SAFETY RULES AND SUGGESTIONS

EMERGENCY AND INFORMATION TELEPHONE NUMBERS:

An ambulance should be called in the event of any accident requiring medical assistance

Emergency Ambulance or Fire (from UMR telephone): 9-911
UMR Police: 341-4300 or (from UMR telephone) 4300
UMR Safety: 341-4305 or (from UMR telephone) 4305

1. Smoking, eating, drinking, or "horseplay" are strictly forbidden in the laboratory.

2. Haste and inattention cause many accidents. Work deliberately and carefully. Plan your activities prior to the laboratory, familiarize yourself with equipment prior to actual operation, and verify your work as you progress. Learn the location of power switches and ground fault interruptors.

3. Report potential hazards and suspected faulty equipment to the instructor immediately. In particular, do not attempt to perform any diagnosis, maintenance, or repairs yourself. Removing or opening the case from any apparatus may expose parts at line voltage.

4. Minimize exposure to live circuits. Connect to the source of power as the last step when wiring a circuit. Disconnect from the power source as the first step when disassembling a circuit.

5. Exercise caution when adjusting energized circuits. All powered circuits are dangerous.

- Use only one hand as far as practical, keeping the other hand disengaged from circuitry. Do not permit any part of your body to complete a circuit.
- Understand handling dangers. Keep watches, rings, and other metallic objects out of contact with live parts. Wet, sweaty, or bleeding hands increase shock hazard.
- Note exposed wires and other potential shock hazards.

6. Close switches quickly and positively. Do not grope for switch handles with your head turned away!

7. Do not use damaged or misapplied parts. Wires that have poor insulation, setscrews that are loose, and insecure connections that may come apart are hazards. Safety devices, coverings, interlocks, etc. must be operational at all times.

8. Do not use tools or instruments for other than their original purpose.

9. Do not touch or place materials next to surfaces that heat up during normal operation.

10. Understand and minimize all potential operating hazards. Do not defeat safety systems. Use eye protection and other safety devices where indicated. Do not wear jewelry, loose clothing, or long hair near rotating equipment.

FOLLOW PROCEDURES - MINIMIZE HAZARDS - AVOID UNSAFE BEHAVIOR

ELECTRICAL SHOCK HAZARDS

SUMMARY

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. Electrical shock can be lethal. The hazards must be understood and general safety rules must be followed.

- It's the current that kills. 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.
- Alternating Current (AC) is more dangerous than direct current (DC), and 60 Hertz current, that is used in building wiring, 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 of electric shock requires having a healthy respect for all voltage sources and always following safety procedures when working on electrical equipment. Minimize exposure to live circuits and do not permit any part of your body to complete a circuit.
- 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 <u>immediately</u> by a person trained in CPR (cardiopulmonary resuscitation). Also an ambulance should be called <u>immediately</u>.

ELECTRICAL HAZARDS

Figure 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. Note that a very small current can produce a lethal electric shock. *Any current over 10 milliamperes will result in serious shock.*

As shown in the chart, shock is more severe as the current rises. At values as low as 20 milliamperes, breathing becomes labored, finally ceasing completely even at values below 75 milliamperes. As the current approaches 100 milliamperes, ventricular fibrillation of the heart occurs--an uncoordinated twitching of the walls of the heart's ventricles. Above 200 milliamperes, 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.

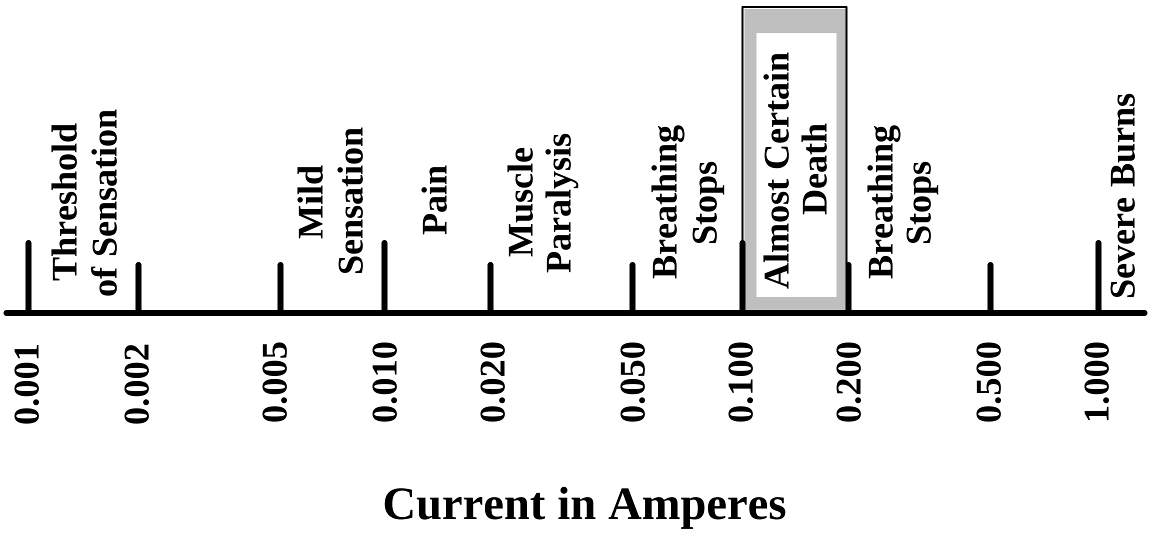


Figure 1 – Physiological Effect of Current

Alternating current (AC) is four to five times more dangerous than direct current (DC). For one thing, AC causes more severe muscular contractions. For another, AC can lower skin resistance and thereby increase the shock-current. The skin resistance goes down rapidly with continued contact because sweating is stimulated and the skin oils and even the skin itself are burned away. Consequently, it is extremely important to free the victim from contact with the current as quickly as possible before the current increases to the fibrillation-inducing level. Also, the frequency of the AC influences the effects on the human body. Unfortunately, the standard electrical power frequency of 60 Hertz is in the most harmful range. At this 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.

ELECTRICAL SAFETY

The measure of a shock's severity lies in the amount of current (amperes) passed through the body, and not the voltage. The electric current does the damage. Current equals voltage divided by resistance (e.g. Ohm’s Law 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". Any electrical device at common voltages of 120 V and 220 V can, under certain conditions, transmit a fatal current. Safe procedures minimize the hazard due to electrical shock.

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 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.

The condition of the skin at the points of contact are critical. The actual resistance of the body 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.

In addition, common protection technologies include isolation and grounding. Note that circuit breakers and fuses do not provide reliable protection upon failure of isolation and grounding. Circuit breakers and fuses are sized to protect equipment and conductors from excessive line currents. *They will not protect you.*

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. 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 laboratory. 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.

A Ground Fault Interrupter, abbreviated GFI, is a device designed specifically to protect against lethal currents from *line-to-ground* shocks. The device is generally installed at the electrical receptacle. Various trip settings are available in the range of 5-20 mA. It may be easily reset. The most common type utilizes a differential transformer to detect small differences between line and neutral currents. Most of the receptacles in our laboratories do not have a GFI.

CmpE 112
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 experimenter 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 <u>some</u> 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 <u>NOT</u> 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. If tests are conducted on some device clearly identify that device and give theoretical or nameplate characteristics. Include wiring diagrams and identify measurement equipment. 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 instrument or software yielded which data. Examples of each type of 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. Do not forget that 'measurement equipment' includes all probes, leads, and wires used as well as the operator of the 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 loose-leaf, 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. <u>Organization</u>

1. Objectives - <u>Briefly</u> 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 publication.

3. Equipment List and Wiring Diagrams. Be sure another person can tell exactly how your experiment was connected. Include ratings and nameplate data part numbers and pin numbers on schematic diagrams where appropriate. Identify the device tested by some unique method (serial #, inventory #, software revision number 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. Avoid transcribing large amounts of computer generated data. Manual copying is a common source of error.

6. Calculations and Results. Work out one example of each type calculation and <u>tabulate</u> the results. Include percent errors and percent deviations. Be aware of the precision of your data and watch the significant digits.

7. Conclusions. Base conclusions on 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.

d. Prediction of performance.

e. Testing for compliance with specifications.

f. Exploration for new information.

CmpE 112
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. At least one formal report is 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, contact information, and department affiliation 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
   dcjones@umr.edu

   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. You should be able to completely separate the abstract from the report and have it make sense so be sure to include title, author, date, affiliation, and contact information on the abstract page.

   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:** A brief report of only a few pages probably does not need a table of contents. Longer reports are easier to navigate with a good table of contents. Your GTA will specify whether a table of contents is required for any given report.

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, <u>background and theory</u>, and <u>procedure, results, and analysis</u> need to be discussed. The material should be logically sequenced and divided into appropriate sections with a meaningful name for each. The text may be supported by <u>graphs</u>, <u>figures</u>, <u>tables</u>, <u>equations</u>, source code, 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.

   <u>Background and Theory</u>: 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. Input data, command sequences, instrument settings and any other data which might help another reproduce your results should be included here. 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.

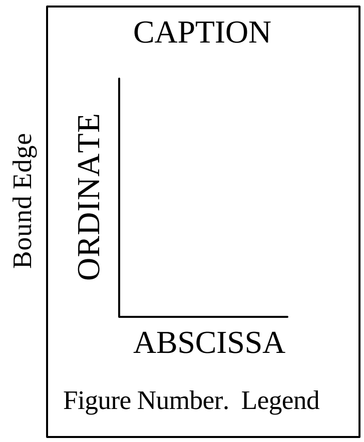
Results must be thoroughly analyzed and explained. Actual results need to be compared to theoretical results. Percentage error may need to be included. Discrepancies need to be discussed. Possible reasons for error need to be included. "Human error" is not a legitimate explanation. An honest statement 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.

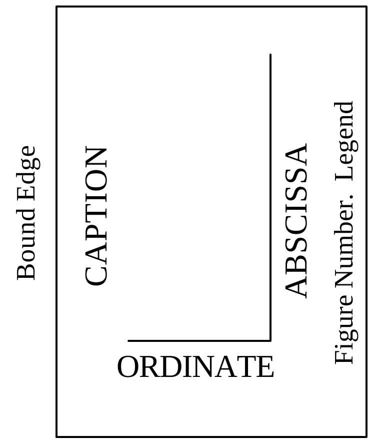
Graphs: Care should be taken when making graphs so that they are easy to read and show what is intended. If a certain graph is specified, that type of graph is to be used. Otherwise, the type of graph should be chosen so that it clearly illustrates the concept intended. Use computer generated graphics as much as possible and avoid hand drawn graphs and figures. Avoid 'screen captures' which have limited resolution and use output to a postscript printer or other standard graphics file format when possible. Neatness is very important. 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 in Figure 1-1 below. Graphs may need a legend or brief explanation. Also note that it is desirable to caption or title all figures, graphs, etc.



a) Portrait



b) Landscape

Figure 1-1. Acceptable figure orientations

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 but the focus should be on the current experiment and not on what might be done in the future. 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 symbolic 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. ‘Appendix A’ is not an acceptable title. ‘Appendix A Manufacturer’s Data Sheet’ is better.

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:

    1. Author, "paper title," name of periodical, published date, pages.
    2. Author, "book title," publisher, year published, pages referenced.

    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. Number each page of the report starting with the Introduction as page one. Do not number the title or abstract pages.

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 a word processor program and print the report on one side of plain white 8.5 x 11" paper. Handwritten annotations should be a last resort but if necessary should be done neatly in black ink. Unless they are essential for the reader's understanding, avoid use of color or photographs since these do not reproduce well.

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 similar. ‘Glitz’ is not a substitute for technical accuracy but you should strive to present your hard technical work in the best possible light.

PRESENTATION - 35%

You should make a finished product of the reports you turn in. Obviously, they should be legible if handwritten, but usually it is better to use a 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 proof read 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. Do not use a report binder unless your lab instructor specifies one to use.

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 do not want the reader 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 <u>you</u> 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 <u>your best efforts</u>. Be proud of it! Give your report to a friend to read. Your friend might find an error you missed. It should make at least some sense to a person who is not overly familiar with the material, or you have not done your job well.

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: ________

COMPUTER ENGINEERING I

CmpE 112
LABORATORY EQUIPMENT

Most of the equipment that will be used to perform computer engineering experiments in EE 112 will be different from equipment that you have used before. The following description of the equipment should be read before you begin the first experiment so that you might understand the capabilities and limitations of the instruments you will be using.

The equipment package on your workbench which contains four plug-in instruments is referred to as a Tektronix TM-5006 instrument package. It contains a dc power supply, a variable frequency signal generator, a digital multimeter, and a frequency counter. A PC and an 18 channel 100 Mhz Hewlett Packard 54645D Mixed Signal Oscilloscope is also provided at your lab workstation. A PS5004 Precision power supply is also included.

To properly use the Tektronix TM-5006 instrument package in the laboratory, there are several things that you should know. Observe the instruments in the package as you read the following material:

1. The PS-5010 Programmable Power Supply has three separate sets of power output terminals corresponding to the positive, negative, and logic power supplies. The voltage of each of the supplies can be adjusted separately, or the positive and negative voltage supplies can be locked together in "tracking mode" so that one front panel data entry sets the two supplies to equal magnitude and opposite polarity voltages.

   When the power switch is first turned on, the PS-5010 will show a bright LED display with the positive and negative supplies set to 0 volts and the logic supply pre-set to 5.0 volts.

   TO SET THE POSITIVE VOLTAGE SUPPLY: In the "Parameters" block in the center of the control panel, press the button in the blue area labeled "Supply Select." Then press the left button (#4) in the row with the blue label "Pos." The LEDs will dim. Enter the desired voltage, using the numeric keys, and press ENTER. The LED display for the positive supply will display the desired voltage in bright numbers. If you should make an error in setting the voltage, you may either reset the voltage or use the "Increment" switches to raise or lower the voltage by 0.1 volt per increment.

   TO SET THE NEGATIVE VOLTAGE SUPPLY: Repeat the procedure above, except select the first button (#7) in the row with the blue label "Neg" before setting the voltage magnitude. When ENTER is pressed, the LEDs for the negative supply will display the voltage setting in bright numerals.

   TO USE THE PS-5010 AS A TRACKING SUPPLY: You can set both the positive and negative supplies to the same voltage magnitude (such as ±12 or ±15 volts) with one front panel data entry. Press "Supply Select," then press the first button (#1) in the row labeled "Track." When you set a voltage with the numeric buttons and press ENTER, both the positive and negative supplies will be set to the same voltage, as will be indicated by the bright LEDs on the control panel.

The logic supply is pre-set to 5 volts and usually does not have to be changed. If a change is required, however, the procedure is the same as that given above. Also, the logic supply can be incremented by 0.1 volt per step, either positive or negative, by selecting the supply and then using the "Increment" buttons at the top of the control panel.

NOTE: THE POWER OUTPUT TERMINALS ARE NOT ENERGIZED UNTIL THE "OUTPUT ON" SWITCH IS PRESSED AND THE LED INDICATOR IN THE SWITCH IS ILLUMINATED.

2. The FG-503 Function Generator is a fairly straightforward device. The output waveform, frequency, and amplitude are set or adjusted by separate front panel controls. The TRIG OUT connector provides a rectangular waveform output which can be used to externally trigger an oscilloscope and/or provide a signal to a frequency counter for display of the signal frequency or period. The FG-503 Function Generator output can easily be set to exceed the 5V limit on TTL integrated circuits and damage them. When using the FG-503 as a clock for a digital logic circuit be sure to adjust the output amplitude and offset and waveform to get a 0 to 5 volt square wave with an appropriate frequency.

   A dc offset control on the function generator front panel provides the capability to internally add a dc voltage to the ac waveform. On the FG-503 the maximum available offset is approximately 6 volts, either positive or negative. When selecting the output waveform, note that there are two positions on the selector knob for each of the available waveforms. The selection shown in the silver area on the panel (which also includes the offset control) provides an output with variable dc offset, and must be used with caution. The waveform selection shown in the gray painted area on the right side provides an output with zero average value, but is not normally used in digital experiments. It is usually a good idea to buffer the FG-503 output with a 74x04 inverter in order to avoid damaging more expensive parts.

3. The DC-504 Frequency Counter/Timer provides the capability to measure the frequency of periodic signals, to measure the period between events, or to totalize (count) the occurrence of events. The range selector knob is labeled in "kHz" or "Mhz" for frequency and "SEC" or "MSEC" for period. The resolution, which is the units of the least significant digit displayed, is determined by the number of samples taken before a value is displayed. Normally the resolution is selected which will provide a counting interval or "gate" of one second for frequency measurements.

   Connect the TRIG OUT output of the FG-503 function generator to the input of the DC-504 counter/timer. Adjust the FG-503 frequency selector to 1 kHz. The INT-EXT switch on the DC-504 must be in the EXT position for proper operation with an external input, as indicated by the color coding. Adjust the trigger level control to a position slightly on the positive side of zero. Now adjust the frequency range selector to each of its three positions for reading kHz and observe the counting interval light. The range switch position which results in a counting interval of one second is the preferred position for this measurement (for shorter intervals, the counter may overflow, producing an incorrect reading). Repeat the above for 10-kHz and for 50-kHz. Also, determine the period of each of the waveforms to three significant figures.

4. The DM-502 Digital Multimeter reads ac and dc voltages and current. It has 0.1% accuracy on dc measurements and 0.5% accuracy on ac measurements. The meter responds to the average of the internally rectified ac waveform and is calibrated to read out the RMS value. In AC VOLTS or AC mA settings, the input is capacitor coupled so that the meter displays only the RMS value of the ac part of the waveform. It does NOT indicate the true RMS value of waveforms which have both an ac and a dc component. The DM-502 is usually used in a "floating" mode to make voltage, current, or resistance measurements. That is, unless it is connected to the ground of an external circuit which is grounded, neither terminal of the DMM is at ground potential. As with all other ground terminals in the Instrument Package, the white terminal on the instrument front panel is connected to the instrument case and then to earth ground through the 3-wire power cord.

   Because the digital multimeter has a very high input impedance on the voltage reading scales, a very low input impedance on the current readings scales, and is actually a source of voltage (electrical current) on the resistance scales, it is very important to have the meter adjusted to the proper scale before connecting it into the circuit. A multimeter set to read current presents a short circuit to the system when connected (in parallel) to read a voltage. A fuse will be blown, as a minimum, and other damage to the meter may also take place. You are responsible for learning and using the proper measurement techniques.

   When sensitive measurements are made, or a three-wire measurement probe is used, the front panel ground connection may help to eliminate interference from conducted or radiated electromagnetic noise.

   A more likely problem than electromagnetic interference in these experiments is the tendency to try to make measurements to more digits of significance than is necessary. In order to have a stable, non-flickering display of your voltage or current measurements, always select a scale or range so that no more than three significant figures will be displayed. For example, to measure .1, .25 and .50 milliamps, three decimal places would be the maximum that you would want to display on the multimeter, and two decimal places would generally be sufficient. The general rule is not to take or write down data with more "significance" than you can graph with accuracy.

5. The EE 112 Lab oscilloscope is a Hewlett Packard 54645D 18 channel 100 Mhz digital scope. It is controlled by an internal microcomputer and most adjustments can quickly be made by simply pressing the Autoscale button at the top of the control panel. Use a piece of coax cable with a BNC connector at each end to connect the FG-503 to channel A1 of the 54645D. Set the FG-503 for a 10 kHz square wave and press the Autoscale button on the scope to display the waveform. Adjust the FG-503 amplitude to get a 5V peak to peak square wave and then

adjust the offset on the FG-503 to get a square wave that switches between 0 and 5V. Be sure the function knob is set to a DC offset range or the offset adjustment will have no effect. Use the oscilloscope to determine the highest frequency square wave you can generate with the FG-503 and have the waveform still looks "square".

The Autoscale button can make a lot of the scope adjustments for you but it can't do everything. Much of the functionality is accessed via the various menu buttons. Take a few moments to explore the labeled buttons and notice each of the menu items displayed. Be sure to keep notes in your lab notebook as you go along. Hit Print/Utility; Service Menu; Clear Menu buttons to clear the menu area at the bottom of the screen.

This laboratory course is concerned with instrumentation and measurements in digital electronic circuits. It should be noted that a good understanding of what you are doing will be essential in coming to a satisfactory conclusion in the following experiments. No effort has been made to fully explain everything that you will be doing or to provide a "cookbook" for you to follow. Your co-requisite computer engineering course and programming course background are assumed, and you should be able to draw on them for your understanding of the labs.

Keep these ideas in mind as you begin to learn from Experiment No. 1.

OVERVIEW OF EXERCISES

Purpose

The purpose of the laboratory portion of EE111 is to reinforce the material you are learning in the lecture portion and give you some 'hands on' experience with digital design. Part of this will include familiarization with some basic laboratory instruments including a PC, Unix workstation, oscilloscope, and logic analyzer. Another part will include familiarization with design automation software and modern hardware components.

References

Your text for EE111 is the best reference. The world wide web is a wonderful source of data but it can sometimes be difficult to find useful information here. Each exercise will include references useful to that portion of the laboratory.

Materials Required

Each exercise will list the primary material required. Most of the equipment will be supplied either in the lab or in various computer learning centers however you will be required to purchase a solderless breadboard if you don't already have one.

Preliminary

You should read through the exercise and reference material prior to coming into the lab. In some cases you will need to do some preliminary design work. Keep in mind that the lab time is short. You should be well prepared in order to receive the most benefit from your time in the lab.

Procedure

Most digital design work today is done with the aid of various software tools collectively referred to as Electronic Design Automation or EDA software. Two primary tools include a schematic capture tool for drawing logic diagrams and a logic simulator for testing your designs. We will be using the tools available from Mentor Graphics called *design architect* for schematic capture, and *quicksim* for logic simulation. Most hardware design is done either with off the shelf large scale circuits like microprocessors, memories, input/output controllers, and the like, or with so called *application specific integrated circuits* or ASICs. We will be using one form of ASIC called a field programmable gate array for our hardware verification. It is an expensive process to model ASICs with a hardware prototype and prototypes constructed with small scale integrated circuits do a poor job of modeling complex IC's anyway. Consequently designers today rely on simulators to determine if their designs are going to work when they are committed to hardware. The goal is to produce working hardware on the first try (after perhaps several simulation iterations of course) since producing an actual ASIC such as a custom chip or gate array is an expensive process often costing tens of thousands of dollars per copy. Field programmable gate arrays are a type of ASIC which will allow us to quickly realize our designs in hardware at relatively low cost.

Although the parts are fairly expensive compared to common MSI TTL parts (our XC4005 parts cost about $100 in single unit quantities) they are far less expensive than a custom IC and much less expensive on a per gate cost than SSI/MSI parts. There is also less chance of making a wiring error or knocking a wire loose since there are far fewer wires to contend with.

In addition to schematic capture and logic simulation, we will require a suite of *physical design* tools. Our designs will be in the form of primitive gates similar to those used in the lecture portion of EE111. ASIC's on the other hand are composed of a variety of technologies. Some consist of an array of primitive gates, all alike, called gate arrays. Some are build up from a library of primitive cells and are called standard cell designs. Some are similar to gate arrays but are composed of more complex configurable components that can be *programmed* or customized in the field and are called field programmable gate arrays. All require some form of *technology mapping* or *fitting* in order to translate from our primitive gate design to the form of components used in the particular ASIC. After our design has been retargetted to the particular ASIC technology we are using we need to wire up the components by using a process similar to that of laying out a printed circuit board. Finally we need to take our netlist of components which has been placed and routed for our specific ASIC and put it into a format suitable for fabrication. This can run the gamut from a graphics file of primitive polygons describing the layout of a chip for an IC fabricator like Orbit or Mosis to a programming file for a programmable logic device such as an FPGA. We will be using a suite of tools called XACT from Xilinx for their line of FPGA's.

The exercises will proceed in stages from tutorials designed to familiarize you with the equipment and software tools used in the lab through a number of design exercises which will ultimately result in the design of a straightforward but fairly complex digital system. The block diagram of our end goal is shown in Figure 1 below. We will start the design with a simple seven segment decoder for displaying a four bit binary value with a seven segment LED display. You will then be guided through the design of a four bit adder, add a register to the adder to form a simple binary counter, add functions to the adder to form a simple registered ALU, and finally add a control unit to implement a simple computational algorithm.

In summary then, the procedure for EE112 will be to use schematic based design and logic simulation to verify a design's correctness combined with realization of those designs using electrically reprogrammable field programmable gate arrays for hardware verification. The exercises are intended to be challenging and it is not expected that all students in every section will finish every exercise. It is better to understand as much as you can before going on rather than rushing through to try to finish everything. Your TA will adjust the pace of the lab in order to match your skill and background.

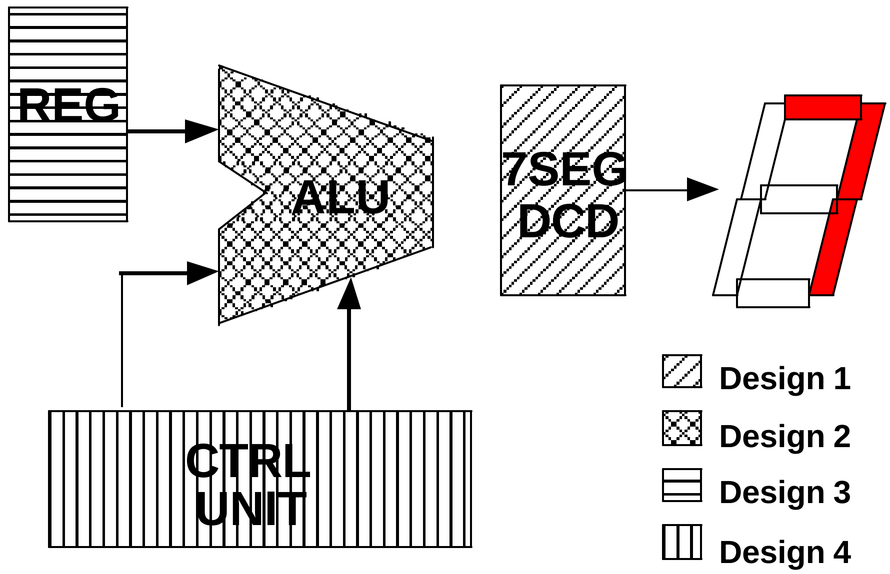


Figure 1 Four bit registered ALU with control unit

CmpE 112 - Computer Engineering I Laboratory Schedule (Sample)

Date	Exp.	Description	Page
Week 1	Introduction	Introduction to Lab Safety, laboratory equipment. World Wide Web, E-Mail and UNIX. This lab involves using the Web to research basic UNIX commands, attaching a binary file to an Email and sending it to the instructor.	1-1
Week 2	Equipment	Learn the use of an Oscilloscope, Function Generator, Programmable Power Supply and Counter as it applies to digital circuits.	2-1
Week 3	EDA-1	Introduction to Digital Design with Mentor EDA tools, schematic capture and logic simulation. Design of a two input logic circuit refereed to as 4-Parts, using the four logic gates AND, OR, NOR and NAND.	3-1
Week 4	FPGA-1	Introduction to Xilinx FPGA's and Xilinx Prototype 'board. Downloading design to the Prototype Board, testing and verifying design in hardware. The 4-Parts design is used for this laboratory.	4-1
Week 5	Quiz 1	Short closed-book quiz over Unix and Mentor Graphics	5-1
	SSI Components	Use of discrete components to build a multifunctional gate	
Week 6	EDA-2	Introduction to more advanced features of Schematic Capture and Simulation using Design architect and QuickSim. Hierarchical design, Schematic capture and simulation of a Full Adder.	6-2
Week 7	7 Seg Dcd-1	Design, Schematic Capture and Simulation of a 7	7-1

		segment decoder.	
Week 8	7 Seg Dcd-2	Design testing and verification of the 7 segment decoder with Xilinx. Download the bit file created for the 7 segment decoder design to the demo board. Test and verify the design.	8-1
Week 9	VHDL	Introduction to VHDL, vcom, and vsim. Design a multi-function gate through modification of existing VHDL code.	9-1
Week 10	Quiz 2	Short closed-book quiz over VHDL and Mentor Graphics.	10-1
	RAM	Use of RAM/ROM to implement combinational logic. Further exploration of discrete components/testing.	
Week 11	Data Path-1	Registered Arithmetic/Logic Unit (ALU)	11-1
Week 12	Data Path-1	Completion of ALU design/verification	11-1
Week 13	Counter	Design and implementation of a generalized sequence counter. State machines and state diagrams	13-1
Week 14	Control Unit-1	Design and simulation of a Control Unit	14-1
Week 15	Lab practical	A lab practical over your ability to use software and equipment used in labs and other material covered.	