THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC

SCHOOL OF ENGINEERING AND APPLIED SCIENCE
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ECE 2110: CIRCUIT THEORY LABORATORY

Laboratory Report Format

Required Sections for all Laboratory Reports

Title Page
Introduction
Background information
Methods and Materials
Experimental Procedures
Measurements and Results
Analysis and Discussion
Conclusion
References
Appendixes

Detailed Contents of Each Section

Title Page:

-Must be its own separate page
-Number and title of experiment
-Names of primary author(s) and all lab partners
-Course # and section #
-Lab instructor's name
-Due date of lab report

1. Introduction

It states the ***objective*** of the experiment and provides the reader with background to the experiment. State the topic of your report clearly and concisely, in ***one or two*** sentences:

Example: The purpose of this experiment was to characterize three different types of diodes: Germanium based, Silicon based, and Gallium Arsenide Phosphide based. The characterization for each was performed using three separate methods: simulator based, multimeter based, and curve tracer based.

Simply "copying" the objectives from the lab manual is unacceptable and will not be allowed. There is no sense in repeating information we have given you in the lab manual, this section serves to show ***your own*** comprehension of the problem.

Note on Verb Tense:

Introductions often create difficulties for students who struggle with keeping verb tenses straight. These two points should help you navigate the introduction:

- The experiment is already finished. Use the past tense when talking about the experiment.
  "The objective of the experiment was..."
- The report, the theory and permanent equipment still exist; therefore, these get the present tense:
  "The purpose of this report is..."
  "The scanning electron microscope produces micrographs ...

2. Background Information

Provide background theory (if any), previous research, or formulas the reader needs to know. If any formulas are given, label them as follows:

$$PE = \frac{|NV - MV|}{NV} * 100$$

Equation 2.1 – Percentage Error (PE) Equation, Nominal Value (NV), Measured Value (MV)

$$V = I * R$$

Equation 2.2 – Ohm's Law Equation

Explain variables that would not be obvious to other engineers (NV for instance). Current (I) does not need explanation for other engineers to understand. Labels are required so that the equation may be referred to later in the report without any confusion or need for reprint.

Also include any relevant circuit schematics or diagrams from the lab manual or Multisim that need to be referred to throughout the lab report.

3. Methods and Materials

Can usually be a simple bullet list or centered table, but make sure it is accurate and complete. Do not copy and paste from the lab manual, typically no quantity is given and in some cases circuit symbols are given (D1, R1, etc.), they have no meaning in this section.

Example:

Equipment	Components (Quantity and Type)
Agilent E3631A Triple Output DC Power Supply	(1) 9.1Ω Resistor
Keithley Multimeter - Model 175	(1) 200Ω Resistor
Breadboard	(1) 3.9kΩ Resistor
…	…

Table 3.1 – Equipment and Components List

4. Experimental Procedures

You are to rewrite the exact steps you followed in lab in your own wording, **DO NOT COPY AND PASTE DIRECTLY FROM THE LAB MANUAL**. This section describes the experimental process in chronological order. Using subsections and a clear paragraph structure, explain all steps in the order they actually happened, not as they were supposed to happen (e.g. "At step 4 we performed four repetitions instead of three, and ignored the data from the second repetition"). If you have done it right, another researcher (or yourself in another year or two) should be able to duplicate your experiment.

Use the sections from the lab manual, to 'sub-section' this section. For example, in ECE 2110's first lab, your subsections should appear as follows:

4.1 Prelab
4.2 Resistance Measurment
4.3 Solderless Prototype Breadboard

If you have done the experiment in a different order, make sure that is reflected in the subsection order. No more than a few sentences or 1 paragraph should be necessary under each subsection to explain the procedure. Do not include any results in this section, however you may refer to results in section 5, ex: refer to Table 5.1.

5. Measurements and Results

This section is usually dominated by calculations, tables and figures; however, you still need to state all significant results explicitly in verbal form, for example:

Using the Equation 2.1, the percentage difference between its nominal (NV) resistance and measured resistance for the 9.1Ω resistor is calculated as:

PE: 5.1 %

Number and title tables and graphs. Graphs need to be clear, easily read, and well labeled. While lab 1 does not require any graphs, future labs will. For example, if plotting current versus voltage (Ohm's law relation), label with caption: Figure 1: IV Curve for the 9.1Ω resistor. In addition all axes must be labeled and all units provided y=(I – Current Through Resistor – (mA)), x=(V - Voltage Across Resistor – (V)). An important strategy for making your results effective is to draw the reader's attention to them with a sentence or two, so the reader has a focus when reading the graph.

In most cases, providing a sample calculation is sufficient in the report. Leave the remainder in an appendix. Likewise, your raw data can be placed in an appendix. Refer to appendices as necessary, pointing out trends and identifying special features.

Realize that no analysis or interpretation is to be done in this section. It is merely meant to serve as the section to **REPORT** the data you collected in tabular, graphic, or another explanatory format.

6. Analysis and Discussion

Discussion is the most important part of your report, because here, you show that you understand the experiment beyond the simple level of completing it. ***Explain. Analyze. Interpret.*** Some people like to think of this as the "subjective" part of the report. By that, they mean this is what is not readily observable from your data. This part of the lab focuses on a question of understanding "What is the significance or meaning of the results?" To answer this question, use both aspects of discussion:

Analysis
What do the results indicate clearly?
What have you found?
Explain what you know with certainty based on your results and draw conclusions:

"Since none of the samples reacted to the Silver foil test, therefore sulfide, if present at all, does not exceed a concentration of approximately 0.025 g/l. It is therefore unlikely that the water main pipe break was the result of sulfide-induced corrosion."

Interpretation
What is the significance of the results? What ambiguities exist? What questions might we raise? Find logical explanations for problems in the data:

"Although the water samples were received on 14 August 2000, testing could not be started until 10 September 2000. It is normally desirably to test as quickly as possible after sampling in order to avoid potential sample contamination. The effect of the delay is unknown."

More particularly, focus your discussion with strategies like these:

- **Compare expected results with those obtained.**
  If there were differences, how can you account for them? **Saying "human error" implies you are incompetent.** Be specific; for example, the instruments could not measure precisely, the sample was not pure or was contaminated, or calculated values did not take account of friction.
- **Analyze experimental error.**
  Was it avoidable? Was it a result of equipment? If an experiment was within the tolerances, you can still account for the difference from the ideal. If the flaws result from the experimental design explain how the design might be improved.
- **Explain your results in terms of theoretical issues.**
  Often undergraduate labs are intended to illustrate important physical laws, such as Kirchhoff's voltage law. Usually you will have discussed these in the introduction. In this section move from the results to the theory. How well has the theory been illustrated?
- **Relate results to your experimental objective(s).**
  If you set out to identify an unknown diode by finding IV curve, you better identify the diode from its attributes or explain why you cannot.
- **Compare your results to similar investigations.**
  In some cases, it is legitimate to compare outcomes with classmates, not to change your answer, but to look for any anomalies between the groups and discuss those.
- **Analyze the strengths and limitations of your experimental design.**
  This is particularly useful if you designed the thing you are testing (e.g. a circuit).

7. Conclusion

Typically, the conclusion will be very short in most undergraduate laboratories. Simply state what you know now for sure, as a result of the lab:

Example: The three diodes were fully characterized as shown in the data collected in the previous sections. The curve-tracer based characterization technique proved to be the most accurate characterization method due to the small percentage error between the data collected and the manufacturer's data sheet for each diode.

Notice that, after the conclusion is presented above, the writer provides a justification. The percentage of error is the result that helps us draw this conclusion. This makes a sound and sufficient conclusion. Generally, this is enough; however, the conclusion might also be a place to discuss weaknesses of experimental design, what future work needs to be done to extend your conclusions, or what the implications of your conclusion are.

8. References

Include your lab manual and any outside reading you have done. Use a journal style reference listing your references in order of use in your report, as example:

[1] GWU SEAS ECE Department. "Experiment #1: Introduction to Lab Equipment: Power Supply, DMM, Breadboard, and Multisim." The ECE 2110 Course Website, Fall 2014. http://www.seas.gwu.edu/~ece11/fall14/labs/labs/ECE_2110_Experiment_1.pdf

[2] Thomas, Roland E., Albert J. Rosa, and Gregory J. Toussaint. *The Analysis and Design of Linear Circuits*. 7th ed. Hoboken, NJ: Wiley, 2012.

You may also use an MLA approved format. Cite the reference within your report as follows:

"Ohm's law states that the current through the resistor is directly proportional to the voltage applied across it [2]."

9. Appendices

This section is optional, but it typically includes such elements as raw data, calculations, graphs pictures or tables that have not been included in the report itself for the purpose of clarity in your report. Each kind of item should be contained in a separate appendix. Make sure you refer to each appendix at least once in your report. For example, the results section might begin by noting: "Relevant sections of OpAmp Data Sheet are contained in Appendix A." While lab 1 does not have a data sheet involved, future labs will.

Additional Requirements

- Every page of your report must be numbered.
- A footer is an excellent practice (place experiment #, page #, and author within it).
- Use two spaces after each period.
- Proper grammar is important and points may be deducted if the grader sees fit.
- Never write in the first person in a laboratory report, some examples for avoiding the first person are as follows:

Incorrect:
"I set the Ohm meter to the appropriate range, measured and recorded…"

Correct:
"This researcher set the Ohm Meter to appropriate range…"
Or
"This student set the Ohm Meter to appropriate range…"
Or
"The Ohm Meter was set to the appropriate range…"

Incorrect:
"We decided to omit step 4 …"

Correct:
"Our group decided to omit step 4…"

Additional Notes

Lab reports are the most frequent kind of document written in engineering. Technical writing is a skill that you will use throughout your education and professional career and is not the same as expository writing that you may have done in the past. Lab reports must be **clear but brief**. Run on sentences, long paragraphs explaining minute details must be avoided at all cost. Like any skill, it requires practice; the undergraduate labs will give you the opportunity to practice this skill.

Each professor wants something a little different. Regardless of variations, however, the goal of lab reports remains the same: document your findings and communicate their significance. With that in mind, this document should serve as a basic technical report's format. Knowing the pieces and purpose, you can adapt to the particular needs of a course or professor.

A good lab report does more than present data; it demonstrates the writer's comprehension of the concepts behind the data. Merely recording the expected and observed results is not sufficient; you should also identify how and why differences occurred, explain how they affected your experiment, and **show your understanding** of the principles the experiment was designed to examine. Bear in mind that a format, however helpful, cannot replace clear thinking and organized writing. You still need to organize your ideas carefully and express them coherently.

References

This report format guide has been modified and adapted for GWU from the Engineering Communication Center at the University of Toronto. For further reference on writing technical reports the following may be of use:

Porush, David. A Short Guide to Writing About Science, HarperCollins, 1995.