering At Ohio State: http://www.eng.ohio-state.edu/
- Listing of Engineering Jobs: http://ecojobs.com/engineeringjobs.htm
- Career Advice & Salary Calculator: http://swz-hotjobs.salary.com/
- What Engineers Do: http://www.discoverengineering.org/eweek/about_eng.htm
- Career Profiles: http://www.graduatingengineer.com/careerprofiles/index.html

3. Outline of Oral Presentation (25 pts.)

After you have completed the bulk of your research, your group is required to create an *outline* (one-page minimum) of your oral presentation based on content for presentation and possible presentation time. Make sure to include as much detail as possible. You will be evaluated for:

4. *The overall organization of the contents of your presentation material - Arrange the presentation materials in such that the subsequent topics are connected and has a smooth flow while presenting.*
5. *The approximate amount of time your group will spend on each topic.*
6. *The order in which the team members plan to present*.

You will receive your outline back one week prior to the next assignment being due. Please take your TA's recommendations into consideration when planning your draft presentation. Refer to Chapter 9, pp.191 in Beer and McMurrey for tips on how to plan the outline of your presentation.

Grading of outline of oral presentation:

ITEM	POSSIBLE POINTS
OUTLINE FORMAT	5
CONTENT AREAS	12
SPEAKERS LISTED	3
EFFORT/NEATNESS	5

4. Draft of the Oral Presentation (25 pts.)

After reviewing your TA's comments on your outline, start preparing slides for your presentation based on your outline and the reviewer's comments. Note that **PowerPoint must be used** in this presentation. If you've never used PowerPoint before there are a number of references on WebCT that will be of help to you, including tutorials, how-to guides and more. For your draft, create slides of your possible presentation materials. This draft should be a close approximation of what you are planning for your presentation. In grading this, TA's will be looking at content covered, interview details included, formatting of the slides (e.g., **font, font size, slide color, font color,** etc.), aesthetics and length. There is no minimum/maximum number of slides required; however, keep in mind that the presentation must be eight minutes in length with two minutes set aside for audience question and answer. Be sure to set aside some time to pass out your handout for your classmates and address the information contained on the handout. Please print your final presentation slides - three to six slides per page, to be turned in.

Refer to Chapter 9 in Beer and McMurrey to know about how to make your presentations more effective.

General Tips for Using PowerPoint Effectively
- At most, put four bullets per slide for a clean presentation with a text size of at least 25
- Minimize the number of words on text slides
- Avoid making graphs too complex
- Use a consistent background, font, and bulleting scheme
- Be creative when designing your slides, but avoid being too creative. Do not let design detract from your message
- Be professional and avoid use of contents and images that might be offensive

Note: To print three to six slides to a page, go to the File menu, choose Print, and in the lower left of the print box, choose "handouts" from the drop down list shown as "Print what:". Directly to the right of that box choose the number of "Slides per page" in the "Handouts" menu.

Grading of draft of slides:

ITEM	POSSIBLE POINTS
MAJOR CONTENT AREAS	10
INTERVIEW INCLUDED	5
SLIDE FORMAT	5
SLIDE CONTENT	3
3 to 6 SLIDES TO A PAGE	2

5. Handout (50 pts.)

Your lab group is required to create an original handout to be given to your entire lab section –one for the instructional team and one per student. The point of this is to give your fellow students some information to take home in regards to the discipline you studied. DO NOT give out a handout used by an engineering department; do not print off a copy of your slides. Your handout can be in either of the formats below –

7. A pamphlet/brochure form – Go to Page Setup and select "Landscape". Then go to Format>Columns and select the number of columns that you want in your pamphlet handout.

8. A regular one-page - front and back print out.

Use a readable font and provide information in non-paragraph form. For example, it is not required of you to write a one-page paper. Think of the handout as a brochure. If there are areas within your presentation that you feel need more attention, provide more details on the handout. Tables and charts are most helpful in summarizing information and can be aesthetically pleasing. It may also be a wise idea to provide your fellow students with some of the references you found most helpful in researching the discipline. The handout will be graded on information provided, layout, creativity, and reflection of presentation. Refer to chapter 8 in Beer and McMurrey (pp. 190) for hints on creating effective handouts.

Grading of handout:

ITEM	POSSIBLE POINTS
CONTENT	20
AESTHETICALLY PLEASING	5
CONSISTENT WITH PRESENTATION	5
ORIGINALITY	5
READABILITY	5
LENGTH	5
ENOUGH COPIES?	5

6. Oral Presentation (100 pts.)

a) Presentation Contents - Your presentation SHOULD cover the points listed below –

- Name of engineering major should be mentioned in the slide.
- Is this major closely related to another major? If so, name them.
- State the salary expected and salary increment in the job market industry – corporate and/or university.
- Research and furnish details on job stability/job market/kinds of job available/type of firms employing professionals; e.g., a company like GM might employ Mechanical Engineers, Computer Science Engineers, Industrial System Engineers, etc.
- What options are available to you to further your education with a Master's and what fields offer specialization? For example, an undergraduate degree in Civil Engineering can be furthered with a M.S in Structures, Construction Management, City and Regional Planning, Transportation Engineering, Architecture, etc.
- Which lab experience(s) this quarter is most closely connected with the discipline you researched? Explain the connection.

Other topics that could be covered during your presentation, based on the time availability, are :

- How does this major differ from others that are similar? For example, if you chose Aviation as your topic what are the major difference/similarities of the topic from Aeronautics?
- How research-oriented is it and what research is being conducted in this field at OSU and elsewhere?
- Source of funding to the department – from OSU and from off campus sources.
- Importance of a Master's and/or a PhD in this major?
- Connection of this field with professional organizations.

b) Presentation -

The actual presentation should last eight minutes and teams should allow two minutes for question and answer. Everyone in the team must present some portion of the material, or points will be taken off. You are required to use PowerPoint to make your presentation. You will be required to hand in one copy of the final copy of the slides you've used after you have finished presenting. Please print these out in "handout format", three to six slides to a page.

You must also include a final list of references with your presentation. The list of references should specify all sources of information you used in preparing your handout and presentation. All references should be listed according to the standard formatting rules. Read Chapter 9, pp 187-206 in Beer and McMurrey to learn about the effective ways to deliver a presentation.

Grading will be done based on the Oral Presentation Evaluation form in the packet.

Fundamentals of Engineering
Oral Presentation Evaluation Form

Team Name: ______________________________

Individual Performance Points per Team Member (0 = low to 6 =high)

Names:	____________	____________	____________	____________
1. Poise/Professionalism	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
2. Delivery	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
3. Good organization	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
4. Good use of visual aids	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
5. Transition to speaker	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
Totals (out of 30)	____________	____________	____________	____________

Group Performance Points per Team Member (0 = low to 10 =high)

1. Introduction of members	LOW	0	1	2	3	4	5	6	7	8	9	10	HIGH
2. Creative visual aids	LOW	0	1	2	3	4	5	6	7	8	9	10	HIGH
3. Effective organization	LOW	0	1	2	3	4	5	6	7	8	9	10	HIGH
4. Good use of time	LOW	0	1	2	3	4	5	6	7	8	9	10	HIGH
5. Understanding of topic	LOW	0	1	2	3	4	5	6	7	8	9	10	HIGH
6. Answered questions clearly	LOW	0	1	2	3	4	5	6	7	8	9	10	HIGH

COPY OF FINAL SLIDES 0 5 GROUP TOTAL SCORE: ________

FINAL REFERENCE LIST 0 1 2 3 4 5

COMMENTS

Interview Evaluation Sheet

Students: Complete the top part of the form. Ask the interviewee to complete the bottom part and to return via Campus Mail. Please provide the interviewee with a campus envelope already addressed.

Name of Faculty / Practicing Engineer / Graduate Student: ___________________________________

Department or Company: ____

Date of Interview: _________________________

Name & e-mail of GTA: ____

Names of students present:

1) 3)

2) 4)

Interviewee: Please complete the bottom part of the form and return via Campus Mail in the envelope provided.

1. Did the students arrive on time (circle one)?	Yes	No				
2. Are at least TWO members present?	Yes	No				
3. Did they appear to have conducted reasonable research before meeting with you?	1(low)	2	3	4	5(high)	
4, Did the group utilize the time effectively?	1(low)	2	3	4	5(high)	
5. Did the group pose thoughtful questions?	1(low)	2	3	4	5(high)	
6. Overall score for the interview	1(low)	2	3	4	5(high)	

Additional comments –

____

____

Please complete and return via campus mail to – Room 244 Hitchcock Hall, 2070 Neil Ave. OR by U.S. Postal Service to – Room 244 Hitchcock Hall, 2070 Neil Ave., Columbus, OH 43210 to the attention of the students' GTA or to the Director, First-Year Engineering Program.

Signature & Date: ____

Thank you for your time!

Common Questions & Answers
The Oral Presentation

The BIG question:

Why, are we doing this? We are all forced to learn about different areas of engineering in our survey classes. Basically I am stuck with a type of engineering that totally doesn't interest me at all, and this requires a lot of work.

This presentation serves as a means to learn, in-depth, about a major outside of your interest area. We should make the assumption that you haven't had much information presented to you about these disciplines and opportunities afforded by them. Also, except for the undecided students, your survey class is concentrated on the interest area you have already chosen. Our hope is that each student will be armed with a sheet of information about 9 different disciplines and will learn a little something more about each in order to make a better-informed decision on their career goals. Your jobs are to help your fellow students in the same manner that they will be helping you. You never know… a good, in-depth presentation may make your change your mind!! These presentations are a chance to practice public-speaking as well as help YOU make a good decision.

General Questions

If we don't have a zip drive can we burn the PowerPoint presentation onto a CD? Or do the computers we'll be using not have a CD drive?

YES! A CD drive is available.

Where can we use a PowerPoint program if no one in our group has one on their computer?

All campus computer labs and libraries should have PowerPoint on the computers. Check with the nearest lab.

What should we focus upon? For example: the requirements to get into the major, what the main focus of the major is, what classes you must take to get the degree.....

The presentation should focus on those things that are most important to the discipline, not necessarily what it takes to get a degree… unless the degree requires unusual elements. Remember that you are presenting to your classmates an alternative to the major that they may currently be interested in. You want to provide your classmates with the most information possible so that they can learn a little something about each discipline and be better informed of the positive and negative aspects.

The following are suggested topics from the handout on the Oral Presentation (in your lab manuals):

- What types of industries the discipline focuses on
- Common job titles and description of position
- Application of the discipline in the labs performed during 181
- Description of area from the perspective of:
    - A current student (junior or senior level)
    - A faculty member
    - A practicing engineer
- The current job market and salary averages
- Things you learned about the area you did not know before

I am a little unclear on whether we should follow the outline given or do our own research and make our own specific presentation.

The information you present should include those elements found on the second page of the oral presentation handout under "Presentation." However, your presentation is not limited to this information and can include whatever the group deems as interesting and pertinent information. Also, if you can't find some of the information don't panic!!! If it was extremely hard to find, note this in your presentation and move on to the next topic.

For our project do we have to go into great detail about one aspect of the type of Engineering? (Bridge building or civil engineering)

Once again that is entirely up to the group to decide. As a teaching team and administration, we wanted to give you the most lee-way in organizing and presenting information to your classmates.

When are we getting a list or something for the names of working engineers or grad students in engineering?

No such list exists. However, speak with your TA's and peer mentors to see if they know anyone in the department you can speak with. Also you could ask your faculty contact if they could recommend any students from the department. As far as working engineers are concerned, do your best to research companies and see if they have any profiles. This technically would not be an interview, but it would still contain the perspective of a working engineer.

References

What significance would the technical journals have in our presentation? All the ones I looked at for ME are all VERY technical calculations.

Sometimes Technical Journals will have articles that are not research based and include information on career choices or profiles of leading people in the field, or salary information. Don't worry about calculations and if you can't find anything but technical calculations don't use the journal as a resource. Keep in mind that the list was suggested!!

Do we need to have a reference from each of the categories given in the description?

Your references should correspond to the information you present. Therefore, if you had 30 references on your original list of references, but only used information from 20, then you need only include those references. The list on the handout was only to give you some direction as to where to look for the information. You are required to have at least five references.

Is there a certain amount of people we should interview?

One interview is required out of the three possible choices.

Handouts

Does the handout have to be in a certain form or standard? There was a standard of 12pt and double space for the handout, and I think if it is a free standard we could make it more visual and easy to read according to our subject.

AND

What exactly are the requirements on the handout?? My group turned in a draft of ours, but we did not see anything that provided an outline of what was required. Is it supposed to look professional, or can it be "casual"??

The standard is 12 point font and double spaced, but this does not by any means imply a paragraph structure or a required font. You can be as creative as possible with your handout as long as it is readable. Feel free to add whatever you like as long as you believe you have conveyed the information clearly! Remember you audience is your peers… think about what form YOU would like to see while you are doing this assignment!

It's a bit unclear to me whether the handout should be a one page written information sheet or more like a bulleted list of items. Can we just print up our power point slides as our handout -- then people could get all our information.

This is a possibility… however it will be costly and not efficient space-wise. The most likely scenario is that you have so much information that you will only be able to hit major points in your presentation. More detail can be included on the handout. Feel free to use the information on your slides on the handout as well, but try and condense it to fit in one page. This will also save you some money!!! On the topic of producing copies: CopEZ and Kinkos both provide a service where copies are 3 cents a piece. You should make enough for your classmates as well as a copy for your TA, lab instructor, and peer mentor. Be sure to ask your TA for a final number of students in your section.

I was wondering for the handout that we need, is it to be made up by the group or can it be information that we get from the college of engineering about the discipline in which we are doing our presentation on?

The information contained on the handout should be information you gain from the College of Engineering and the department as well as any other information you can dig up on other aspects of your presentation. Whatever information you find from your various sources should be included on the handout as a summary of the content of your presentation.

How much detail do we have to go into in our handouts & outlines? Will we be docked points if the presentation we give varies from our handed-in outline?

All of your draft documents should be looked at as starting places. Things can definitely change in your presentation such as content and ordering. Points *will not* be taken off if the final version varies from your drafts.

I don't really understand the handout? Should it be a paper with facts and such on it or is it a picture? I would like some more guide lines on this.

Again, you can include whatever information you want on the handout and organize it in whatever way that your group feels is appropriate. Don’t feel as though you need to stick to conventional methods!!

The Actual Presentation

Can we have guest speakers?

Yes you can! However, those “guest speakers” cannot give your presentation for you. You still need to make sure that all members participate. A good place to utilize guests would be to incorporate them into the question and answer session!!!

About how many "slides"/pages long do you expect the presentation to be?

There is no requirement on the number of slides or pages that your presentation needs to be. As long as you have 8-9 minutes worth of material reflected in the slides, the number is insignificant. Some people may choose to put more information on a slide than others. It is entirely up to your team.

If we are to do this on PowerPoint, how many slides should it be given that the presentation will last approximately 8 minutes long?

You will need to rehearse the information that is on the slides and make sure that your presentation fits in the time allotted. If you are running into a problem with length, remember to hit the high and major points in your presentation and include further detail in the handout that you give out. If you do this, make sure to reference the handout in the presentation.

How long should the actual written report be? Or does the written length not matter just as long as it fits the actual time of presentation requirement?

There is NO written report like a lab report. The only things you have to turn in are an updated list of references (if they’ve changed significantly), the final copy of your handout, and a printed version of your presentation.

One question that has been bothering me is how we will determine the order of the presentations. Will we be able to fit them all in one day, or will there be sign up sheets for certain days?

The order of the presentation is up to your lab instructor. You may want to check with him/her prior to presentation day to prepare yourself!! All presentations will be held in the last lab of the quarter!

Are you allowed to use props or diagrams other than the PowerPoint presentation?

YES!! Use whatever you deem necessary- increase the creativity points!!

If a group member does more of the preparation to the presentation, do they have to talk as long as all of the other group members or is this assignment for they assessment of our public speaking skills?

Each person in your group is expected to make an equal amount of the presentation. All of the preliminary tasks you are completing prior to the presentation (list of references, handout draft, etc…) are designed to help you outline the content of your presentation. As you can see from the criteria listed above, the actual presentation is graded on content as a group and also on the individual speaking skills of all of your members.

Do you want the oral presentation in memo format?

The information you present should not be in a memo format, but contained within your PowerPoint slides and handout. **THERE IS NO WRITTEN MEMO/REPORT COMPONENT!!!**

Do we need to have the report memorized?

You can use note cards and your presentation to help you when speaking so, no, you do not have to have the information memorized, but be sure to rehearse using the slides so you don't lose any points on the organization aspect of your score.

What kind of information do you want on the PowerPoint presentation?

All of the information gathered should be organized and included in the presentation. A list of possible areas to speak about is listed on page 2 of the handout.

What all do we have to hand in?

On the day of the oral presentation, you will be required to turn in a copy of your PowerPoint slides, printed 6-Up as well as a final version of your handout and your final list of references.

Does it have to be done in PowerPoint? Can we narrate the slides?

Yes, your presentation should be done in PowerPoint. If all members of your group are unfamiliar with PowerPoint as a tool, there is an instructional presentation on WebCT in the Course Materials section. You should not narrate the slides (use PowerPoint to include speaking voices). All members of your group should speak in class that day.

I am not exactly sure how we put everything together (the interviews). How should this presentation be given to link everything together and meet all the requirements?

How you link the information in your presentation together is entirely up to the group. Again, try and focus on what you feel is most important for your classmates to know. Pick some major topic areas and use the information you gathered from interviews and other sources to support those topics

Grading

How exactly is the grading of the actual oral presentation done? I would just like to know how the points are earned.

This is the form that will be used to evaluate individual & team performance in the oral presentation:

Introduction to Engineering

Oral Presentation

Evaluation Form

Team Name: ______________________________

Individual Performance	Points per Team Member (0 = low to 6 =high)		
Names:	____________	____________	____________
1. Poise/Professionalism	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
2. Delivery	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
3. Good organization	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
4. Good use of visual aids	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
5. Transition to speaker	0 1 2 3 4 5 6	0 1 2 3 4 5 6	0 1 2 3 4 5 6
Totals (out of 30)	____________	____________	____________

Group Performance	Points per Team Member (0 = low to 10 =high)									
1. Introduction of members	LOW	0	1	2	3	4	5	6	7	8
2. Creative visual aids	LOW	0	1	2	3	4	5	6	7	8
3. Effective organization	LOW	0	1	2	3	4	5	6	7	8
4. Good use of time	LOW	0	1	2	3	4	5	6	7	8
5. Understanding of topic	LOW	0	1	2	3	4	5	6	7	8
6. Answered questions clearly	LOW	0	1	2	3	4	5	6	7	8

COPY OF FINAL SLIDES 0 5 GROUP TOTAL SCORE:

FINAL REFERENCE LIST 0 1 2 3 4 5

COMMENTS ______________________________

The presentation and all assignments involved with the project will be worth 10% of your final grade. The actual presentation will be weighted heavier than the assignments. Check on your oral presentation handout for a description of each assignment, the grading scheme for each assignment, and the allotted points.

101 Tips for Effective Presentations

Preparing for your presentation

Know who your audience will be

1. How many people will be in attendance?
2. What kind of work or profession do they do?
3. What is their level of understanding about your subject?

Remember your objective

4. You may need to inform or persuade, or both
5. Be confident with your material and delivery
6. What are you going to tell them? -- Identify 5-9 key points you want your audience to take away, know them by heart, and be prepared to repeat them throughout your talk

Anticipate the questions

7. Consider the points your audience is likely to ask for further information about
8. Identify points they want to hear
9. Pinpoint the details they are likely to challenge
10. Be aware of any points that are likely to upset them
11. Carefully plan how will you deal with all these scenarios

Practice, practice, practice

12. Make several "dry runs" before the actual presentation
13. Rehearse in front of a mirror, with a tape recorder, and/or a video camera
14. Have a friend, family member, or co-worker listen and offer a critique
15. Time your presentation
16. Stop, go back, and repeat the segments you did not present the way you intended

Take care of yourself

17. Get plenty of rest the night before your presentation
18. Don't strain your voice the day(s) before your presentation
19. Don't eat or drink right before you talk; if you do, be particularly careful with food and drinks and don't spill them on your clothes
20. Drink plenty of water in the 12 hours before your talk; avoid milk, thick juices, and other beverages that will make your mouth and throat sticky
21. Make sure you use the restroom before your presentation
22. Check your appearance – hair, clothing, etc. before entering the room

Verbal communication strategies

Volume

23. Make sure everyone can hear you; ask people sitting in the back if they can hear you
24. If you speak too quietly, it will be hard to hear; if you speak too loudly, it will be annoying
25. If you are comfortable, slightly lower the volume to draw people in, and then raise the volume to make key points
26. Think about making your voice fill the room

Pace

27. Go slower where you want to make an important point clearly, but don't go so slow that you lose your audience
28. Go faster where you think people will understand, but don't rush through the material so quickly that the words can't be understood

Pauses

29. Use pauses to punctuate the flow of your presentation
30. Strategically-placed pauses can help you dramatize or clarify a point
31. Use pauses to give participants time to think about what you just said
32. Use pauses combined with eye contact when you think you have lost your audience or when some audience members seem to be involved in a side conversation
33. Use pauses of no more than 10 seconds when you need to collect your own thoughts and think through what you will say next

Inflection

34. Use inflection to convey emotions
35. Don't use a monotone voice
36. Don't over-inflect and make your voice shrill, squeaky, or sing-songy
37. Practice using inflection on key words and points to add flair and enthusiasm
38. Listen to your inflection on rehearsal audio or video tape to see how you sound

Tone

39. The tone for most oral presentations is relaxed but serious
40. This is especially the case when presenting to peers and colleagues
41. Presentations to your managers, customers, competitors, and professional associations will be more serious and professional
42. Jokes, if told, must be politically correct (that is, not capable of offending anyone) … and funny
43. Don't tell a joke unless you know it well; there are fewer things worse than a botched joke

Avoid Artificial Fillers

44. Listen for stammer words that are fillers: "Y'know," "Uhh," "Like," "So," "Well"
45. Many people have other unique filler words that they noticeably over-use
46. Be conscious of fillers as you rehearse and eliminate them from your presentation
47. Have a listener count how many times you use such words

Nonverbal communication strategies

Research has shown that most of a message is delivered through nonverbal means

48. 7 % is conveyed by actual words or content
49. 38% is transmitted by tone of voice and volume of speech
50. 55% is delivered via non-verbal information, such as facial expressions, posture, hand gestures, and how you carry yourself

Body Positioning

51. Don't stand directly in front of your slides, charts, graphs, etc.
52. Stand to the side of the screen or board and use your hand, pointer, or mouse to direct attention to important points, with the information to your writing-hand side
53. Direct all speech at your audience; don't talk into the screen or flip chart
54. Don't hide behind a podium or table, or sit in such a way that some or all audience members cannot see and/or hear you

Posture

55. Stand with your feet about shoulder-width apart, with knees slightly bent when you are not moving about the room
56. This posture gives the appearance of being in control, relaxed, and confident
57. This posture should be comfortable and not awkward; practice ahead of time to get a feel for it

Movement

58. Be animated as you present your material
59. Move around somewhat, even if you must remain in the area of the podium or projector
60. Don't make erratic or unorthodox movements, like bouncing, rocking, pacing, or other distractions

Hands

61. Gesture naturally, not mechanically, with your hands
62. Do not use your hands excessively, unless it fits your personality
63. Be careful not to make unnatural hand movements that could be interpreted as lewd or culturally offensive (e.g. To a Brazilian audience, the "O.K." sign Americans make with their hands by forming an "O" with the thumb and index finger, with the remaining three fingers raised up, means the same thing as raising the middle finger in America)

Facial Expressions

64. Use facial expressions to show concern, enthusiasm, empathy, and understanding
65. Appropriate expressions will make you more believable to participants
66. Be genuine! Check yourself in the mirror before experimenting with facial expressions

67. Smile as much as possible, naturally

Eye Contact

68. Practice establishing eye contact with your audience to make them feel included
69. Spend several seconds looking at one person before moving your visual focus to another person
70. Eye contact of longer than 3-5 seconds can make a participant uncomfortable
71. When the audience stops looking at you, it can be the first sign that they've also stopped listening

Nervousness

Accept it

72. Recognize and accept the signs of nervousness—they'll diminish as you proceed through your presentation
73. Remember that a certain degree of nervousness can be very positive in giving you the energy and drive you need for an enthusiastic presentation

Be prepared

74. Reduce nervousness by knowing your content and presentation ahead of time
75. Rehearse several times prior to presenting

Be your natural, professional self

76. Keep in mind that the audience trusts that you are qualified to deliver this material
77. Remember that your peers and/or superiors consider you to be the best choice for the job

Know the audience

78. Familiarize yourself in advance with the audience's size, composition, and needs
79. Provide examples relevant to the group
80. Speak with a few people one-to-one before you begin to build familiarity

Maintain physical control

81. Breathe deeply and slowly before you begin in order to establish your composure
82. Pause frequently to take a deep breath during your presentation
83. Direct your attention toward a friendly face occasionally for reassurance
84. Move around slowly to prevent "paralysis"

At the podium

Appearance

85. Be aware of the image you are projecting as the speaker—you never get a second chance to make a good first impression
86. Dress appropriately for the occasion and audience
87. Avoid distracting colors and patterns in your clothing
88. Check for all the non-verbal cues addressed above
89. Project calmness and authority

Opening and introduction

90. The opening should capture and hold the listeners' attention
91. In the first minute, you should state the problem (need or opportunity) that is the focus of your discussion
92. Explain why is it important, who it affects, and how
93. Tell them what your going to tell them in response the problem, need, opportunity, or situation

Delivery

94. Now tell them what you came to tell them
95. Be convincing, know your material, and present your logical points in a confident and organized way
96. Stress the main points of the content; reiterate them throughout your presentation
97. Be objective and air both positive and negative views where appropriate
98. Listeners should be able to build their notes into a near replica of your presentation outline

Conclusion

99. Finally, tell them what you told them
100. Tie all your ideas together in a summary that clearly and neatly packages your message
101. When you end your presentation, the audience should leave with an unmistakable understanding of your message

COURTESY: http://feh.eng.ohio-state.edu