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Introduction

This workbook provides supplementary material for the Digital Design Laboratory, supporting ECE2031. The schedule, exercises, and procedures vary from one semester to the next, and this workbook includes all information that is specific to the spring semester of 2015.

The required textbooks for this lab are

*Digital Design Laboratory Manual, Second Edition*, by Thomas R. Collins and Christopher Twigg, and


In the lecture and elsewhere, these will normally be referred to as the “lab manual” and the “textbook,” 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:

You can get to the website directly at

- [http://powersof2.com/ece2031.html](http://powersof2.com/ece2031.html)

Or indirectly through the main Digital Design Lab website at

- [http://powersof2.com](http://powersof2.com)
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. Students scheduled to be in a given section are given priority for workstations, but available extra workstations may be used by students from other sections after the quiz is completed.

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

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. CS majors taking ECE2031 have the same technical communication requirements and get the same advice and consultation on written and oral communication skills.

UPCP resources are posted to the UPCP web site:

- [http://upcp.ece.gatech.edu](http://upcp.ece.gatech.edu)
Faculty and Staff

With over 200 students in ECE 2031 during some semesters, this course 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
detailed instructions at http://powersof2.gatech.edu/resources/RIMoffice.html
Office Hours: Thursday 3:00-4:30 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 with preset numbers, or you can use your cell phone.)

Lecturer Kevin Johnson (KJohnson@gatech.edu) is the co-instructor for this course. He is a graduate of Georgia Tech (BSEE, MSEE), and he has been through all aspects of ECE2031 (student, UTA, Lead UTA, and GTA). He plays the lead role in the formulation of the communication-related assignments (written reports and oral presentations), sets the requirements for formatting reports, and supervises the grading of these reports through the Graduate Teaching Assistants. He works under the direct supervision of Christina Bourgeois (christina.bourgeois@ece.gatech.edu), the coordinator of the Undergraduate Professional Communication Program (UPCP) in ECE. Kevin also serves as the ECE2031 lab administrator. In addition to being able to resolve a variety of lab hardware and software problems, he is a valuable resource for complicated design problems late in the semester.

Office Location: Van Leer Room E276
Office Hours: Walk-ins, or by appointment
Telephone: 404.894.2924

The GTAs (Graduate Teaching Assistants) handle the grading of all written reports and exams. A GTA is assigned to each laboratory section and is available during the early part of the section’s scheduled period for administering quizzes, collecting writing-related assignment, and general assistance. Students should always contact their GTA first for any questions about assignment format and grading, because the GTA is the person who will be doing the grading. In some semesters, a more-experienced GTA might do the grading of major assignments for a new GTA.

The UTAs (Undergraduate Teaching Assistants) are undergraduates who have been through the course (some as recently as the previous semester), and have returned to provide immediate technical assistance during lab times. 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 Lead UTAs (usually called LTAs) are undergraduates who have served at least one semester as a UTA, and were selected based on their technical skills and their instructional abilities. There is one Lead UTA 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 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 less than 5:1. There are procedures (described below) to get additional attention from the faculty when you need it, though.

Syllabus and Schedule

The lecture held on Thursday and/or Friday of each week is designed to provide information necessary to understand the laboratory assignments for the following week. This includes some review of prerequisite 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.

Topical Outline:

Laboratory projects will use a PC based CAD Tool environment that supports schematic capture, logic simulation, and VHDL based logic synthesis on FPGAs (Field Programmable Gate Arrays). Discrete logic devices will be used for two designs, but VHDL-based logic synthesis on FPGA-based design boards (with hundreds of thousands of equivalent gates) will be used for more advanced design implementations. The semester will culminate with design projects specified and undertaken by teams of four to five students. Technical communication skills are developed through laboratory reports, project documentation, and an informal presentation.
Topics:

- CAD Tools
- Combinational design using multiple methods: discrete logic devices, schematic capture for FPGAs, and VHDL
- Examination of real timing issues on hardware using timing simulation, oscilloscope, and logic analyzer
- State machine specification, design, and simulation
- State machine implementation with multiple methods
- VHDL models of basic gates and logic operations
- Logic synthesis and simulation using VHDL
- VHDL-based simulation and synthesis with programmable logic devices
- Design verification with a logic analyzer
- VHDL models of data storage elements
- ROM and RAM implementations on an FPGA board
- Hardware design of a simple computer with ALU, registers, control unit, memory, instructions, and I/O
- VHDL-based simple computer simulation and implementation on FPGA board
- Machine language and assembly language programming for the simple computer
- Simulation and implementation of programs on the FPGA board
- Final design project problem specification (examples: video game, control application, robot, or contest)
- Hardware and tools available to solve the final design project problem
- Project engineering issues: top-down vs. bottom-up design, hierarchical decomposition, and modularity

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

- hardware:
  - 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. The web site describes sources for all needed items.

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 one time, this lab used only the 74LS TTL logic family of logic chips, but now we prefer the 74HCT 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 – as long as you know what you have and how to use it. 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 about 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, given late in the semester. There will also be an in-lab practical final exam late in the semester. **There is no exam during finals week.**

Grades are determined according to the following weighting method:

- 20% in-class exam
- 25% practical (in-lab) exam
- 25% prelab quizzes
- 30% prepared work, including
  - Lab results (150 points each)
  - Writing assignment (500 points)
  - Design proposal (300 points)
  - Project demonstration (500 points)
  - Design presentation (200 points)
  - Project logbook (100 points)
  - Design report (500 points)

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 usually unrealistic to assume, for example, that an 85 might be an “A.”

An additional factor, the “GTA perspective,” is a subjective evaluation of each student’s abilities by the GTAs 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 Kevin Johnson may also provide input to TA perspective grades.
Laboratory Overview

Most labs consist of

1. Doing prelab exercises and reading assignments prior to the corresponding lab session,
2. showing up on time, turning in any written assignments that are due, and presenting your prelab work for “check-off”,
3. taking a prelab quiz,
4. completing the laboratory exercises (using open hours if necessary), getting more check-offs along the way, and
5. turning in hardcopies of “results” prior to the due date, usually one week after the period where the lab was performed.

All labs have check-off sheets, which may be found only in a new copy of the lab manual. A TA must verify certain lab steps and check them off. The completed sheet must be turned in at the designated date with the associated results. **Any set of lab results turned in without the ORIGINAL check-off sheet from the lab manual will not be graded. One or more missing or late check-offs will result in proportional loss of points. A missing check-off sheet will result in loss of ALL points.**

IN SUMMER SEMESTER, all sections have two assigned meeting times each week. Sometimes two labs are done in a week, and each meeting time goes according to the description above. But sometimes, only one lab is done in a week, and attendance at the “extra” section is not mandatory (the semester schedule posted on the web site describes exactly which sections are not used for regular labs). See the next box below for more on this subject.

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, check-offs 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.**

IN SUMMER SEMESTER, the “extra” meeting times described above become open hours for any student, in any section. This reduces the need for additional open hours in the summer.

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

Each student should use personal storage to backup all work. However, the CAD software has been known to have errors when compiling files on a network drive. **Errors or not, compilation is 5-10 times SLOWER when you compile files on your Z drive (which includes your desktop) or from a flash 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 activities for each week of the semester are given in a schedule on the course web site. It is available as a Google calendar, “ics” calendar file, and/or PDF.

That calendar covers activates as they vary from week to week. See the web site at [http://powersof2.gatech.edu/weeklyschedule.html](http://powersof2.gatech.edu/weeklyschedule.html) for a detailed HOURLY lab schedule for each week, including the section times, TA assignments, and exact hours of Open Hours. That page graphically shows the GTA assignments, but UTA and LTA assignments are linked there, too.

Open hours will depend on TA availability, but will always include free workstations in regular sections, as described earlier.
Lab Procedures

Late Work
All lab assignments are due at the beginning of your assigned lab time (within the first 15 minutes) on the date specified on the schedule mentioned above. The due dates for larger assignments are listed on their respective assignment sheets. **Late assignments will not be accepted** (except under extenuating circumstances*).

Beginning of Lab
The first 15 minutes of lab will be structured as follows:

1. **Turn in all assignments.** Late assignments will not be accepted. Incomplete assignments can be turned in for partial credit, but missing check-offs incur significant penalties.
2. **Take the prelab quiz.** You will only receive a quiz after turning in all assignments, so if you are not prepared to turn in any assignments that are due, inform your GTA. Only then can you take the quiz.
3. **Obtain prelab checkoff.** For full credit, all prelab work must be completed prior to your scheduled lab time so that the prelab check-offs can be obtained during the first 15 minutes of the section. Even if you did not do the prelab work before coming to lab, **you must still complete it**, but you will lose some points for the late check-off(s).

There is no printer in the lab. All assignments (and any accompanying materials) must be printed, filled out, and stapled prior to your scheduled lab time. This is necessary to prevent EVERYONE from trying to print nearby at the last minute. It is good practice to have everything printed well ahead of time, or preferably the night before, to avoid any last-minute problems (printers not working, etc.), which will **not** be considered valid excuses for late work.

* Extenuating Circumstances
Extenuating circumstances that prevent a timely submittal of an assignment MUST either
a) be discussed with Kevin Johnson 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 repeatedly and backing up all work periodically.
Grade Disputes

All students have the right to ask questions about the grades they receive on assignments. 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 your grade for a writing assignment, send an email to Kevin Johnson 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 Kevin 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 Kevin 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

The sections below address both general announcements and interactive online discussions between faculty and students.

Announcements from faculty to students

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 websites are preferred over email as a means of communication, but note that all class email is sent to the T-Square address, so it will remain available in the T-Square email archive. Check both websites (powersof2.com and upcp.ece.gatech.edu) and the T-Square email archive often, at least on the days immediately preceding a due date or exam!

The ECE2031 faculty members have no direct control over the class mailing lists, because they originate from the T-Square server. T-Square support staff members are the only people who can help you with mailing 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. Go to the “Help” section of T-Square. Contact the support staff and 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.
Online Discussions

Piazza is being used as the primary online forum for this course, and a link to the Piazza ECE2031 course page appears on the course home page (http://powersof2.com/ece2031.html). Many students are already familiar with using Piazza, but anyone new to it should find it relatively easy to use.

Acceptable questions include clarification of assignments, methods of problem solving, locations for additional information, 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.** Dr. Collins and Kevin Johnson will participate in the Piazza interaction, as well as some of the TAs.

If an email question is directed to faculty, and it is determined that the question is both valid and general in nature, the answer will probably be added to Piazza for the entire class, with the name of the original sender removed.

Penalty Points

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

- Leaving trash in the lab
- Tampering with or vandalizing laboratory equipment (possibly severe penalties or fines)

Missed Quizzes

One quiz score can be dropped. If no quizzes are missed, the lowest score is dropped. If a quiz is missed, that’s the one that is dropped. If multiple quizzes are missed due to excused absences, you must have valid documentation for the excuse on ALL of them, and you are allowed to make up all but the first one (by some means to be determined by Dr. Collins). **If you have both excused and unexcused missed quizzes, all of the unexcused ones will be 0’s, because one of the excused ones will consume the dropped score.**

Honor Code

All aspects of the Georgia Tech Honor Code apply, all of which 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 Office of Student Integrity and/or 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 under the Honor Code.

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 or other intellectual property of other students are also forbidden.