MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINEERING

2.671 Measurement and Instrumentation

Instructions for Using Your Laboratory Notebook

Please read before coming to Lab 3. You will receive a lab notebook at that time.

Why is it Important to Keep a Good Laboratory Notebook?

Keeping a complete and accurate record of experimental methods and data is a vital part of science and engineering. Your laboratory notebook is a permanent record of what you did and what you observed in the laboratory. Learning to keep a good notebook now will establish good habits that will serve you throughout your career. Your notebook should be like a diary, recording what you do, and why you did it. You should feel free to record your mistakes and difficulties performing the experiment - you will frequently learn more from these failures, and your attempts to correct them, than from an experiment that works perfectly the first time. It is extremely important that your notebook accurately record everything you did. A good test of your work is the following question: could someone else, with an equivalent technical background to your own, use your notebook to repeat your work, and obtain the same results? For that matter, **could you come back six months later, read your notes, and make sense of them?** If you can answer yes to these two questions, you are keeping a good notebook.

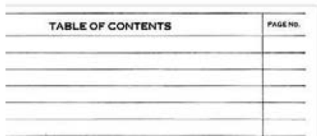
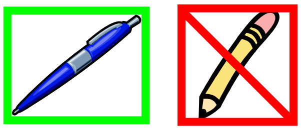
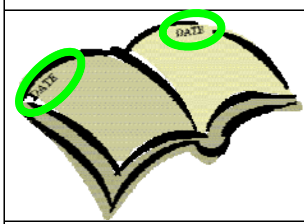
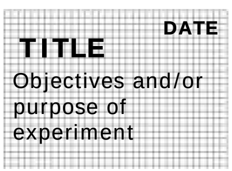
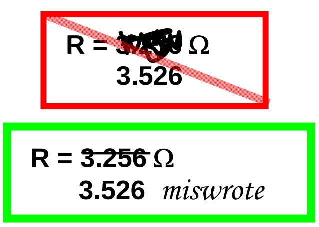
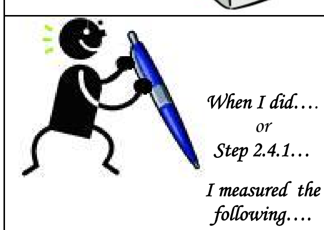
It is also important to maintain a good laboratory notebook in order to protect your intellectual property (e.g. patents). An appropriately maintained laboratory notebook can often mean the difference between gaining or not gaining recognition for a discovery. U.S. patent law states that inventorship is determined by the "first to invent," not the "first to file." The laboratory notebook can be the key piece of evidence in helping to make that determination.

http://www.auburn.edu/research/vpr/communications/resnews/nov01.html

The laboratory notebook forms a permanent record that can be referred to while completing a disclosure report (often the first step in patent preparation) and later, provides accurate documentation of the work done. When an investigator makes an invention during the course of a research project, the dates of the conception and reduction to practice (turning an idea into a reality) become very important. Generally, a sketch and a brief written description are sufficient to establish conception. Reduction to practice is accomplished by actually constructing and successfully testing a material or device incorporating the invention.

During prosecution of a patent application before the U.S. Patent Office, or even after issuance of a patent, the filing of another patent application may initiate an interference proceeding to determine which party was the first to invent. Each party has an opportunity to submit documentary proof of his or her dates of conception and reduction to practice. A laboratory notebook may be, and in several high-profile cases *has been* the crucial piece of evidence in this procedure.

Rules for Maintaining your Laboratory Notebook

	Leave several pages blank at the beginning for a **Table of Contents** and update it when you start each new experiment or topic
	Always use pen and write neatly and clearly
	Date **<u>every</u>** page on the top <u>outside</u> corner
	Start each new topic (experiment, notes, calculation, etc.) on a right-side (odd numbered) page
	Record the **TITLE** and **OBJECTIVES** of each experiment (or notes or calculations) at the top of the first page of the notebook dedicated to this topic.
	If you make a mistake, <u>don't obliterate it</u>! You may need to read your mistake later – perhaps you were right the first time! Use a single cross out and EXPLAIN why it was an error.
	Data typed into the computer must be printed and <u>taped into your lab notebook</u>. Plots of data made in lab should also be printed and taped in your lab notebook.
	When you record an observation in your notebook, include an explanation of what you were doing at the time. If appropriate, you may just record the step number in the instructions followed by your observation.

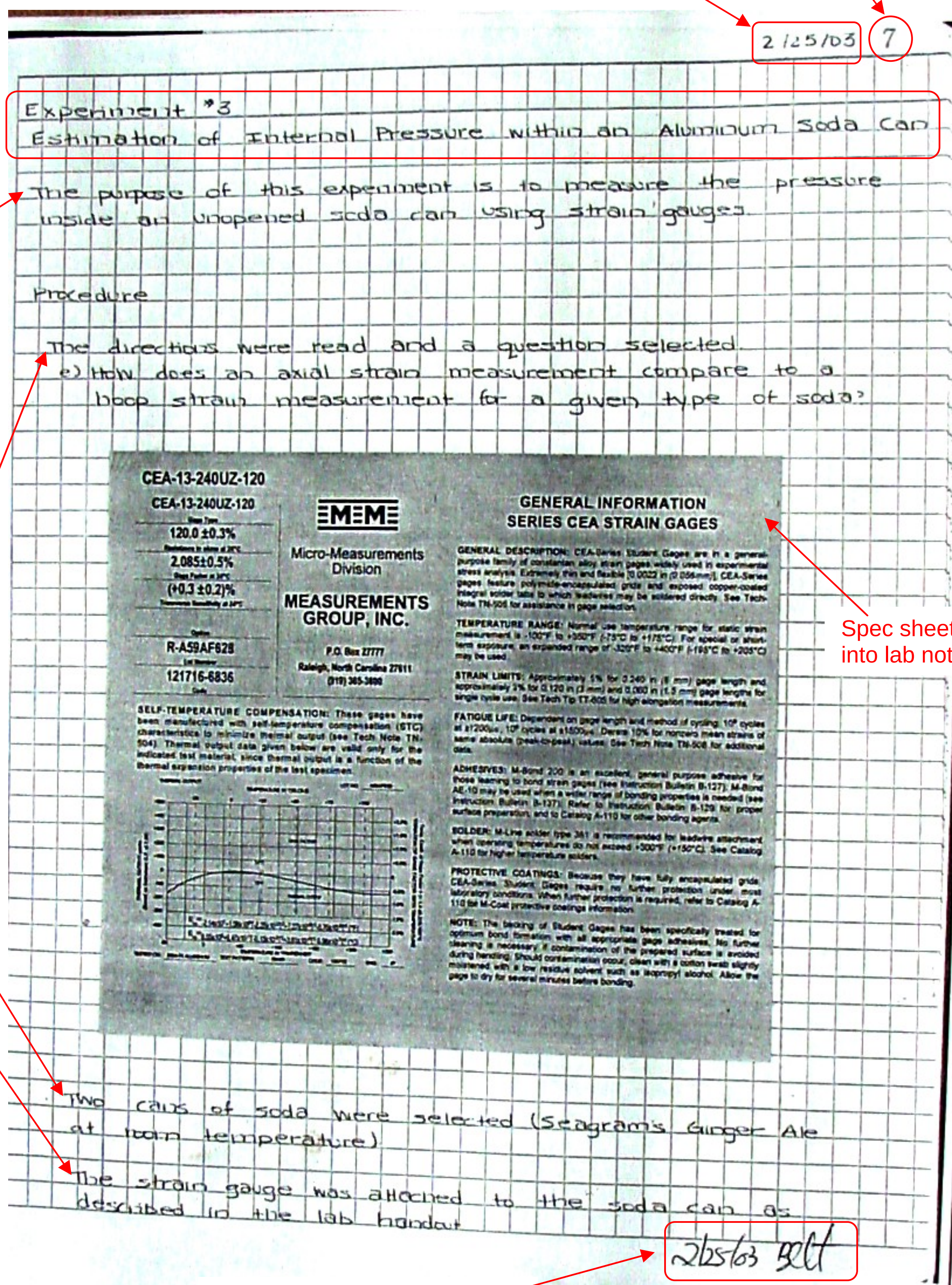
You must have your lab notebook signed by Dr. Hughey or your lab professor before you leave lab each day. Any pages not signed on the day the experiment was performed will adversely affect your lab notebook grade

Metric	Requirements	Worth
Pen	Write in pen, not pencil	10%
Date	Date **every** page at the top	10%
Right Side	Begin each experiment on odd page	10%
Printouts	Attach printouts and plots of data as needed	10%
Legible	Obvious care taken to make it readable, even if you have bad handwriting	10%
Mistakes	Mistakes crossed out with one line and explained	10%
Organized	▪ table of contents ▪ title of experiment on 1st page ▪ objectives of experiment ▪ clear from notebook what you were doing when	20%
Informative	▪ all required data and information ▪ descriptive comments of your observations	20%

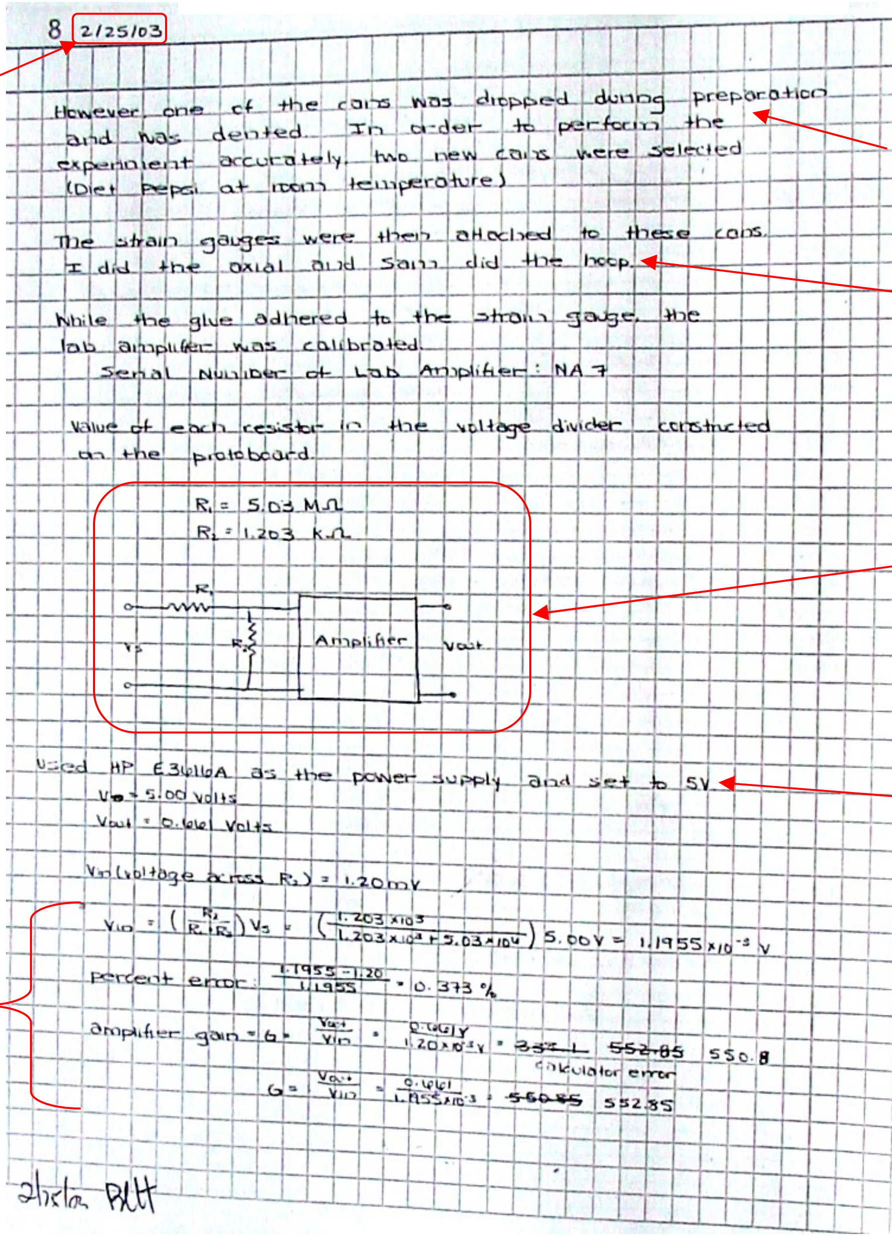
Example: Complete Experiment

Do not copy the words from this example into your notebook – some of the experimental procedure has changed!

First Page:



Second page for Example 1



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However one of the cans was dropped during preparation and was dented. In order to perform the experiment accurately, two new cans were selected (Diet Pepsi at room temperature)

The strain gauges were then attached to these cans. I did the axial and Sam did the hoop.

While the glue adhered to the strain gauge, the lab amplifier was calibrated.
Serial Number of Lab Amplifier: NA 7

Value of each resistor in the voltage divider constructed on the protoboard.

R₁ = 5.03 MΩ
R₂ = 1.203 kΩ

Used HP E3616A as the power supply and set to 5V
Vs = 5.00 volts
Vout = 0.661 Volts

Vin (voltage across R₂) = 1.20 mV

$V_{in} = \left(\frac{R_2}{R_1+R_2}\right)V_s = \left(\frac{1.203\times10^3}{1.203\times10^3+5.03\times10^6}\right)5.00V = 1.1955\times10^{-3}V$

percent error: $\frac{1.1955-1.20}{1.1955} = 0.373\%$

amplifier gain = G = $\frac{V_{out}}{V_{in}} = \frac{0.661V}{1.20\times10^{-3}V}$ = ~~33~~ ~~552.85~~ 550.8
calculator error

G = $\frac{V_{out}}{V_{in}} = \frac{0.661}{1.1955\times10^{-3}}$ = ~~560.85~~ 552.85

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Date at top outer corner

Description of something that went wrong in the experiment and what was done to correct the problem

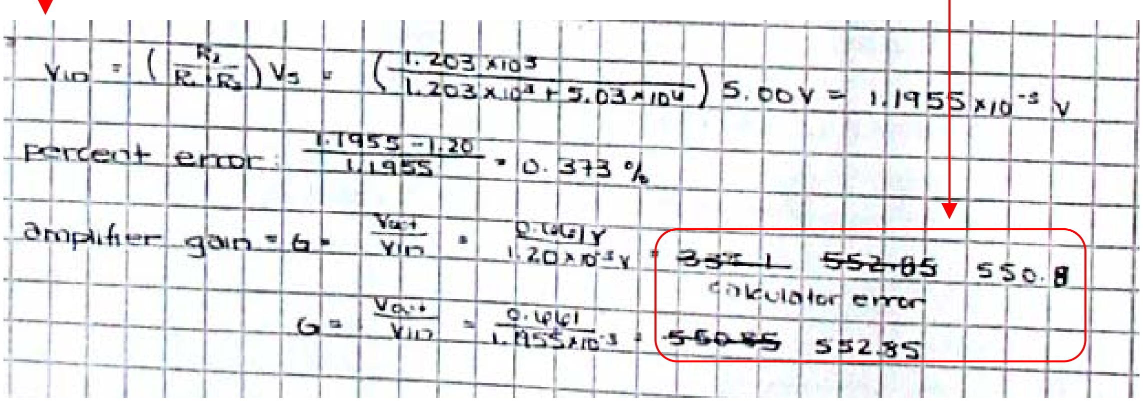
Identification of which member of the team did which task.

Schematic drawing makes clear to what the measured resistances R_1 and R_2 refer.

Model number of the power supply specified

Computation:

1. Intermediate steps shown
2. Errors crossed out with a single line and an explanation ("calculator error").



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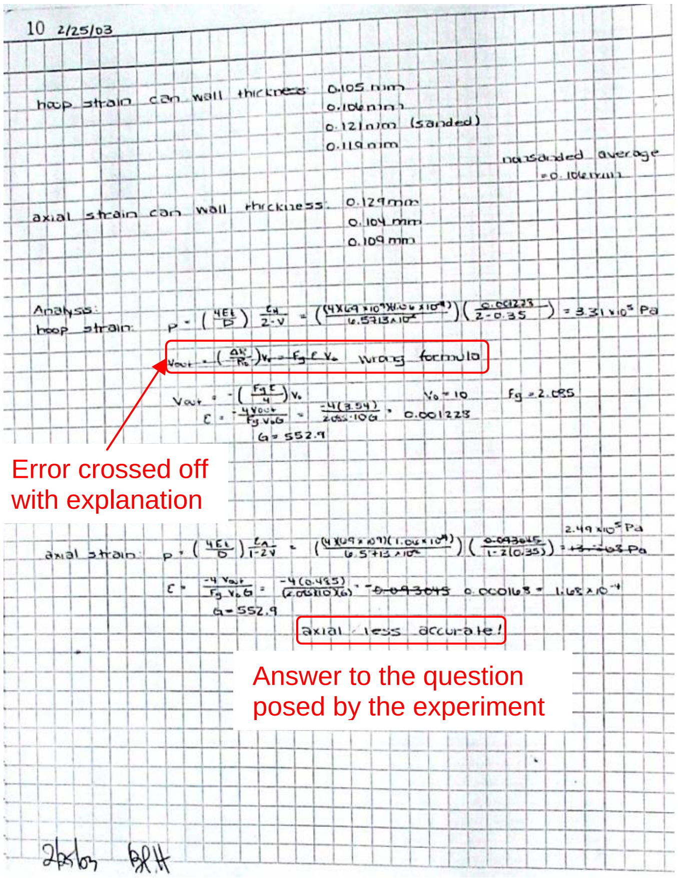
Remaining pages for Example 1:



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hoop strain can wall thickness: 0.105 mm
0.106 mm
0.121 mm (sanded)
0.119 mm
nonsanded average = 0.106 mm

axial strain can wall thickness: 0.129 mm
0.104 mm
0.109 mm

Analysis:
hoop strain: $p = \left(\frac{4Et}{D}\right)\frac{\epsilon_H}{2-\nu} = \left(\frac{(4)(69\times10^9)(1.06\times10^{-4})}{6.5713\times10^{-2}}\right)\left(\frac{0.001228}{2-0.35}\right) = 3.31\times10^5$ Pa

~~$V_{out} = \left(\frac{\Delta R}{R_0}\right)V_0 = F_g \epsilon V_0$~~ wrong formula

$V_{out} = -\left(\frac{F_g \epsilon}{4}\right)V_0$ $V_0 = 10$ $F_g = 2.085$
$\epsilon = -\frac{4V_{out}}{F_g V_0 G} = \frac{-4(3.54)}{2.085 \cdot 10 G} = 0.001228$
$G = 552.9$

axial strain: $p = \left(\frac{4Et}{D}\right)\frac{\epsilon_A}{1-2\nu} = \left(\frac{(4)(69\times10^9)(1.06\times10^{-4})}{6.5713\times10^{-2}}\right)\left(\frac{0.043045}{1-2(0.35)}\right) =$ ~~[illegible]~~ Pa 2.49 × 10^5 Pa

$\epsilon = \frac{-4V_{out}}{F_g V_0 G} = \frac{-4(0.455)}{(2.085)(10)(G)} =$ ~~0.043045~~ 0.000168 = 1.68 × 10^-4
G = 552.9

axial less accurate!

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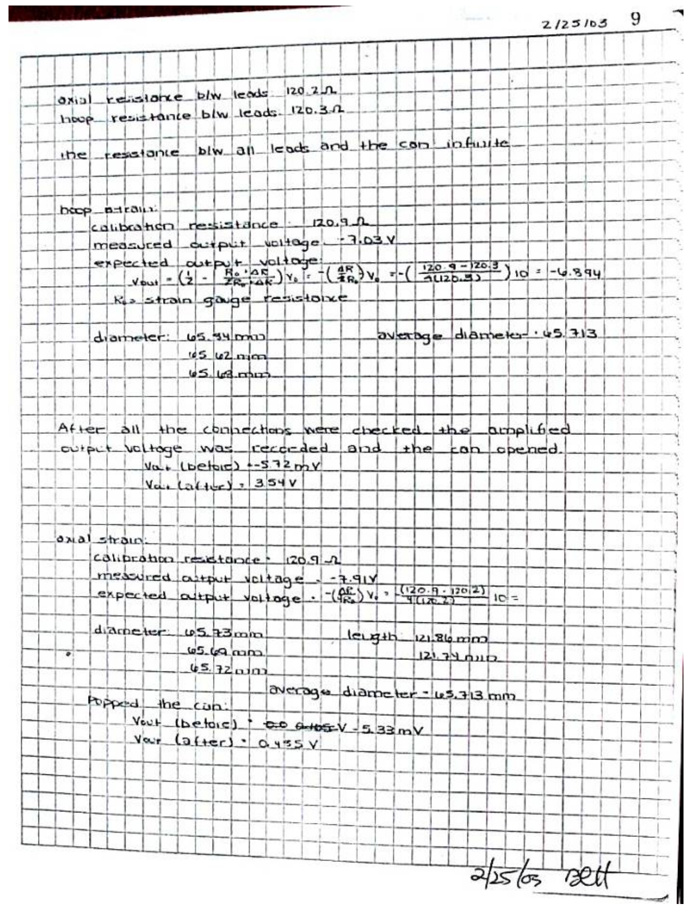

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axial resistance b/w leads 120.2 Ω
hoop resistance b/w leads 120.3 Ω

the resistance b/w all leads and the can infinite

hoop strain:
calibration resistance 120.9 Ω
measured output voltage -7.03 V
expected output voltage:
$V_{out} = \left(\frac{1}{2} - \frac{R_0 + \Delta R}{2R_0 + \Delta R}\right)V_0 = -\left(\frac{\Delta R}{4R_0}\right)V_0 = -\left(\frac{120.9-120.3}{4(120.3)}\right)10 = -6.894$
R_0 = strain gauge resistance

diameter: 65.74 mm average diameter: 65.713
65.62 mm
65.68 mm

After all the connections were checked the amplified output voltage was recorded and the can opened.
V_{out} (before) = -5.72 mV
V_{out} (after) = 3.54 V

axial strain:
calibration resistance = 120.9 Ω
measured output voltage = -7.91 V
expected output voltage = $-\left(\frac{\Delta R}{4R_0}\right)V_0 = -\frac{(120.9-120.2)}{4(120.2)}10 =$

diameter 65.73 mm length 121.86 mm
65.69 mm 121.74 mm
65.72 mm
average diameter = 65.713 mm

Popped the can:
V_{out} (before) = ~~0.0 0.105 V~~ -5.33 mV
V_{out} (after) = 0.455 V

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Key points in this example:

1. Neat and legible handwriting
2. Experiment title and purpose clearly stated
3. Procedure described clearly and succinctly, including errors and the steps taken to correct them
4. Computations performed neatly showing intermediate steps
5. Errors crossed out with a single line and explained
6. All pages dated at the top and signed by lab professor on the same date