Laboratory Workbook

Digital Hardware Design Laboratory Fall 2009

ECE 2031 / CS 2801

Georgia Institute of Technology
School of Electrical and Computer Engineering

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Introduction

This workbook provides supplementary material for the Digital Design Laboratory, supporting ECE2031 and CS2801. All references in this document to "ECE2031" apply to the Digital Design Laboratory component of both classes, including the weekly lecture. The schedule, exercises, and procedures vary from one semester to the next, and this workbook includes all information that is specific to the fall semester of 2009.

The required textbooks for this lab are

Digital Design Laboratory Manual, by Thomas R. Collins and Christopher Twigg, but THIS SEMESTER IT IS ENTIRELY PDF DOWNLOADS FROM THE COURSE WEB SITE.

Rapid Prototyping of Digital Systems, by J. O. Hamblen, T. S. Hall, and M. D. Furman (Either "SOPC Edition" or "Quartus II Edition"), and

The Mayfield Handbook of Technical and Scientific Writing, by Leslie C. Perelman, James Paradis, and Edward Barrett.

In the lecture and elsewhere, these will normally be referred to as the "manual," the "textbook," and the "writing handbook," respectively. The lab manual is the starting point for each lab exercise, and it refers to sections of the textbook, as needed.

The web site will also be a valuable resource:

- http://diglab.ece.gatech.edu

The laboratory is located in room E283 of the Van Leer building. Although "open" hours will be available for general use, all students have an assigned laboratory section that they are expected to attend. During the normal period for each section, prelab quizzes are given, assignments are explained, and written reports are submitted for grading.

There are 22 computers for student use in the lab. Alongside each computer is a prototyping unit, oscilloscope, logic analyzer, and programmable logic development board, as shown in **Figure 1**.

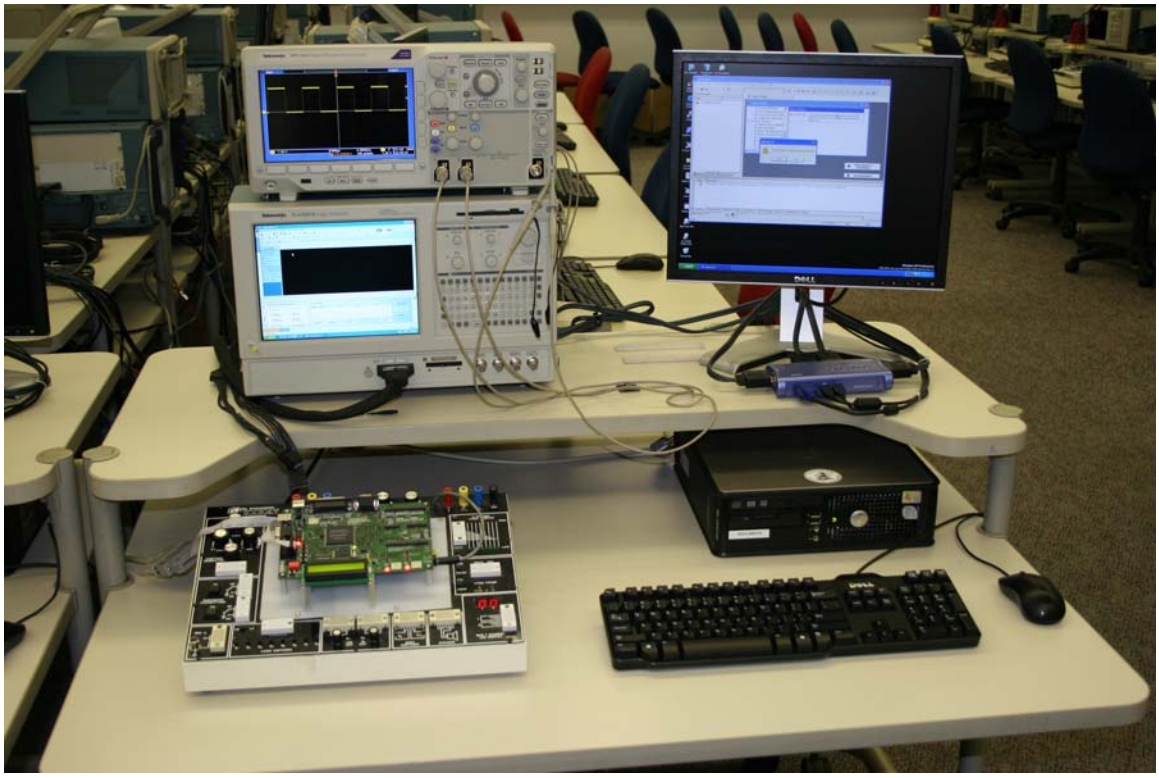

Figure 1. Typical laboratory equipment setup.

The ECE Undergraduate Professional Communication Program

An important part of this course is the ECE Undergraduate Professional Communication Program (UPCP), often called the "Writing Program." This will be the first of several courses in which you are instructed in techniques for presenting technical information. Another valuable resource will be the UPCP web site:

- http://upcp.ece.gatech.edu

Faculty and Staff

With nearly 150 students in ECE 2031 during some semesters, it requires a large group of faculty and staff to provide some personal attention to each student.

Dr. Thomas Collins (tom.collins@gatech.edu) is the instructor who presents the lecture each week. He also is the administrator of the lab facilities, and he determines all quiz and exam problems, creates new laboratory exercises, and determines the final grades. Dr. Collins received his Ph.D. from Georgia Tech in 1994 and has an active research career at the Georgia Tech Research Institute in robotics, embedded systems, and high-performance computing. In addition to having taught courses related to this one here at Georgia Tech, he has worked for IBM, Hewlett Packard, and other companies.

Office Location: College of Computing Building, Room 258
(NOT Van Leer E266 anymore)
Office Hours: Thursday 5:00-6:00 and Friday 4:00-6:00
Telephone: 404.385.2637
(When you arrive at the second floor of the College of Computing building, you will have to call this number to be let in. There is a phone there.)

Instructor Christina Bourgeois (christina.bourgeois@ece.gatech.edu) is the coordinator of the Writing Program and the co-instructor for this course. She plays the lead role in the written formulation of the laboratory exercises, sets the requirements for written reports, and supervises the grading of these reports through the Graduate Teaching Assistants. Instructor Bourgeois received her M.A. in English from Clemson University in 1997. She also coordinates the writing aspects of three

other ECE courses. Prior to her appointment at Tech, Instructor Bourgeois was the Writing Center Director at Armstrong Atlantic State University where she also taught Composition and Rhetoric and several literature courses.

The **GTA**s (Graduate Teaching Assistants) handle the grading of all written reports and exams. One GTA is assigned to multiple laboratory sections and is available during the early part of the section's scheduled period both for writing-related assistance and general technical help.

The **Lead TA**s are undergraduates who have been through the course, served at least one semester as a UTA (see below), and were selected based on their technical skills and their instructional abilities. There is one Lead TA assigned to each section, and they run the lab session along with the assigned GTA. During some semesters, especially during summer semester, LTAs also run some of the open hours.

The **UTA**s are undergraduates who have also been through the course, some as recently as the previous semester. They are familiar with the laboratory exercises, and usually at least two of them will be available at all times that the lab is open. They are usually enrolled as students in ECE 4901 (Special Projects). You, too, can become a UTA, so think about it as the semester progresses.

The key thing to remember is that your Lead TA and your GTA are your primary resources for the personal assistance that the faculty cannot provide to each and every student every week of the semester. Together with the other UTAs, they keep the student-teacher ratio for this course close to 4:1. There are procedures (described below) to get additional attention from the faculty when you need it, though.

Syllabus and Schedule

The lecture held on Friday of each week is designed to provide information necessary to understand the laboratory assignments for the following week. This includes some review of ECE 2030 material in the context of the laboratory environment. **No labs are held during the first week of classes, since no lecture will have taken place for students prior to their lab period**.

In addition to the textbook and lab manual described earlier, you will need to have the following:

- hardware (available from bookstore):
  a wire kit,
  a chip set, and
  a protoboard
- USB storage devices as needed to take files to and from the lab and to save data from lab instruments
- your personal GT computer account and GT Active Directory password, which **must be activated before the first lab** (see the OIT support center if you have never accessed a campus Windows-based computer).

None of the hardware is needed for the first lab, but ALL of it is needed for the second lab.

You will learn in Labs 1 & 2 that there are different "families" of discrete logic chips (integrated circuits with logic gates in them). These are what are included in your chip set, listed above. At this time, the lab is transitioning from using the 74LS TTL logic family to the 74HCT TTL-compatible logic family. Even though the printed manual refers to the 74HCT chips, you may use chips from either family or a mixture of both families – we will be very tolerant during the transition. 74HC chips are also usable. When the time comes to look up information about your chips in "datasheets," you must be conscious of the logic family for each chip!

The lab manual provides detailed information about prelab assignments and recommended reading from the textbook. For any given lab, this prelab material should be reviewed as soon as possible, preferably before the corresponding class lecture. Prelab quizzes will be given at the beginning of the lab, and 15 minutes will normally be allowed. Students who are late will have less time to work on the prelab quiz or may miss it entirely.

There will be one in-class exam and an in-lab practical final exam late in the semester. **There is no mid-term exam. There is no exam during finals week, either.**

Grades are determined according to the following weighting method:

- 35% reports, including
  lab checkoffs,
  technical content,
  writing style,
  grammar, spelling, and attention to formatting guidelines, and
  final project demonstration (with informal presentation)
- 25% prelab quizzes
- 15% in-class exam
- 25% practical final exam

Note that you can compute your own uncurved grade at any time by applying these weights to the scores you have received to date. Since any curve would be applied only in the last few days of the semester, your uncurved estimate is the best indicator of your grade. Typically, the curve is no more than 1-2 percentage points at each grade cutoff, so it's unrealistic to assume that, for example, an 85 will be an "A."

An additional factor, the "TA perspective," is a subjective evaluation of each student's abilities by the TAs who know them best. This is used to determine the final grade of any student in a borderline situation, which typically applies to between 5% and 15% of the class. It can only pull students up, and will never be used to pull a student down below a grade break. Dr. Collins and Instructor Bourgeois may also provide input to TA perspective grades.

Additional information about the points possible for each of the written assignments may be found in a later section, *Types of Writing Assignments Required.*

Laboratory Overview

Most labs consist of

1. Doing prelab exercises and reading assignments,
2. showing up on time, turning in any written assignments that are due, and presenting your prelab work for the first lab "check-off",
3. taking a prelab quiz,
4. completing the laboratory exercises under the direction of the TAs, getting more check-offs along the way, and
5. performing the corresponding writing assignment prior to its due date.

All labs have check-off sheets, which may be found in the lab manual. A TA must verify all steps and check them off. The completed sheet must be turned in at the designated date with the associated writing assignment. **Any assignment turned in without all check-offs completed, using the ORIGINAL check-off sheets from the lab manual, will <u>not</u> be graded.**

Open hours are provided according to the availability of TAs. In general, open hours are not a substitute for the assigned sections, and there is no guarantee that equipment will be available. TAs will limit time as necessary, so being first in the lab does not entitle a student to sole uninterrupted access to a workstation. During open hours, checkoffs are made with no attempt to note late penalties. The TA will note the date and time so that the GTA can determine whether the work was completed on time. **No student is allowed in the lab without a TA.**

Since there are limited open hours, during most regular sections several extra workstations will be available under the same terms as during open hours, but only after the prelab quiz is completed.

Each student has personal storage disk space that maps to the "Z" drive. This should be used as a backup, along with personal storage media as required. The CAD software has been known to have errors when compiling files on a network drive. So, it is wise to copy working files to a local directory, but it is a violation of the honor code to leave files on the local drive or to make any attempt to recover files created by other students.

Scheduled Activities

The calendar on the next two pages lists the activities for each week of the semester. **Actual open hours will depend on TA availability**.

CS2801 students have additional lectures on some Mondays and Wednesdays.

See the web site for the latest detailed lab schedule.

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	16-Aug	**17-Aug**	**18-Aug**	**19-Aug**	**20-Aug**	**21-Aug**	**22-Aug**
Assignments Due				NONE			
Lab Activity				CLOSED			
Lecture Topic						Introduction & Lab 1	
	23-Aug	**24-Aug**	**25-Aug**	**26-Aug**	**27-Aug**	**28-Aug**	**29-Aug**
Assignments Due				Prelab 1			
Lab Activity	CLOSED	OPEN HRS		Do Lab 1		TBD	TBD
Lecture Topic						Lab 2	
	30-Aug	**31-Aug**	**1-Sep**	**2-Sep**	**3-Sep**	**4-Sep**	**5-Sep**
Assignments Due				Prelab 2 & Lab 1 Results			
Lab Activity	OPEN HRS	OPEN HRS		Do Lab 2		TBD	TBD
Lecture Topic						Lab 3 & Writing Assignment	
	6-Sep	**7-Sep**	**8-Sep**	**9-Sep**	**10-Sep**	**11-Sep**	**12-Sep**
Assignments Due		(HOLIDAY)		Prelab 3 & Lab 2 Results			
Lab Activity	CLOSED	CLOSED		Do Lab 3		TBD	TBD
Lecture Topic						Lab 4	
	13-Sep	**14-Sep**	**15-Sep**	**16-Sep**	**17-Sep**	**18-Sep**	**19-Sep**
Assignments Due				Prelab 4 & Lab 3 Results			
Lab Activity	OPEN HRS	OPEN HRS		Do Lab 4		TBD	TBD
Lecture Topic						Lab 5	
	20-Sep	**21-Sep**	**22-Sep**	**23-Sep**	**24-Sep**	**25-Sep**	**26-Sep**
Assignments Due				Prelab 5 & Lab 4 Results			
Lab Activity	OPEN HRS	OPEN HRS		Do Lab 5		TBD	TBD
Lecture Topic						Lab 6	
	27-Sep	**28-Sep**	**29-Sep**	**30-Sep**	**1-Oct**	**2-Oct**	**3-Oct**
Assignments Due				Prelab 6, Writing Assignment & Lab 5 Results			
Lab Activity	OPEN HRS	OPEN HRS		Do Lab 6		CLOSED	CLOSED
Lecture Topic						Lab 7	
	4-Oct	**5-Oct**	**6-Oct**	**7-Oct**	**8-Oct**	**9-Oct**	**10-Oct**
Assignments Due		(HOLIDAY)		NONE			
Lab Activity	CLOSED	CLOSED		OPEN HRS		TBD	TBD
Lecture Topic						Lab 8	
	11-Oct	**12-Oct**	**13-Oct**	**14-Oct**	**15-Oct**	**16-Oct**	**17-Oct**
Assignments Due				Prelab 7 & Lab 6 Results			
Lab Activity	OPEN HRS	CLOSED		Do Lab 7		TBD	TBD
Lecture Topic						EXAM IN LECTURE	

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	18-Oct	**19-Oct**	**20-Oct**	**21-Oct**	**22-Oct**	**23-Oct**	**24-Oct**
Assignments Due			Prelab 8 & Lab 7 Results				
Lab Activity	OPEN HRS	OPEN HRS	Do Lab 8			TBD	TBD
Lecture Topic					Project Assignment		
	25-Oct	**26-Oct**	**27-Oct**	**28-Oct**	**29-Oct**	**30-Oct**	**31-Oct**
Assignments Due			Prelab 9 & Lab 8 Results				
Lab Activity	OPEN HRS	OPEN HRS	Introductory Project Exercises, Brainstorming			TBD	TBD
Lecture Topic						Proposals	
	1-Nov	**2-Nov**	**3-Nov**	**4-Nov**	**5-Nov**	**6-Nov**	**7-Nov**
Assignments Due			Design Proposal, Lab 9 results & Logbook checkoff				
Lab Activity	OPEN HRS	OPEN HRS	Work on Project			TBD	TBD
Lecture Topic					Review for Practical Exam, Project Questions		
	8-Nov	**9-Nov**	**10-Nov**	**11-Nov**	**12-Nov**	**13-Nov**	**14-Nov**
Assignments Due			Logbook checkoff				
Lab Activity	OPEN HRS	OPEN HRS	PRACTICAL FINAL EXAM (in lab)			TBD	TBD
Lecture Topic					Oral Presentation Tips		
	15-Nov	**16-Nov**	**17-Nov**	**18-Nov**	**19-Nov**	**20-Nov**	**21-Nov**
Assignments Due			Logbook checkoff				
Lab Activity	OPEN HRS	OPEN HRS	OPEN HRS			TBD	TBD
Lecture Topic					Design Report Tips		
	22-Nov	**23-Nov**	**24-Nov**	**25-Nov**	**26-Nov**	**27-Nov**	**28-Nov**
Assignments Due					(HOLIDAY)		
Lab Activity	OPEN HRS	OPEN HRS	OPEN HRS	CLOSE EARLY	CLOSED		CLOSED
Lecture Topic						No lecture	
	29-Nov	**30-Nov**	**1-Dec**	**2-Dec**	**3-Dec**	**4-Dec**	**5-Dec**
Assignments Due			Logbook checkoff				
Lab Activity	CLOSED	OPEN HRS	Project Demo and Presentation			CLOSED	CLOSED
Lecture Topic						No lecture	
	6-Dec	**7-Dec**	**8-Dec**	**9-Dec**	**10-Dec**	**11-Dec**	**12-Dec**
Assignments Due		Final Reports	NONE				
Lab Activity	CLOSED	(DUE NOON	CLOSED				
Lecture Topic		MONDAY)					

Lab Procedures

Late Policies

All assignments are due at the beginning of your assigned lab time (as you walk in the door) on the date specified on the schedule above. **Late assignments will not be accepted** (except under extenuating circumstances[*]). All prelabs must be completed before coming to lab. The first 15 minutes of lab will be structured as follows: turn in any assignments due for the day, take the quiz, and obtain prelab check-offs. Students are expected to abide by the policies and procedures outlined below in the order in which they appear:

1. **Turn in all assignments as you walk in the door**. Late assignments will not be accepted.
2. **Take quiz**. If you are not prepared to turn in any assignments that are due, simply inform your GTA, so that a grade of zero can be recorded. Only then can you take the quiz.
3. **Obtain prelab check-off**. All prelabs must be completed prior to your scheduled lab time. You will not be allowed to work on prelab exercises during class. Students should have their prelab exercise out and be ready for a check-off as soon as the quiz is over at about 20 minutes after the hour.

Students will not be permitted to use the lab printer during the first 20 minutes of lab. All assignments (and any accompanying materials) must be printed, filled out, and stapled prior to your scheduled lab time. This rule is necessary to prevent EVERYONE from trying to print at the last minute. It is good practice to have everything printed hours ahead of time, or preferably the night before.

Nothing will be accepted after the first twenty minutes. No prelab quizzes, no prelab checkoffs, and no assignments due from previous labs.

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[*] **Extenuating Circumstances**

Extenuating circumstances that prevent a timely submittal of an assignment MUST either
a) be discussed with Instructor Bourgeois at least **24 hours** prior to the due date, or
b) be of a nature that under Institute policies would be unquestionably accepted by the Office of the Dean of Students (including a death in the family, serious injury, or illness). The Office of the Dean of Students does not necessarily have to be involved, but they could be involved in cases as needed.

Students must be able to provide appropriate documentation verifying the extenuating circumstances that prevented a timely submittal of the assignment. Schedule conflicts, technical difficulties (corrupted disks, printer problems, crashing computers), and procrastination will not be treated as extenuating circumstances. Please plan accordingly, saving all files on disks and backing up all work.

Grade Disputes

All students have the right to ask questions about the grades they receive on assignments. However, "haggling" or negotiating over points or grades will not be tolerated. Students who wish to discuss their grade must follow the procedures outlined below:

1. Make an appointment where you can discuss the grade with your GTA **outside of the lab and in private.**
2. If you still have questions or concerns about a writing assignment grade, send an email to Instructor Bourgeois that clearly and concisely explains the problem. For concerns about a quiz or exam that remain unresolved after discussions with your GTA, send an email to Dr. Collins or visit him during office hours.
3. Sometimes an email response from Instructor Bourgeois or Dr. Collins may be enough to solve the problem, but they may request that you make an appointment to discuss the grade, or you may feel it necessary to request an appointment yourself.
4. When Instructor Bourgeois or Dr. Collins become involved in re-grading an assignment, the entire assignment will be reviewed, not just the area questioned by the student. Understand that your score could go up **or down** upon review.

Communication

From time to time, last-minute announcements will be necessary. Students are responsible for reading their email and checking the website. Often, email is not delivered because students run out of space in their OIT accounts or redirect mail to another address with limited storage space. Partly for this reason, the web site and the newsgroups (see below) are preferred over email as a means of communication. **Check the website and the newsgroup often, at least on the days immediately preceding a due date or exam!**

It is quite possible that the whole semester will go by without a single email message being sent to the class. So please do not inquire about why you are not getting email, because in all likelihood, no one is! The ECE2031 faculty members have no control over the class mailing lists. ECE computer support staff members are the only people who can help you with mailings lists! If you are convinced that other students in class are getting class-related email that you are not receiving yourself, then do the following:

1. Get someone to forward the message in question to you,
2. Make sure that it was directed to the whole class (i.e., that it was not sent by a specific TA just to their section),

3. Send a message to help@ece.gatech.edu. Forward the message you got in step 1, and explain that you are in ECE2031 and you believe that you should have received that message.

Several newsgroups are available to ask general questions of the faculty/staff and other students. Acceptable questions include clarification of assignments, tips and tricks for using the laboratory tools, etc. **Seeking direct answers to fundamental lab exercises is inappropriate and considered to be a violation of the honor code, as is answering such questions.** TAs who monitor the newsgroups will ensure that Dr. Collins is made aware of questions that cannot be answered by anyone but faculty.

The newsgroups are:

- *git.ece.class.ece2031.questions* – General questions, including underlying principles, lab procedures, etc.
- *git.ece.class.ece2031.announce* – Announcements from faculty and the Lead GTA, late-breaking news.
- *git.ece.class.ece2031.software* – Procedural questions about software tools, other than those specifically related to writing tools.
- *git.ece.class.ece2031.writing* – Issues related to the writing assignments, formatting, the use of word processing tools, etc.
- *git.ece.class.ece2031.lab_man* – Errata in the lab manual, textbook, or this workbook (so that we can get it fixed next time)

By directing your questions to the most appropriate group, you increase the chances of getting a prompt answer. For example, a GTA will be monitoring the "writing" newsgroup, and it is likely that only UTAs will be monitoring the "questions" newsgroup. So you might not get an informed answer on a writing question that is directed to the "questions" newsgroup.

Do not cross-post your question to multiple newsgroups. Pick the most appropriate one.

Instructions for accessing the Georgia Tech news server from off campus are provided at the OIT web site, in their frequently-asked questions. Briefly, it amounts to setting up the proper secure path and logging in each time with your OIT account information.

Penalty points

Penalty points can be assigned to students for the following reasons:

- Leaving trash
- Unauthorized tampering with laboratory equipment (possibly severe penalties or fines)

Attendance and time spent in the lab affects the TA perspective, a subjective evaluation that can make the difference in the letter grade of a borderline student.

Missed Work

One quiz can be dropped. If only one is missed, that's the one that is dropped. If more quizzes are missed, you must have valid documentation for excuse on ALL missed ones, and you are allowed to make up all but the first one (by some means to be determined by Dr. Collins). If no quizzes are missed, the lowest one is dropped automatically. Here it is one more time, because some students always miss this: **You get to drop a low quiz score, but if you squander your drop on an unexcused absence, you CANNOT get it back, even if your next absence is excused.**

Honor Code

All aspects of the Georgia Tech Honor Code apply and will not be repeated here. Some key points follow.

Do not plagiarize or engage in academic misconduct. Plagiarism is the act of using someone else's words, ideas, or organizational patterns without giving credit to the source. It constitutes a serious offense and is a violation of the Academic Honor Code. Georgia Tech and the School of ECE define plagiarism as "Submission of material that is wholly or substantially identical to that created or published by another person or persons, without credit notations indicating authorship" (Section XVII. C. Academic Misconduct, General Catalog).

Do not copy or cut-and-paste from any websites, textbooks, lab manuals, etc. simply to create material for your reports. Citing other sources can be a valuable way to bolster your conclusions, and direct quotes can be particularly relevant or entertaining, but should you find it necessary to consult these types of resources, you must cite your source(s). Refer to the *Mayfield Handbook* for proper documentation of sources (IEEE formatting only). Additionally, be aware that inappropriate collaboration is considered a violation of the Honor Code and will be treated as academic misconduct. Students may, of course, discuss assignments in general terms with one another, but all work should be generated individually (except for those labs specified as group or team projects). Likewise, students may receive assistance on lab reports from the course instructor, lab instructors, or writing consultants. However, students are expected to write their own reports and do their own work. Copying or allowing peers to copy or paraphrase all or portions of lab reports is considered plagiarism and academic misconduct. All instances of academic misconduct will be immediately reported to the Dean of Students.

Under no conditions is it ever acceptable to copy even the smallest fragments of another student's work without specifically citing the source. If you cite another student as the source, it may impact the grade (depending on whether that was considered to be appropriate), but at least you will not face plagiarism charges.

Do not attempt to gain special access to TAs that you know personally, or to gain access to the lab outside of the time made available to your section or to the class as a whole. (It is allowable for an LTA or a GTA to conduct special tutorial sessions for an entire section, either in the lab or elsewhere.)

Additional requirements for ECE2031 include the following

- Students must keep electronic copies of all material that is submitted for grading.
- Students must never leave files on disks in the lab, nor leave results accessible to other students. Attempts to recover files are also forbidden.

Guidelines for Writing and Formatting ECE2031 Documents

> *Our schools had better get on with what is their overwhelmingly most important task: teaching their charges to express themselves clearly and with precision in both speech and writing; in other words, leading them toward mastery of their own language. Failing that, all their instruction in mathematics and science is a waste of time.*
>
> *--Joseph Waizenbaum, M.I.T.*
>
> *The man who makes no mistakes does not usually make anything.*
>
> *--English proverb, 19th century*
>
> *Science can amuse and fascinate us all, but it is engineering that changes the world.*
>
> *--Isacc Asimov, Russian-American biochemist and writer*

In ECE 2031, several types of writing assignments are required, including lab summaries, formal lab reports, design proposals, and formal group reports. To standardize the way these reports are written and formatted, and in an attempt to introduce engineering students to technical writing skills appropriate to and accepted in their discipline, the following guidelines have been produced.

The organizational style and the requirements for writing and formatting ECE 2031 writing assignments are course-specific. That is, the format used in other courses may differ from the format required in ECE 2031. Do not assume that this organizational style will serve all reports in all courses, nor will one organizational strategy "fit" all writing assignments.

It is also imperative to explain that the reports written in this course serve an important purpose: they give students the opportunity to "write-to-learn." Amazingly, some students are able to conduct and complete lab exercises without ever understanding what they did, why they did it, or what the outcomes mean. Writing about the exercise forces students to think critically and to formulate answers to complex questions. The very act of writing the report allows students to synthesize the information they have collected, to interpret their data, and to reason inductively. Thus, the process of writing not only reinforces the skills learned in the laboratory, it also reinforces the concepts behind those skills and encourages the kind of analysis engineers will need to advance both in the university and in the workplace.

Writing Resources

L. Perelman, J. Paradis, and E. Barrett, *The Mayfield Handbook of Technical and Scientific Writing*. Mountain View, CA: Mayfield Publishing Company, 1998.

UPCP web site – http://upcp.ece.gatech.edu – Or start at the ECE 2031 page http://diglab.ece.gatech.edu and select "Writing Resources." Here you will find all of the writing resources for this course, including downloadable templates, tip sheets, examples of properly labeled figures, and much, much more!

The writing personnel are the ultimate resource when you've already checked the text, this workbook, and the online resources:

- Christina Bourgeois, Coordinator, Undergraduate Professional Communications Program
  christina.bourgeois@ece.gatech.edu
  Van Leer E268
  404.894.9597
- Writing Consultants (GTAs, names, office hours, and email addresses posted on the UPCP web site)
- Communication Studio, Van Leer C448—all GTA writing consultants share this space
  (404.894.7297)

Types of Writing Assignments Required

- **Results** – The core figures, tables, etc. that sometimes constitute the only requirements for a writing assignment, but at other times are just essential elements. These are summarized near the end of each lab exercise.
- **Lab Summary** – See Assignment Sheet posted on UPCP web site. Use template on 2031 web site and on the UPCP web site for formatting purposes. (There may be no Lab Summary reports in a given semester.)
- **Special Assignments** – like email etiquette and memo writing.
- **Design Proposal** – See Assignment Sheet posted on UPCP web site.
- **Group Design Report** – See Assignment Sheet posted on UPCP web site.
- **Formal Report** – See the section titled *Guidelines for Writing and Formatting ECE2031 Documents*, beginning on page 22.
- **Logbook** – Logbook forms (not needed until project) are posted on UPCP web site.

Assignment Sheets and full descriptions of these documents are posted on the UPCP web site; hardcopies of all guidelines and assignment sheets will be distributed in lecture throughout the semester. The rules for formatting (as presented on the pages to follow) apply to all writing assignments.

Type of Assignment	Point Value
Results and checkoffs only	100
Lab Summary	300 (including results and checkoffs)
Design Proposal	at least 300 (including results and checkoffs)
Formal Reports or Group Design Report	at least 500 (including results and checkoffs)

Required Lab "Results"

For each specific laboratory, there are different reporting requirements, varying from a simple assemblage of key "results" (schematics, waveforms, etc.), up to a formal report. But students often get confused about these key elements from the lab that make up the required results and are essential to create at least a minimal report. For this reason, a list of key "results" is included near the end of each laboratory exercise. This is subject to minor changes, so always watch the website and take this information in the context of the specific writing assignment.

Whenever possible, place more than one item on a page to conserve paper.

Formal design reports may utilize additional results, often at the discretion of the student.

Check-off sheets are always a requirement.

Mandatory Requirements for All Writing Assignments

ATTENTION: The guidelines and requirements listed below apply to all assignments in this course (lab summaries, properly labeled results, formal lab reports, design proposals, and formal group reports).

While these requirements may appear to be arbitrary, they are in fact representative of the sort of rules that will be imposed by various publishers, professional societies, corporations, government funding agencies, and other organizations. These are not the ultimate set of formatting rules – they are not even followed in most of THIS document. But they are selected as being appropriate for ECE2031 reports, so you must demonstrate your ability to follow them.

Due Dates: All assignments are due at the beginning of lab (as you walk in the door) during your assigned lab time on the date specified on the syllabus. **Late assignments will not be accepted.**

Audience: The report should be written with a specific audience in mind. For the purposes of this course, assume that your audience consists of computer engineers

working in industry who have not taken this course or conducted this experiment in several years (perhaps three or more years). Thus, you will need to use an appropriate (professional) tone, tailoring the use of scientific language and jargon to fit the needs of your audience. Since you are writing for engineers who have been out of the academic setting for a few years, you need to think carefully about how to integrate discussions of theory, but you will also need to balance the level of detail you use so as not to seem condescending to your readers. You are not writing a textbook; you are writing a report that documents the work you have done and demonstrates your understanding and analysis of the subject at hand. Remember that the primary purpose of each assignment is *writing to learn* the concepts of that lab, but you also face the challenge of *writing to inform*. As students yourselves, the act of writing helps you understand and learn the material more thoroughly; your audience, however, is interested in your ability to take this newfound knowledge and create a meaningful, articulate presentation of facts.

Form: All reports must use a word processor; all illustrations must be prepared using drawing programs. Use *Microsoft Equation Editor* or comparable equation editing tools for all equations other than those which are simple plain text. Print the report on 8 ½ x 11-inch paper only. Reports must be free of any binding and must not be submitted in notebooks, folders, or the like. Simply staple or place a binder clip in the upper left corner of the report. Do not use paper clips.

"How-To" Guides: Several "How-to" guides are available on UPCP web site. These guides will show you how to import figures from Altera design software and Excel into Word.

Line Spacing: Text within the body of the report must be double-spaced (unless otherwise specified). Use the templates on the 2031 website. Do not triple or quadruple space between paragraphs.

Font Size and Style: Use 11- or 12-point font for all text. For headings, use a 14-point **bold** font with initial capitals. "Times New Roman" is recommended.

Report Length: Length will vary depending on the assignment; however, "the body" of formal lab reports (Abstract, Introduction, Design Specifications, Procedures, Results, Conclusions) should not exceed 10 pages. Appendices may be longer. Lab Summaries should be between 1½ -2 pages long (See Lab Summary assignment sheet for more details).

Margins: Set margins at 1 inch (top, bottom, left, and right).

Indentations/Tabs: Set standard tab (0.5) for all indentations.

Pagination: Each page must be numbered. Page numbers must be placed in the lower right corner. Use Arabic numerals (1, 2, 3, etc.) to paginate the body of the report (beginning with the Abstract, including the Appendices). The first numbered page is the Abstract, which is page 1.

The appendices should be numbered separately from the body. Begin each new appendix on a separate page and create a new cover sheet for each appendix. As long as your appendices are labeled and paginated in a consistent and reasonable manner, you may use any system of numbering the pages as you see fit. In the past, some students have numbered the appendices using the following system: A1, A2, A3; B1, B2, B3, etc. (as page numbers on the bottom right corner). Figures in the appendices

should also be numbered. Check out the template found on the UPCP web site if you need more help.

Incorporation of Illustrations and Equations:

Formal Reports, Design Proposals, or Design Reports ONLY	**Results and Summary Reports ONLY**
Tables and figures should be placed as closely as possible to the textual reference. This integration of text and graphic will help the reader understand the content and argument of the report, and this method of accountability requires that the writer discuss all illustrations rather than using them as filler. "Set up" all graphics with introductory sentences, and then "follow up" with discussion/analysis. It is possible to introduce several figures or tables at one time, but there must always be adequate discussion. Figures, tables, graphs, calculations, equations, and the like should be incorporated following standard formatting procedures	Include "results" in the order given in the exercises (in the order in which they were generated), attaching them to the back of the summary report, if there is one. **Do not integrate figures into the body of the summaries.**

Equation Examples:

$E = mc^2$	**(Eq. 1)**
$Z = X + WY$	**(Eq. 2)**

Sometimes equations can be created simply by using appropriate font formatting (superscripts, etc.) and symbol fonts. In other cases, it may be necessary to use the Equation Editor in Microsoft Word.

Enumeration: Number tables and figures sequentially as Table 1, Table 2, Figure 1, Figure 2, and so on. Number all equations discussed in the text sequentially as Eq. 1, Eq. 2, etc. When equations are simply presented without referring back to them in the text, it is allowable to omit equation numbering. (Label figures and graphics in the appendices using the A1, A2, B1, B2 system.)

Line Spacing: Double-space above and below tables or figures so that they stand out from the text. If there is not enough space available on the page for the entire table or figure to fit, it is acceptable to place it on the next page (up to one-fourth of the page may be left blank).

Tables: Identify each table with a number and a title, which are placed *above* the table, flush left. Use Arabic numerals to number tables. Use a **bold** style for the word "Table" and the number. Place a period after the number. Use initial capital letters for table titles. Columns and rows must be separated by horizontal and vertical lines. Refer to tables by their number within the text (Table 1, Table 2, etc.). If possible, center the table in the allotted space. Use 10-, 11-, or 12-point type for table titles and for text within the table.

Table 1. Course Enrollment (Summer 2000)

Course	Total No. of Students	No. of Women	No. of Men	No. of ESL Students
ECE 2031	150	30	120	38
ECE 3041	175	45	130	55
ECE 3042	100	17	83	16

Figures: Each figure must be boxed where needed to allow it to stand out in the text. It must be clearly labeled with a number and a title, placed *below* the illustration, flush left. Use Arabic numerals to number figures. Use a **bold** style for the word "Figure" and the number. Place a period after the number.

Punctuate figure captions the same as sentences by placing a period at the end of the caption. All of this is shown by example in Figure 2 below. When illustrating graphs, label each axis clearly and show units of measurement by means of regularly spaced ticks. Clearly show significant data points plotted between *x* and *y* axes. Clearly label plotted lines. Refer to figures by their numbers within the text (Figure 1, Figure 2, etc.).

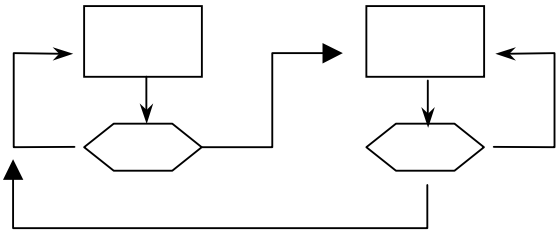

Figure 2. Diagram of a simple flowchart.

Formatting Graphics: Some Dos and Don'ts

Do…	**Don't…**
Organize results in the order generated in the exercises	Randomly staple them together
Include a printed copy of all results listed in the lab instructions	Attach anything extra
Show only relevant signals	Submit traces of all signals
Show bus signals as a whole bus; group in buses	Present irrelevant, disjointed signals
Label all simulations, waveforms, diagrams, schematics	Forget to include title box for schematics
Place title box in lower right corner, inside larger figure box	Place title box anywhere else
Treat code that is one page or less as a figure—use Courier New for fixed width	Put a box around code that spans more than one page, and don't label it as a figure. (Instead, put it in a separate appendix.)

To label code—put the following as your first comment lines in the code:
1) name of file
2) descriptive title of the code
3) your name and gt number
4) class and section
5) date
 	
The resulting title block will serve both as commenting and as a header when you incorporate the code in a writing assignment:
 	
`-- ORGATE.VHD`
`-- This VHDL code produces a`
`-- negative-logic OR circuit.`
`-- George P. Burdell (gte123a)`
`-- ECE2031 L01`
`-- 01/31/2003`
	Put the descriptive title anywhere but at the top of the page before your name

Use word processing software for everything	Handwrite anything
Use drawing software to generate all graphics, except as noted.	Hand draw anything where the instructions do not specifically tell you to do so.
Use 11- or 12-point font for figure captions	Use fonts too small or too large

Use landscape and portrait when appropriate	Forget to staple in top left corner
Include more than one graphic per page (optional)	Forget to label each one separately
Ask questions when in doubt	Remain in the dark and do poorly
Review examples of properly labeled graphics available on the UPCP web site (under *Guidelines for Formatting Graphics*)	

Also, when preparing Formal Reports, do…

- Follow the Structure of the Formal Laboratory Report, beginning on page 22.
- Integrate graphics into the body of the report portrait style only
- Include relevant graphics and code in an appendix when appropriate

Some of the point deductions for specific errors have been standardized, as shown in the following table. Frequently, the graders have to determine penalties for less obvious situations on their own.

Problem/Error	**Points Deducted**
Graphics are too large or too small	-2
Improper labeling:	
Title box (lower right corner)	-5
Figures labeled, descriptive caption	-5
Missing results	varies
Unnecessary results	-10 (any or all)
Results out of order	-5 (any or all)

NOTE: If the same error is propagated throughout the report, points will only be deducted the first three times the error occurs (for example, if five out of seven simulations are missing a title box, only the first three will be marked wrong). This policy does not apply to missing results.

Writing Style

Follow the conventions of good technical writing, and abide by all rules of grammar and mechanics. Consider the following tips:

- **Use language that is formal, precise, and clear.** Remember, you are writing like an engineer for an audience of engineers.
- **Personal pronouns:** The use of personal pronouns depends on the purpose of the assignment and the audience. In general, engineers avoid the use of personal pronouns: "I used the oscilloscope," or "We built the robot." Moreover, engineers also try to stay away from third person: "The student built the filter." Instead, they simply say, "The voltage was measured," or

"The robot was built." However, there are times and places when personal pronouns can be used (reports that document a team effort to design a product or device, for example). For the purpose of this course, try to avoid using personal pronouns in Summaries. Assignment sheets for Formal Reports and Email reports will explicitly comment on whether or not personal pronouns are appropriate.

- **Anthropomorphisms are unacceptable:** "The oscilloscope started acting crazy." Do not attribute human characteristics or feelings to inanimate objects.
- **Avoid unnecessary or confusing tense shifts.**
- **Do not plagiarize or engage in academic misconduct.** Plagiarism is the act of using someone else's words, ideas, or organizational patterns without giving credit to the source. It constitutes a serious offense and is a violation of the Academic Honor Code. Georgia Tech and the School of ECE define plagiarism as "Submission of material that is wholly or substantially identical to that created or published by another person or persons, without credit notations indicating authorship" (Section XVII. C. Academic Misconduct, General Catalog). Do not copy or cut-and-paste from any websites, textbooks, lab manuals, etc. Should you find it necessary to consult these types of resources, you must cite your source(s). Refer to the *Mayfield Handbook* for proper documentation of sources (IEEE formatting only). Additionally, be aware that inappropriate collaboration is considered a violation of the Honor Code and will be treated as Academic Misconduct. Students may, of course, discuss assignments in general terms with one another, but all work should be generated individually (except for those labs specified as group or team projects). Likewise, students may receive assistance on assignments from the course instructor, lab instructors, or writing consultants. However, students are expected to write their own reports and do their own work. Copying or allowing peers to copy or paraphrase all or portions of assignments is considered plagiarism/Academic Misconduct. All instances of plagiarism or Academic Misconduct will be immediately reported to the Office of the Dean of Students.
- **Grammar and Mechanics:** Students who need to review the rules of punctuation, grammar, and mechanics should consult the *Mayfield Handbook*. For additional assistance or further explanation, see Instructor Bourgeois. Several student-friendly handouts are available on the UPCP web site.
- **Writing Style – Structure and Development:** For help with organization, development of ideas, and tips on sophisticating writing style, chapters 5, 6, 8, and 9 of the *Mayfield Handbook* are very helpful. To discuss a lab report or any type of writing assignment in more detail, make an appointment with Instructor Bourgeois or with any of the GTA writing consultants.

Structure of the Formal Laboratory Report

This applies **only to formal laboratory reports**. Each formal lab report will contain the following components organized in the order listed below:

1. Check-off Sheet(s)
2. Evaluation Form (Grade Sheet)

3. Title Page
4. Table of Contents
5. Abstract
6. Introduction
7. Design Specifications
8. Procedures
9. Results
10. Conclusions
11. Appendices

Check-off Sheets

Check-off Sheets are found in the lab manual and must be attached to the report. These forms should be signed and dated by the LTA, GTA, or UTA, indicating that the exercise was completed in a timely manner. Only your GTA will make an indication of lateness, based on the date and time recorded by other TAs.

Evaluation Form

The Evaluation Form or Grade Sheet provides the rubric for scoring the report. An Evaluation Form must be attached to the report, or it will not be graded. This form also contains the Pledge of Academic Honesty, which must be signed and dated by the student. These forms are available on the UPCP web site.

Title Page

The Title Page must include the name of the Institute, the College, the School, the title and number of the course, the section number, the semester and year, the day of the week and the hours for the lab section, the number and title of the experiment, the experimenter's name, the experimenter's gt number (email address), and the date the report was submitted. *Use the template on the UPCP web site; it has already been formatted correctly.*

Table of Contents

The Table of Contents lists the main subject headings of the laboratory report: Abstract, Introduction, Procedures, Results, Conclusions, and Appendices. The report should be numbered consecutively, with the Abstract page as page one. Do not begin each section of the report on a new page. *Use the template on the UPCP web site; it has already been formatted correctly.*

Abstract

The Abstract is a concise summary of the report in a brief (7-10 sentence) paragraph of 100-200 words, which clearly states the purpose of the exercise, and it also emphasizes the main points of the Procedures, Results, and Conclusions of the experiment, in this order. Assume that the reader has some knowledge of the subject but has not read the report. Since the Abstract is simply a synopsis, it should not cite whole sections of the report, nor should it include tables, figures, or calculations. Think of the Abstract as the "report in miniature." It is a stand-alone document. A

reader should come away from the Abstract with a clear understanding of what the report is about without having to read the entire document. The first sentence or two of the Abstract should provide the scope/perspective (a brief statement that explains how the topic is related to electrical engineering). The next sentence or two should clearly state the purpose of the experiment. All subsequent sentences should summarize the Procedures, Results, and Conclusions sections in this order. The Abstract should be written last, after the rest of the report has been completed since it is a summary of all of the other sections of the document. Abstract should be no longer than ½ page. *Refer to pages 181-82 in the Mayfield Handbook for sample Abstracts.*

Introduction

The Introduction introduces the subject to the reader, giving him/her an idea of what to expect in the report. The information in the Introduction should be organized from "general-to-specific"; that is, begin with a few general statements about the topic before introducing specific issues—this is particularly helpful for readers who may not be specialists in the field. Keep in mind that your audience consists of electrical engineers who are now working in industry but who may not have taken this course or a similar course in three or more years. Therefore, you need to briefly remind them of important theoretical concepts in the Introduction. The Introduction also states the purpose of the experiment. The Introduction is not a "cut-and-paste" of the Abstract, but it will contain some of the same information. It also includes a brief explanation of the experiment, it identifies the objectives and the importance of the experiment, and it provides an overall background for understanding the experiment. An introduction generally does the following (although not necessarily in the order listed below):

- States the subject of the document as clearly as possible
- Defines the problem being addressed, explains the experimenter's approach to the problem, and demonstrates why this problem is important
- States what the experimenter hopes to achieve by conducting the experiment
- Provides necessary and relevant background information, including theory, definition of key terms, explanation of technical principles, formulas, equations, and calculations

Calculations, equations, and schematics included in the Introduction should be in general form; do not use specific values. Synthesize information found in lecture notes and in the lab manual. *Do not plagiarize*. Since most of what is presented in the Introduction is conceptual (definition of terms, explanation of key concepts, presentation of theory), you will primarily be writing in the present tense. *Refer to pages 186-191 in the Mayfield Handbook for sample purpose statements, Introductions, and tips on integrating background and theory into the report.*

Design Specifications

The design specifications are the explicit performance parameters a design must achieve in order to be successful. Think of them as the rules or requirements that define the problem statement. They are NOT the design choices. If all of the students are working on the same well-defined problem, they everyone has the same design specifications, and they may be extracted from the description in the lab manual or from the lecture. But since everyone may be free to choose different

components, different lines of code, etc., these choices are NOT part of the design specifications. When you are working on a more open-ended problem, you may create some of the specifications yourself before you start the design. For example, if you are given the assignment to implement a computer game with video output, and you choose to implement chess, then the rules of chess become part of your specification. Your chess pieces must obey the rules for proper moves in order to have a successful design. But it is unlikely that the specifications would include the size, color, shape, and resolution of the video images of chess pieces – you probably have at least some design CHOICES there. Design specifications can be organized in paragraph form, they can be bulleted, or a combination of both can be used. Tables and figures can be utilized in this section, if appropriate. *Refer to pages 191-192 in the Mayfield for further explanation of writing the Design Specs.*

Procedures

This section discusses and explains the steps taken to complete the exercise. In this case, you, the writer and experimenter, are telling the reader what you did (past tense) in the lab to complete this exercise. Start at the beginning. What was the first thing you did (prepare the protoboard? take preliminary measurements?) Avoid giving details that are common knowledge in the field in which you are writing; for example, it is not necessary to tell the reader how to use an oscilloscope. Learning how to discern which details belong in this section and which details are best left out is tricky, but not impossible. Keep in mind that there are two main reasons for carefully documenting the procedures used to perform the exercise:

- To inform those reading the report how an exercise was actually carried out in case analysis leads to modifications
- To replicate this work in the future, if necessary

List all steps chronologically. The Procedures section should be written in narrative form using past tense, with illustrations of all test setups and procedures included within the text. Do not use personal pronouns ("*I* did this"). Organize the material to follow the actual sequence of events. Use transitional words and phrases to show chronology and relationships between actions (first, next, subsequently, as a result). Separate each group of actions into one or more paragraphs, and describe each distinct action in one or more sentences. State precisely what happened, not what was supposed to transpire or what the lab manual said. However, if deviations from the procedure occurred, explain what changes were made and how they affected the outcome. Include all relevant calculations, tables, graphs, charts, and figures in this section of the report. *Refer to pages 193-94 in the Mayfield for sample Procedures; note the use of transitions and past tense.*

Results

The Results section is the most anticipated part of the report; this is where the outcome(s) of the exercise are stated and where all appropriate information produced by the research procedures is described. Obviously, this is probably the place to include the items listed in as important results within the laboratory instructions, but with appropriate explanatory text, unlike a "Results Only" Lab Report. Be sure to present the actual results and not what should have happened. Whether results are qualitative or quantitative, using figures and tables can help to support claims. However, all illustrations must be labeled, given a reference number, and explained with adequate discussion. All axes must also be labeled. Graphics do not convey

meaning alone. Explain why the tables are significant, why the calculations are important, and what the figures mean. Each illustration must be introduced with a sentence or two and then followed-up with discussion as well. Deciding how much data to include can be confusing. Present only the information most appropriate to the audience's purpose in reading the document, summarizing other key information in graphs and figures. Tabulate results when possible. Use an appendix for raw data and for less important information. You do need to briefly discuss the individual results, but save analysis and interpretation of data for the Conclusions section. The Results section is written in a combination of past and present tense. *Refer to pages 195-96 in the Mayfield for sample Results.*

Conclusions

The focus of the Conclusions section is to make general, concluding remarks about the experiment as a whole. Therefore, do include an analysis and discussion of all outcomes and findings. It is imperative to interpret the results, demonstrating understanding of the experiment. Compare the experimental results with theoretical and simulation results. It is not enough to simply complete the experiment. Think critically about it as well. Consider the following questions:

- What results were expected? What results were obtained? If there were any discrepancies, how can they be accounted for?
- If difficulties were encountered in the experiment, what were there sources? How might they be avoided in future experiments?

Summarize the key points discussed in all of the major sections of the report. Think about the "Big Picture" here. What did you learn by conducting this experiment? What important findings were documented? Think outside of the box, and make connections with other courses and with current trends in industry if possible. It is appropriate to make recommendations regarding how the experiment could be improved. It is not advisable to complain about time constraints or to whine about the lab environment. A combination of past and present tense is used to write this section. *Refer to pages 196-99 in the Mayfield Handbook for samples of Conclusions; note that for the purpose of this course, the Conclusion includes the discussion—it is not a separate section of the formal lab report.*

Appendices

The appendices are where information that is too detailed to be integrated within the text of the report is placed. However, anything that shows up in an appendix MUST be referenced in the body of the report. This will prevent you from using the appendices as a dumping ground for every printout you generated while conducting the lab. Only relevant waveforms, ASM charts, diagrams, simulations, screen captures, code, etc. should be included in an appendix. **Assign a letter** and an appropriate title to **each appendix** (e.g., Appendix A: SPICE Simulations; Appendix B: Calculations). Place only **one type of information** in each appendix. Begin each new appendix on a separate page and create a new section for each appendix. Paginate the appendices separately from the body of the report using any reasonable system as you see fit. Just be sure you are consistent. Create a cover sheet for each new appendix. *Use the template found on the UPCP web site if it helps.*

Report Length: The body of the report (Abstract, Introduction, Design Specifications, Procedures, Results, Conclusions) should not exceed 10 pages. The appendices can be longer.