Safety

Avoidance of preventable accidents is an important measure of the foresight and capability of supervision in the engineering industries. You may soon be supervising technical work involving varying degrees of hazard. Give serious thought to the subject of accident prevention and prepare yourself mentally to recognize and avoid dangerous situations, and to cope with emergencies. This self-training is essential, since a set of rules cannot be given to apply to all situations.

Our goals, along with minimizing the occurrence of laboratory accidents, are to cause you to think about electrical hazards and safe procedures and to provide you with information which will remain useful long after graduation.

Implementation of the safety material will be as follows:

1. Your lab instructor will go over the attached material and answer any questions during the first laboratory period.

2. You should study the material carefully before the second laboratory period.

3. The second period will start with a quiz over the safety material. This quiz will not affect your grade in the course, but you must score at least 90% before performing any additional laboratory experiments.

4. The quiz may be repeated; however if you fail to receive a passing score after three attempts you may be dropped from this course for your own protection, and the protection of those working around you.

Your assistance is essential in assuring safe working conditions. All of our activities must be kept free from hazards which might cause injury or even death.

Due to the nature of our operations, risks must be recognized and eliminated. We will make every effort to remove these hazards and we enlist your assistance in this endeavor. Inform me of any hazards or unsafe practices found in the department. Review and correction will follow as soon as possible.

Safety records show that unsafe individual actions are the dominant causes of accidents. Therefore, please act safely during all of your activities.

From time to time you will receive instructions which are intended to make you aware of the safe way to carry out your activities. We ask that you accept these instructions positively and apply them so that the Department of Electrical & Computer Engineering will remain a safe and healthful environment.

Thank you for your assistance and cooperation.
SAFETY RULES AND SUGGESTIONS

1. No smoking, eating, drinking, or "horseplay" is permitted in the laboratory.

2. Haste causes many accidents. Work deliberately and carefully. Verify your work as you go along. Good planning before coming to the laboratory will promote safety.

3. When working on live electrical apparatus, use only one hand as far as practical, keeping the other hand disengaged from circuitry. All power circuits are dangerous. Adjustment in energized circuits should be made with caution. Do not permit any part of your body to complete a circuit.


5. Do not grope for switch handles with your head turned away!

6. Be careful to keep watches, rings, and other metallic objects out of contact with live parts when working around electrical apparatus.

7. Do not use wire with poor insulation. Set-screws that have loosened and worked to the surface expose you to contact with the conductor. See that all connections are securely made and not likely to come apart.

8. Do not touch any electrical equipment when your hands are wet, sweaty, or bleeding.

9. When wiring a circuit, always connect to the source of power as the last step. When disassembling a circuit, disconnect from the power source as the first step.

10. If you suspect faulty equipment, tell your instructor who will have it checked by the proper shop. Do not attempt to perform any maintenance yourself. Removing the case from any apparatus may expose parts at line voltage.

ELECTRIC SHOCK

IT'S THE CURRENT THAT KILLS

Offhand, it would seem that a shock of 10,000 volts would be more deadly than 100 volts. This is not necessarily so! Individuals have been electrocuted by appliances
using ordinary house circuits of 120 volts and by electrical apparatus in industry using as little as 42 volts. The real measure of a shock's intensity lies in the amount of current (amperes) passed through the body, and not the voltage. Any electrical device used on a house wiring circuit can, under certain conditions, transmit a fatal current.

It's the electric current that does the damage. Current equals voltage divided by resistance (I = V/R), but the resistance of the human body varies so widely it is impossible to state that one voltage is "dangerous" and another is "safe".

The actual resistance of the body varies depending upon the condition of the skin at the points of contact (moist or dry). The skin resistance may vary from 1000 ohms for wet skin to over 500,000 ohms for dry skin. However, once the skin is broken through (for example by the burning away of skin) the body presents no more than 500 ohms resistance to the current.

The path through the body has much to do with the shock danger. A current passing from finger to elbow through the arm may produce only a painful shock, but the same current passing from hand to hand or from hand to foot may well be fatal.

Therefore, the practices of using only one hand (keeping one hand in your pocket) while working on high-voltage circuits and of standing or sitting on an insulating material are good safety habits.

**THE PHYSIOLOGICAL EFFECT OF ELECTRIC SHOCK**

Electric current damages the body in three different ways: (1) it harms or interferes with proper functioning of the nervous system and heart; (2) it subjects the body to intense heat; and (3) it causes the muscles to contract.

(1) Chart 1 shows the physiological effect of various currents. Note that voltage is not a consideration. Although it takes a voltage to cause current, the amount of shock-current will vary, depending on the body resistance between the points of contact. It should be realized that the chart is based on average values and individual responses will differ.
As shown in the chart, shock is relatively more severe as the current rises. At values as low as 20 milliamps, breathing becomes labored, finally ceasing completely even at values below 75 milliamps.

As the current approaches 100 milliamps, ventricular fibrillation of the heart occurs--an uncoordinated twitching of the walls of the heart's ventricles.

Above 200 milliamps, the muscular contractions are so severe that the heart is forcibly clamped during the shock. This clamping protects the heart from going into ventricular fibrillation, and the victim's chances for survival are improved. However, there will certainly be other effects, depending upon the current level and duration of the shock (see Chart 1).

(2) AC is said to be four to five times more dangerous than DC. For one thing, AC causes more severe muscular contractions. For another, it stimulates sweating that lowers the skin resistance. Along that line, it is important to note that resistance goes down rapidly with continued contact. The sweating and the burning away of the skin oils and even the skin itself account for this. That is why it's extremely important to free the victim from contact with the current as quickly as possible before the current increases to the fibrillation-inducing level.

The frequency of the AC influences the effects on the human body. Unfortunately, 60 Hertz is in the most harmful range. At the house current frequency, as little as 25 volts can kill. On the other hand, people have withstood 40,000 volts at a frequency of a million Hertz or so without fatal effects.

(3) A very little current can produce a lethal electric shock. Any current over 10 milliamps will result in serious shock.
SUMMARY

Voltage is not a reliable indication of danger because the body's resistance varies so widely it is impossible to predict how much current will result from a given voltage.

The current range of 100- to 200-mA. is particularly dangerous because it is almost certain to result in lethal ventricular fibrillation. Victims of high-voltage shock usually respond better to artificial respiration than do victims of low-voltage shock, probably because the higher current clamps the heart and hence prevents fibrillation.

AC is more dangerous than DC, and 60 Hertz current is more dangerous than high-frequency current.

Skin resistance decreases when the skin is wet or when the skin area in contact with a voltage source increases. It also decreases rapidly with continued exposure to electric current.

Prevention is the best medicine for electric shock. That means having a healthy respect for all voltage and always following safety procedures when working on electrical equipment.

If a person does suffer a severe shock, it is important to free the victim from the current as quickly as can be done safely. Do not touch the person until the electric power is turned off. You cannot help by becoming a second victim. The victim should be attended to immediately by a person trained in CPR (cardiopulmonary resuscitation). Also an ambulance should be called immediately.

In the event of an accident of any type requiring medical assistance immediately UMR University Police at extension 4300 (or 1-573-341-4300)

PREVENTION OF ELECTRIC SHOCK

Because the human body is vulnerable to the danger of electric shock, it is essential that steps be taken to guard against the hazards which exist when using electrical equipment. Primarily, there are two techniques in common use. These are isolation and grounding.

In some situations it is possible to isolate energized equipment so that the operator does not come in contact with it. Sometimes equipment is "double insulated," meaning that the operator is separated from current-carrying parts by a double system of insulation. Many hand held power tools are constructed in this manner. It should be realized that such devices may still present a shock hazard if they are subjected to abuse which damages the insulating materials.
Grounding is probably the most common method of protecting against electrical shock. All exposed non-current-carrying metal parts of electrical equipment should be grounded. This includes the cases for meters, power supplies, oscilloscopes, etc. used in the lab. The case is connected by a grounding conductor to the third prong of a grounding plug which (when inserted into a grounding receptacle) is connected to the building's grounding system.

Proper equipment grounding will eliminate high voltages between the equipment and other grounded conducting surfaces. Also, if an energized conductor does touch the grounded case (due to insulation failure, for example) the resulting large current through a low impedance ground path will open the branch circuit fuse or circuit breaker. Without the grounding conductor, the case could be raised to line voltage and the current path to ground might be through the next person to touch it, resulting in a lethal shock.

It should be noted that circuit breakers and fuses are sized to protect equipment and conductors from excessive line currents. They will not protect you. Remember, less than one tenth of one amp (100 mA) can be fatal. There is a device designed specifically to protect against lethal currents from line-to-ground shocks. It is called a Ground Fault Interrupter, abbreviated GFI. The most common type utilizes a differential transformer to detect small differences between line and neutral currents. Various trip settings are available in the range of 5-20 mA. They are not installed in our laboratories.

THE LABORATORY NOTEBOOK

I. INTRODUCTION

The technical notebook is a basic tool for any experimental work, whether it be basic research, product development, or engineering design. It is primarily for the experimenter's own use, but another person with similar technical background should be able to understand and duplicate any experiment, data, and conclusion, or to prepare a technical report by following only the lab notebook details.

There are many reasons to keep an accurate and complete record of experimental work. Among these are:

1. to establish the authenticity of the work.
2. to defend patents.
3. to act as a basis for technical reports and articles.
4. to avoid duplication of effort.
5. to avoid repetition of erroneous procedures.

The nature of the work and the purpose of the experiment will influence the content and format of the laboratory notebook. Many companies have rigid internal requirements tailored to their specific needs. The notebook formats which follow should
not be interpreted as "industry standards". Rather, they are intended to suit laboratory work in the Department of Electrical & Computer Engineering, and provide experience in following some acceptable format.

II. CONTENT REQUIREMENTS

Instructors are encouraged to return ungraded any notebooks that do not meet the following three requirements.

1. The notebook must be understandable to a person with a comparable technical background.
2. It must be legible.
3. It must stand alone; that is, "We performed step 2 in the handout" is NOT an acceptable entry unless the handout is incorporated.

The laboratory notebook must answer the following questions:

**WHAT WAS DONE?** This includes the approach to the problem or project, as well as the experimental procedure. Computer code printouts and computer generated figures must be included. These are to be clearly annotated to identify what was done, when it was done (date), and who did it (your name). Do not waste space with trivial or obvious details, but give essential steps. Another person should be able to repeat the experiment using your notebook only.

**WHO DID IT?** List all members of the lab group, including yourself, at the beginning of the write-up. Initial all subsequent pages. Any corrections or alterations should be initialed.

**WHEN WAS IT DONE?** It must be obvious to any reader when the experimental work was performed. Date all entries in the notebook. It is possible that a single experiment may have 2 or 3 different dates. Do not leave blank spaces and never "back-date" notebook entries.

**WHAT WERE THE RESULTS?** Data must be distinguished from calculated values. It should be obvious which meter yielded which data. Examples of each type calculation must be given. Graphs must have titles, and labels and scales are required for both axes. Do not "freehand" curves. If you have redundant results (i.e., values that should be the same) calculate percent deviations.

**WHAT DOES IT MEAN?** Make observations and draw conclusions from the results of your work. Be precise and concise. Compare your results to the theoretical (give references). Specifically why do you believe or disbelieve the results? Discuss errors relative to the accuracy of the measurement equipment.

IV. FORMAT
This section includes format requirements for all notebooks in EE lab courses

A. General

The lab notebook is available from bookstores as a "computation book" with brown or blue covers and black binding. Its size is 11 3/4 X 9 3/8 inches, and it has about 152 numbered and crosshatched pages. The notebook should be bound, never looseleaf, and the pages numbered consecutively, preferably by the printer.

A neat, organized, and complete lab notebook record is as important as the investigation itself. The lab notebook is the original record of what was done. It is not a report to be written after completing an investigation. Do not write first on scratch paper expecting to transfer it later to the lab notebook, because you may forget some details or lose the loose sheets. Use a blue or black ball-point pen. Errors, mistakes, and blunders are not erased, but simply marked through with a single line.

Use only the right-hand, odd-numbered pages for the notebook record. Avoid leaving any of them blank and avoid leaving blank spaces on any of them. Use the left-hand, even-numbered pages for sketches, rough calculations, and reminders to yourself. You may also place wiring diagrams and graphs on the left, opposite corresponding procedures and calculations.

B. Organization

1. Objectives - Briefly state the major goals of this experiment.

2. Preliminary - State your approach to the experiment, i.e., how you intend to achieve the objectives. This may include a brief summary of theory, a few important equations, and/or a reference to some relevant text.

3. Equipment List and Wiring Diagrams. Be sure another person can tell exactly how your experiment was connected. Include ratings and nameplate data. Identify the device tested by some unique method (serial #, inventory #, etc.,). You may "cut and paste." Be sure diagrams are correct.

   NOTE...Items 1 through 3 should be completed prior to class.

4. Procedure. Give essential details on how the experiment was conducted. DO NOT recopy the lab manual.

5. Data. This section may be combined with the previous one, so that it appears adjacent to the corresponding procedure. Record data directly into your notebook. Tabulate data wherever possible.
6. Calculations and Results. Work out one example of each type calculation and tabulate the results. Include percent errors and percent deviations. Be aware of the precision of your data and watch the significant digits.

7. Conclusions. Base your conclusions on what was done, not on what should have been done. Be factual and concise. Do not conclude something unless the results actually support that conclusion.

Remember that the conclusions must relate to one or more of the basic functions of laboratory work:

a. Familiarization with instruments, measurement techniques, basic concepts and/or behavior of devices and systems.

b. Model identification and range of validity.

c. Validation of assumptions.


e. Testing for compliance with specifications.

f. Exploration for new information.

**FORMAL REPORTS**

The written formal report is one of the most frequently used forms of communication in industry. It is a vehicle that carries the specialist engineer's information to colleagues, supervisors and managers. Therefore, it is important to develop the skills of good technical writing. Depending on the course, one or two formal reports are required in each lab course.

The formal report should be a narrative presentation of the background, theory, laboratory work, and results of the experiment. The text, graphs, and tables should tell a coherent story to a reasonably intelligent reader. The "story" should be written in an interesting and organized fashion without boring the reader with trivial details and unnecessary words. Obviously, judgment and careful planning are required to write a good formal report.

The bulk of the following material was prepared by Ann Kruse, a former English teacher and should facilitate the preparation of a satisfactory formal report. The requirements of the format resemble a formal technical paper quite closely. You may look at a technical paper (for instance, in an IEEE Transactions) to get an insight into the "formalities". Note the differences from a typical lab notebook, technical diary, homework, or other "informal" routine writings.
1. **Title Page:** The title page of your report should contain the experiment number, an appropriate title, the author's name, and department centered on the page. The title should be carefully chosen so that it summarizes the whole work in just a few words. It should not be too long. For example the following may appear in the center of the title page of a formal report.

   Experiment No. 5

   DESIGN AND TESTING OF AN A-D CONVERTOR
   David C. Jones
   Department of Electrical & Computer Engineering
   University of Missouri-Rolla

   In the lower right quarter of the page, the following should appear:
   1. Laboratory course number and section letter
   2. Group members
   3. Date submitted.

2. **Abstract:** The abstract is, in essence, the report in a "nutshell". It gives a quick synopsis of the work in just a few sentences without the reader having to dig through the report. The abstract should preferably be brief. In most cases, no reference has to be made to any equation, figure or table; stand-alone words are enough.

   The abstract should be a short synopsis of the work reported in the paper. An experienced reader of technical reports turns to the abstract first with specific questions he or she wants answered. Usually these questions concern whether the report suits his or her purpose. If it does, the reader will continue to the conclusions. If it does not, the abstract should be sufficient to let the reader know. It needs to summarize the main ideal of the purpose in one or two sentences. Then, the general method needs to be summarized in one or two sentences, followed by one or two sentences summarizing the main points of the results. The abstract needs to be a synopsis of what was done in the investigation being reported, not what can be done. It needs to tell what the paper does present, not what it should present. An abstract should state the purpose, but it is not a statement of objectives. Details are not appropriate in an abstract. Much care should be taken in wording the abstract.

   Put considerable thought into the writing of the abstract. It may be best to write the abstract after the results are carefully analyzed. Before writing the abstract, the writer needs to clearly understand the purpose, procedure, and results. An IEEE Transactions, available in the library, is a good source of examples of abstracts.

3. **Table of Contents**
4. **Introduction:** The introduction should introduce or lead the reader into the report by discussing the main idea of the experiment or research, its nature, and scope. It should orient the reader to the main theme. If the investigation being reported was motivated by a previous investigation, the introduction might mention this. The introduction might include something about the organization of the report. Extensive discussions of theory, details of the procedure, or results and conclusions do not belong in the introduction. A little overlap with the abstract can occur.

5. **Body of the Report:** The portion between the sections named Introduction and Conclusion is important and should be titled appropriately based upon the experiment. Sections included in the body of the report may vary depending on the purpose of the report. For most formal reports for laboratory classes, background and theory, and procedure, results, and analysis need to be discussed. The material should be logically sequenced and divided into appropriate sections with a name for each. The text may be supported by graphs, figures, tables, equations, etc., as necessary. A technically sound report will have adequate explanation of purpose. It is also important to furnish reasoning or theoretical justification of the "happenings". However, it is undesirable to make statements about things that are very obvious.

**Background and Theory:** Background for a report might include a discussion of previous investigations that are important to the investigation being considered. It might also include other information that aids the reader in understanding the report.

Presented theory predicts results. All theory necessary to understand and explain the investigation should be discussed. Equations should be presented and numbered. Short derivations may be included in this section. Longer derivations need to be in an appendix with the result in the body of the report. The appendix needs to be referenced by name and page number. Theory should be discussed in a logical progression.

**Procedure, Results, and Analysis:** The procedure section should contain a detailed account of exactly how the investigation was performed. The reader should be able to repeat the experiment based on the information in this section. Details that do not explain how the experiment was conducted, such as equipment lists and serial numbers, should be included in an appendix.

All results, whether observations or data, need to be included. Long tables of data need to be in an appendix. When deciding whether to include data in the body of the report, think about whether it is necessary for the reader to understand what occurred. If it is necessary, put it in the body; otherwise, it may detract from the readability of the report. Again, it is important to reference the appendix. Graphs or charts belong in this section. If a calculation is necessary to understand the results, it belongs in the body; otherwise, sample calculations belong in an appendix that should be referenced.
Results must be thoroughly analyzed and explained. Actual results need to be compared to theoretical results. Percentage error may need to be included. Discrepancies need to be discussed. Possible reasons for error need to be included. "Human error" is not a legitimate explanation. An honest statement of the actual and possible errors resulting from a close inspection and impartial observation will strengthen rather than weaken the report. If part of the experiment is comparing different quantities, such as results from different circuits, the similarities and differences need to be discussed. If graphs and charts are included, they should be used in this discussion. Reasons for results should be discussed. Results need to be discussed in specific terms, not with vague or general statements.

The order of procedure, results, and analysis might vary depending on the nature of the investigation. Some experiments are better presented by giving the procedure for a portion, then the results for that portion, before proceeding to the next portion. Other experiments might be better presented by giving all the procedure then all of the results. The most important thing is that the reader is clearly able to understand the investigation.

**Graphs:** Care should be taken when making graphs so that they are easy to read and show what is intended. If a certain graph is specified, that type of graph is to be used. Otherwise, the type of graph should be chosen so that it clearly illustrates the concept intended. Graphs may be done on commercial graph paper and photocopied, or they may be computer generated. Computer generated graphs must show the same detail as those on purchased graph paper. Neatness is very important. All data points should be identified. A smooth curve should be fitted to the data. If graphed on graph paper, French curves are available to help construct smooth curves. The axes must be neatly and descriptively labeled. Key points or ranges should be labeled on graphs. Examples are half-power frequencies or bandwidths. If two things, like two different circuits, are being compared, they are usually best compared on the same graph. A legend should clearly identify what the curve or curves are. All graphs should have descriptive captions. The reader should be able to understand the graph and its significance without having to refer to the text of the report.

**Figures and Tables:** Figures and tables need to be neat and easy to understand. The reader should be able to understand them without referring to the body of the report. Captions should explain the figure. Each figure needs to be numbered. When referring to a figure in the body of the report, the number and page should be given. Information in tables should be organized for easy reading. Long data and results tables should be in appendices. The appendix should be referenced with appendix letter or number and page. Figures and tables should not be crowded. They need to be visually distinct from the body of the report, i.e., there should be enough space both above and below figures and tables to easily distinguish them from the text.

The figures should be drawn with graphical aids, rather than by free hand. Tables, graphs and figures should be neat enough to interest the reader. Two
possible orientations of figures/graphs are given below. Graphs may need a legend or brief explanation. Also note that it is desirable to caption or title all figures, graphs, etc.

Circuit diagrams, graphs and charts are designated by sequential Figure Numbers; tables by Table Numbers. They should be properly referenced in the text by these "call numbers" and located close to the first place of reference.

6. Conclusions: It is very important that the Conclusions section be well written. This part is as important as the abstract. Experienced readers of technical reports turn to the conclusions after reading the abstract, and then the rest of the paper (if they are still interested!) Conclusions should briefly summarize the purpose, what was done, and how it was done. Key results should then be summarized. Comparisons may be included here. No new information about the procedure, results, or analysis should be included in the conclusions. The summary should be specific, but not detailed. Examples of statements that are not specific are: "After recording the data and analyzing the plots, it was seen that the findings appeared to conform with theory.", "The behavior of the filter proved to be as anticipated.", and "the cascade effect of a certain type of filter." The conclusions may also give additional insight and suggested uses. They should tell what the significance of the investigation is. Conclusions might give suggestions for further investigation. Conclusions should stand alone. References to circuit diagrams, graphs, or charts are usually not appropriate in conclusions. Since the Conclusion is a part that requires much thought from the author, ask yourself, "Have I convinced the reader that I know what I am talking about? Have I sold my point of view?"

7. Appendices: Usually details are pushed into appendices when, if included anywhere else in the report, they hinder its readability. Appendices to the report usually contain information that is not vital to preliminary understanding. The
author should recognize such material which deserves to be "isolated" from the rest of the report. More than one appendix may be needed, in which case the appendices may be numbered in numerals or alphabetic characters and logically arranged. In a report, there may not be an appendix or there may be several. All the appendices must be referenced properly in the text of the main report. Also, in one appendix, keep only one type of information; do not make an odd mixture within an appendix.

For this laboratory course, the appendices may include longer tables of original data, sample calculations, the equipment list, etc. A sample set of calculations for one condition should be included. In general, the fundamental symbol equations should be given first (if possible) and the numerical values substituted in the same order in the next step. Always include units if applicable.

Appendices should be lettered sequentially. They need titles and brief explanations. The reader should be able to understand the appendix without referring to the body.

8. **Acknowledgment:** This section is optional. It recognizes significant help obtained by any individual or association in any form. While this is almost always found in research papers, you may omit this part in the formal lab report.

9. **References:** The references are to credit the work of previous authors used in the report. References to previous reports, articles, books, patents, etc. pertaining to the investigation are listed in this section. References are specifically referred to in the text and should be numbered in order of appearance. When referring to reference number 1, write [1] at the appropriate place in the text.

For this laboratory course, the following format should be used for references:


It is very important to remember that listing a document on your references page does not give you the right to copy or paraphrase anything you want from the document without giving a citation in the body of the report. Refer to the policies listed below when preparing the formal report.

a. **FIGURES**
All figures which are not your own original work must be referenced when used in the formal report. (i.e. if you use figures from the lab manual in your formal report you must footnote each one.)

b. **EQUATIONS**
You must provide references for equations used in the formal report unless they are extremely fundamental (i.e. V=IR, etc.). In general, if you can
derive the equation given a blank piece of paper, then it is not necessary to reference it.

c. TEXT
All text (objectives, introduction, procedures, conclusions, etc.) should be in your own words. If you paraphrase something from the lab manual or another book, you must provide a footnote in the body of the report near the appropriate text. Paraphrasing is more than just rearranging the words or clauses in a sentence.

**PLAGIARISM**

Plagiarism is defined as "the act of taking the ideas, writings, etc. from another and passing them off as one's own." (Webster's New Universal Unabridged Dictionary, 2nd Ed., Dorset & Baker, 1983.) It is a form of academic dishonesty and may result in a grade of zero for the formal report, failing the course, and/or dismissal from the university! So, always remember to use a reference for anything in your report that is not your own work.

**Additional Notes on Report Writing**

1. A novice author may have a tendency to write very long paragraphs. Proper paragraphing is an essential ingredient of good writing.

2. Whenever appropriate, present the data in the form of a table, with its structure suitably chosen and labeled.

3. Good writing is uniform and balanced in its content and information density.

4. The pages of the report should obviously be numbered.

5. Appearance: A report that is well-spaced, accurately typed (or printed in black ink), illustrated as required, and neatly bound creates the impression of professional competence. Correct punctuation, clear titles and subtitles, and consistent use of indentation contribute to ease in reading.

6. Use 8 1/2" x 11" paper. Use only one side of each sheet. Type or write the report using black ink. Any handwritten equations should be done very neatly in black ink.

7. Write the report in the past tense, passive voice. Avoid any use of personal pronouns. Exercise care to insure proper use of the English language. All slang expressions and phrases like "hooked up the circuit," and "that would blow the whole purpose" should be avoided. Contractions are not proper in formal writing.
8. The formal report should be concise. Omit obvious steps in derivations and calculations and avoid wasting sentences in trivial arguments.

9. Spend some time thinking about and outlining the report before beginning to write. At least the crucial sections like Abstract and Conclusions should be phrased properly on a scratch pad and then transferred to the report.

10. Time should be taken to proofread the report because obvious errors and typos detract from the credibility of the report.

FORMAL REPORT GRADING

The purpose of the following material is to help you understand how your laboratory reports are to be graded and to help the laboratory instructors know what to base the grades on and to grade consistently.

Determining what grade you have earned on each lab report is one of the most difficult tasks a lab instructor must do. Grading and evaluation generally have subjective processes present, either consciously or subconsciously, so that the results may, unfortunately, depend on whim or personal prejudices instead of only your efforts. One particular reader may prefer neatness and good grammar to a technical discussion. Another reader may stress validity of your conclusions over how you make references to graphs and diagrams. In an effort to eliminate such inconsistencies and to inform you of the emphasis, your reports will be graded as follows:

- Presentation - 35%
- Clarity - 35%
- Technical Content - 30%

There is more emphasis on Presentation and Clarity than on Technical Content because good-looking, neat, clear, readable, and understandable reports are usually more impressive and better received than those done otherwise, even though the technical details are somewhat incomplete.

PRESENTATION - 35%

You should make a finished product of the reports you turn in. Obviously, they should be legible if handwritten, but usually they are prepared either by typewriter or by word processor. All graphs, diagrams, charts, tables, etc., need to be neatly prepared and properly identified for the reader's benefit.

Organize the material according to the required format. If you use other than the required format, explain why.

Use only one side of standard 8 1/2 x 11 inch plain white paper. Small, large, or mixed sizes of paper are awkward to handle. Do not use ruled or crosshatched paper.
Multiple copies of industrial reports are often made and sometimes photocopied for microfilming, and lines reproduce just as well as typed letters, resulting in unnecessary clutter which complicates reading.

The grammar, spelling, and punctuation should not impress the reader as being poorly done, otherwise a report is subject to immediate rejection. If you have a typist and draftsman put your rough draft into final form, do not expect them to make even minor corrections to your draft. In fact, you should definitely proofread their work to locate their errors so that corrections can be made before submitting a report.

Staple everything together. Staples do not get loose like paper clips can and they help keep a large number of reports from getting messed up. Otherwise, use the holder that is required.

**CLARITY - 35%**

Clarity pertains to your ability to communicate effectively. Clarity refers to ease of reading and understanding, discussed as follows.

**EASE OF READING** includes how your ideas are tied together for a smooth progression. Prefer short, familiar words arranged in short, simple sentences instead of unfamiliar vocabulary, big words, and long complicated sentences. Complex verbiage does not make a simple idea profound. Warn the reader before making a sudden change in your point of view or subject. Omit irrelevant or illogical information. Stress important ideas in proportion to their inherent significance.

**UNDERSTANDING** refers to reader response. Effective communication means that the reader understands your report. You don't want him to misinterpret your report or wonder what it is about. Try to convince the reader that you know what you are doing, which means that you must know. If you include in the report any graphs, diagrams, charts, tables, computer results, derivations, or calculations, the reader must be able to follow references to each one and understand how you take information from each. Computer printouts and lengthy derivations generally belong in appendices. The reader benefits if you convert computer output into a more useful form when needed. Include in the report only the pertinent computer material.

**TECHNICAL CONTENT - 30%**

The technical material is what you are reporting on. It begins with a brief statement of the problem. Then any assumptions, theory, and formulas which are used must be applied correctly. Methods used to obtain results must be such that they lead as directly as possible to the solution of the problem. The methods used may be any combination of such things as hand or computer calculations, experimental laboratory measurements on the actual apparatus, computer simulation, a literature search, analyzing results of a questionnaire, or a phone call to a friendly and trusted expert of your
acquaintance. A discussion of errors and discrepancies shows the depth of your technical knowledge.

Finally, evaluate what you have created. Recheck everything. Be tough on yourself. Are there situations where the results and conclusions are not valid? If so, mention them. Describe an interesting and worthwhile feature of your work just finished. Mention an application or two. Let the reader know that you have some creative ability to contribute. After all, the report will bear your name and you should create a product which represents your best efforts. Be proud of it!

SUMMARY OF REPORT GRADING

The various items which determine the report grade are summarized on the check sheet called "Report Critique." It is used by the instructor to indicate those items which, in his opinion, need improvement and his estimate of your grade for each of the three main parts. He will usually mark any discovered errors on the report itself, and summarize the grading on the "Report Critique."

REPORT CRITIQUE

Student Name: ___________________________    Course EE ________
Report: _________________________________   Instructor _______________

PRESENTATION - 35%

Format (does not follow required format, parts missing, wrong order)
Neatness (printing, drawings charts, stapling, inking)
Paper (color, mixed sizes, rough edges, too thin, transparent, dirty)
Legibility (poor handwriting, broken type, needs improving)
Graphs, diagrams, charts, etc. (poorly done, needs improving)
Spelling (some misspelled words, typos, inconsistent spelling)
Punctuation (hyphenation, periods, commas)
Abbreviations (inconsistent, non-standard)
Other: ______________________________________________________

Grade: ________%  

CLARITY - 35%

Ease of reading (jumps around, extra material, simplify, stress)
Understanding (misleading, not convincing, vague, like double-talk)
Use of graphs, diagrams, etc. (references to them poor, numbered wrong, cannot follow their use, titles missing)
Use of computer results (references to them poor, meaningless output, titles missing, extra material, use appendix)
Use of derivations (references to them poor, too long, use appendix, do not apply, used poorly, inadequate, not necessary)
Calculations (references to them poor, some not necessary, simplify)
Other: _____________________________________________________

Grade: ________%

TECHNICAL CONTENT- 30%

Statement of the problem (vague, abstract, simplify, not convincing)

Accuracy (calculations, computer, discrepancies, some errors)

Correctness (theory, formulas, assumptions, graphs, diagrams, use of instruments, poor measurements)

Methods used (not suitable, improperly used, poor procedures, odd)

Evaluation of results (how do conclusions follow results, justify assumptions, validity, recommendations, applications)

Other: _____________________________________________________

Grade: ________%

Report Letter Grade:

_______