1) Each student must submit his/her own report despite the fact that a group of students may collaborate in the conduction of the experiments. It is understandable that lab partners will have similarities in their data but the presentations cannot be identical and certainly editorial items such as Abstract, Introduction and Objectives, Background and Relevant Theory, Discussion and Conclusions are expected to be completely individualized.
2) Plagiarism, i.e. copying others' work and presenting as one's own, is a form of cheating and it is treated as such.
3) The Report is due on The week of 12/3/2018 at the end of lab period. The following grading penalties will be applied to late laboratory reports:
   1 day or less: 50%
   More than 1 day: 90%

Lab Project in IEEE template

Full Name
Engineering Electromagnetics, Section I, II or III – Dr. Hanafi
Dec xx, 2018
Email:

Example Lab Report in IEEE Format

***Abstract*—This is a template which you can use for your lab project report. This type of format is what I am looking for in your submission, especially since you have four weeks to actually perform the lab. You can either use LaTeX or Word, however, LaTeX works a lot better for technical documents. There is a small learning curve associated with LaTeX, however it would benefit you IMMENSLY to learn how to use for later courses. In the abstract, you want to summarize what you actually did in the lab, as well as the overall results and findings during the lab. You normally do this part of the report last since it is essentially just a summary of the entire report. Normally a good metric for length is the abstract should be about 10% of the total length of your paper.**

I. Introduction and Objectives (*Heading 1*)

In the introduction, your goal is to bring the reader into the “mindset" of the experiment or research and state what problem you are trying to solve or investigate. You need to talk about what you are actually trying to accomplish and what results you expect to see from the experiment. You may be thinking “This seems sort of redundant, since we kinda already did the experiment," and you would be right... if you are writing this after you perform the lab. This section **SHOULD** be written before stepping foot in the lab; however, at the least you should consider laying out this section before starting your lab.

OBJECTIVES

1. Design a circuit ….. etc.
2. Build the circuit using …..etc.
3. Measure the circuit characteristics ……..etc.
4. Simulate the circuit in SPICE …….etc.

Try to make this more than a simple “We were told to test different op-amp configurations" or “This is a lab we had to do". You want to talk about what you are looking at and why you would want to actually investigate it. This section should be short at about 5-10% of the length of the paper. This section should be distinct from the following section “Background and Relevant Theory".

II. Background and Relavent Theory

This section should contain any background theory which is necessary to bring your reader up to speed with the content covered in the paper. One of the toughest parts of writing this section is targeting your audience, but luckily for you, I will give you the target audience. You need to write this targeted to an audience of students which are just about to learn about operational amplifiers in their circuits class (whether that be PECA for ECE's or PAECE for ME's). You do not need to talk about how ``In the beginning, there was the electron...", but you need to talk about anything which was covered in this course which deals with the scope of the project.

A. Equations (Heading 2)

It would be in your best interest to talk about op-amp theory and actually derive the transfer functions for each of the circuits covered in the lab and utilize tools such as equation editor to make the math actually look neat and legible. Please do not shy away from making subscripts and using proper fraction notation as these could actually lead to a deduction of points for legibility. For example, it is very clear to see which one of the following equations would be easier to read for the reader:

$$V_{out} = V_{in} \cdot Gain_1 + \int \frac{V_A^2}{V_B} dt \qquad (1)$$

Vout = Vin*Gain1 + int(VA2/VB, t) (2)

Eq. 1 is the clear winner in terms of appearance and readability, where as Eq. 2 looks like something that was typed into a TI-89 calculator. Notice how the equations are numbered and centered to the column.

When you have a derivation or a long list of calculations, you have to make the decision whether or not to put them in the paper or in an appendix. For a general rule of thumb, if your derivation is going to be longer than roughly a third of a column, then place them in an appendix, and place an abbreviated set of calculations in the report itself.

B. Figures

It would also favor you well to include schematics of the circuits you tested and use them to exemplify your calculations. While figures are important, you need to make sure that there are not too many figures (basically, don't make your report a picture book). You want to use the layout in Figure 1 for any figures you wish to include in your report. You want to make sure that your figures are either at the top or bottom of your columns and that any figures are named with what they are showing. Notice that there are no outlines, borders, or any extra enhancements to the pictures.

It may seem like a waste of time, but you need to make your OWN schematics for this report. When you copy schematics of images from other documents, the end picture looks very grainy and unprofessional (not to mention that you could be infringing on someone’s copyrighted material).

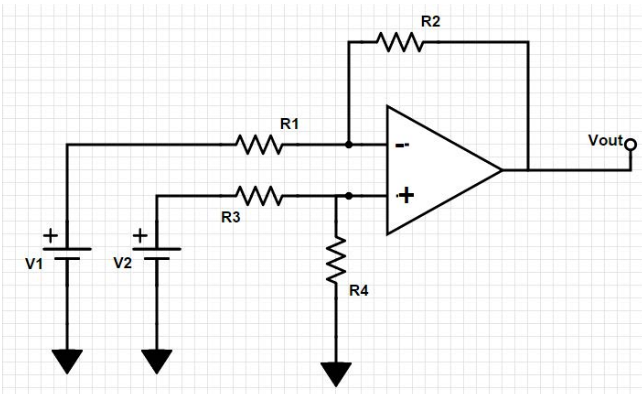

Fig. 1 Difference Amplifier

There are many many resources available for FREE for you to make schematics such as:

1. SchemeIT
2. CircuitLAB
3. PSpice
4. Fritzing

Overall, the Background and Relevant Theory section should be a major section in your report, taking up about 30% of the length of the report. Make sure that you take an ample amount of time to really explain the theory and show us (the graders of this report) that you really understand what you did in the lab.

III. Procedure

The "Procedures" discusses how the experiment occurred. This should include a concise step by step outline of what you actually must do to perform this experiment. As an example, you may state that: "This experiment consisted of several steps. First, a circuit should be designed to meet specific characteristics given a set of parameters. Next, the circuit should be build. Finally, its characteristics should be measured and analyzed. Once this is complete, everything should be simulated in SPICE".

IV. Results and Discussion

This section will contain both your results from your lab as well as an engineering discussion/analysis about what those results actually mean. An engineering analysis and discussion leaves nothing to the imagination of the reader. This means that for every single section in the lab, you need to explain how the data was actually collected, with information such as how the circuit was constructed, what instruments were used, how those instruments were configured, etc. This seems like overkill, however the idea behind these types of reports is so that your results can be reasonably reproduced by another person.

A. Presenting Results

When you present your results, they are most likely either going to be in one of two forms: a figure, or a table. Each one of these have a specific way in which they should be presented, but the main goal is to make a clean, professional looking version of your results which are easy to read and understand. You will first have to present your results (either as a subsection or clearly worded) before you can do any discussion.

Figures:

Figures should be presented in the same fashion as discussed before and shown in Figure 1. When referencing figures in your report, please make sure to use the notation that you have been seeing throughout this document (Fig. #). Make sure that these figure numbers match with what you are actually trying to reference. If you are using Word, you can utilize its built in tools to have the software actually keep track of these for you.

Any figures or plots you wish to present in your report must either be directly from a data capture from the oscilloscope or plots from PSPICE. **DO NOT** copy and paste images from the lab protocol, other peoples reports, or from photos taken from a cell phone. All of these will not look professional and it will be obvious whether or not you have genuine plots and graphs. Remember that these papers will most likely be read in a Black and White format, so make it easy for the reader to see your data (i.e., do not rely on colors to mark which data is being plotted). When using pictures from the oscilloscope, try to make the readings as clear as possible, either by applying an offset on your oscilloscope input, or scaling your input.

The captions underneath your figures should actually be meaning-full, and not just a simple "These are the results for part 6". They should contain information about the test environment and what the data actually is. This is covered more in-depth in the *Tables* subsection.

Tables:

Much like our figures, tables can both be a powerful tool, and a massive eyesore if not treated carefully. Below in Table 1 is a good example of not only how a table should look, but also what should be contained in the caption below both tables **AND** figures.

Amplitude (V)	0.5	1	2.5	5	7.5	9	10
TL072 Slew Rate (V/μs)	9.70	12.15	12.82	12.26	12.43	15.51	12.56
LM324 Slew Rate (V/μs)	0.451	0.455	0.467	0.463	0.498	0.491	0.470

Table 1: Slew Rates under varying amplitudes, using a $2k\Omega$ $100pF$ load, 1KHz sine wave, and $\pm 15V_{supply}$. All Measurements had an uncertainty of $\pm 0.094\ V/\mu s$ for the TL072 and $\pm 0.026\ V/\mu s$ for the LM324.

Tables should be concise places to find information on the experiments you ran. They should be easily readable, regardless of the method you choose to actually layout the table. This means if you utilize a basic Word table, make sure that your data is not lost in a sea of lines and borders. All tables should also have units within them, since the scales of some measurements will be different.

PSPICE Simulation:

In discussing PSPICE simulations, you should include a circuit schematic, a complete netlist showing all circuit connections, device models used with their parameters, input and output waveforms. The results of the simulation must be compared to measured hardware explaining the reason(s) for any discrepancies.

B. Discussion

This could quite possibly be the most crucial part of your entire lab report for this project. This is where your team (notice I didn't say you) has a chance to show us that you actually performed the work in this lab and have the ability to take what is written in a book and correlate it to real-world phenomena. You will see in this lab that these devices are not perfect, and your job in this lab is to see how much they differ from our models and attempt to explain why they happen.

As Engineers, you will be required to perform quantitative analysis in everything that you do. Just saying that "Our circuit worked" is grounds for no points for that section. Worked, did work, succeeded, and other qualitative terms have no place in the analysis of what you did in the lab. You need to provide actual numbers to back up what you are trying to describe. For example, instead of saying “The voltages at the input terminals were not the same and it is because of the device not being ideal.", you should instead write something along the lines of “The LM324 we placed under test had a difference of .01V between the two input pins, which falls under the manufacture's allotted uncertainty. We believe that this is due to the input terminals not having an infinite impedance, thus allowing..."

This type of analytic language is paramount in describing to your reader your thought process as well as giving your results some meaning. Imagine going to a machinist's shop and asking for a box to put your circuit in and saying you want it to about “this big" and about “yay wide" and you show them with your hands. They would probably laugh you out of the shop, since they need specifications such as actual measurements, material choices, material thickness, other shapes which need to be in the design, and more. Think about this when you are writing your analysis.

When answering questions in your lab protocol, please do not just say ``Question 3: The op amp does not...", instead you should be including these answers seamlessly into your discussion. Think of these questions more as discussion points rather than just answers on an exam. You want to try and make this report readable and not just a snore fest of exam style answers. You will learn through practice that even when you are trying to stay professional, your writing can have personality and can be enjoyable. There is an art to balancing technical writing with personal style, and I would like to see you practice that in the report.

You may be thinking then, ``Well what is professional and what is non-professional." The best way I can think of giving a general metric for which to go off of is to look at the writing in textbooks. Their job is to convey information; however, some authors do infuse their own personalities into their writing. This means that you can include some humor in your writing, but again adding humor to a technical document is an art and doing it incorrectly can lead to people not taking your paper seriously. If you read your paper and you feel like it is borderline unprofessional, then it most likely is. If you are unsure of your writing, then seek out help from other students or take advantage of draft review services on campus.

This section (both the results and discussion) should be a major part of the lab coming in at about **<u>40-50%</u>** of the entire report length. This does not mean you should add ‘fluff' to your writing to meet this condition. Instead, you should look into what you actually tested in the lab and answer the question “Why did we do this?"

V. Conclusions

This section is actually quite short and is all about restating your problems and goals laid out in the introduction and stating whether or not you actually obtained them. NO NEW INFORMATION including results or discussion should be introduced in this section. This section should be roughly about 5\% of the length of the paper.

References

[1] G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] K. Elissa, “Title of paper if known,” unpublished.

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[7] M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.