Syllabus & Course Information

Digital Hardware Design Laboratory

ECE 2031

Summer 2026 remote

Georgia Institute of Technology
School of Electrical and Computer Engineering

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Contents

General Information

This document provides logistical material for the Digital Design Laboratory and ECE 2031. The course schedule and due dates for assignments are on Canvas.

The course will be fully remote with synchronous lecture and asynchronous lab. Students will purchase their own FPGA prototyping board, breadboard, and related hardware.

Prerequisites and Co-requisites

Either ECE 2020 or CS 2110 is a required prerequisite in digital logic theory, with a minimum grade of C. General programming experience and use of integrated development environments, such as from ECE 2035 or ECE 2036, is also required.

Course Goals and Learning Outcomes:

The goal in ECE 2031 is to experience the conception, design, fabrication, and testing of digital hardware in a hands-on setting.

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 will be used for more advanced design implementations. The semester will culminate with a design project specified and undertaken by teams of four to five students.

Technical communication skills are developed through laboratory reports, project documentation, and an oral presentation.

Course Objectives

As described at https://www.ece.gatech.edu/courses/course_outline/ECE2031, the objectives for students are to

1. apply their knowledge from ECE 2020 (or CS 2110) to practical laboratory experience in digital computing systems.
2. apply the concepts of basic combinational logic circuits, sequential circuit elements, and programmable logic in the laboratory setting.
3. develop familiarity and confidence with designing, building and testing digital circuits, including the use of CAD tools.
4. develop team-building skills and enhance technical knowledge through both written assignments and design projects.

Course Outcomes

Also from the ECE web site, upon successful completion of this course, students should be able to be able to do the following:

- implement combinational logic circuits both with TTL devices on a protoboard and within a complex PLD.
- analyze the timing of digital circuits with oscilloscopes and logic analyzers.
- design and implement state machines to meet design specifications.
- design circuits with a graphical schematic CAD editor.
- simulate circuits within a CAD tool and compare to design specifications.
- design, implement, and simulate circuits using VHDL.
- implement a simple computer within a PLD.
- write machine language programs and assembly language programs for the simple computer.
- use a complex sequential logic circuit as part of a solution to an open-ended design problem.
- write laboratory reports and documentation conforming to technical writing standards.
- work effectively as team members to develop and write a group report.
- work effectively as team members to design an approved project.

Topics

The primary topics of the course include

- CAD Tools
- Combinational logic design using multiple methods: discrete logic devices, schematic capture for FPGAs, and VHDL
- Examination of real timing issues on hardware using software simulation and hardware test equipment (oscilloscope)
- State machine specification, design, simulation, and implementation with multiple methods
- VHDL models of basic gates and logic operations
- Logic synthesis and simulation using VHDL
- 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

The learning outcomes for this course are proficiency in all of the topics listed above.

The ECE Undergraduate Professional Communication Program (UPCP), often called the "Writing Program," is integrated with ECE 2031. This will be the first of several courses in ECE in which you are instructed in techniques for creating and presenting technical information. CS and other majors taking ECE2031 have the same technical communication requirements and get the same advice and consultation on written and oral communication skills.

Faculty and Staff

With over 300 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.

Senior Lecturer Kevin Johnson (KJohnson@gatech.edu) is the primary instructor. Along with Dr. Collins (below), he creates the course content and assessments and oversees all grading. He also manages the graduate and undergraduate TAs, and administrates the lab.

Office Hours: See Canvas. Please email beforehand to ensure that the time is still available.

Dr. Thomas Collins (tom.collins@gatech.edu) is the co-instructor of the course. He works with Kevin on all aspects of the course.

The **UPCP GTA**s (Graduate Teaching Assistants) handle the grading of all written reports and most non-exam assignments. A GTA is assigned to each laboratory section and is in the lab during the first 1.5 hours to administrate the lab activities. Students should always contact their GTA first for any questions about assignment that they grade.

The **UTA**s (Undergraduate Teaching Assistants) are undergraduate students who have been through the course and have returned to provide students with assistance. They will be in the lab during scheduled sections and during open hours. They are familiar with the laboratory exercises, and are the best source of immediate assistance in the lab.

Required Books and Materials

There are no required textbooks for this course. All text is available electronically.

There will be no assignments made from the textbook *Rapid Prototyping of Digital Systems*, by J. O. Hamblen, T. S. Hall, and M. D. Furman ("SOPC Edition"), but for anyone who seeks additional background, an electronic version is available online through the Georgia Tech library.

For any students who desire additional prerequisite logic course coverage, a recommended textbook is Harris and Harris, *Digital Design and Computer Architecture*. No assignments will be made in this textbook, but students often ask for suggestions, and this not only covers the core aspects from the prerequisite, but also provides some additional coverage of VHDL, which will be covered in this course, and it is available for free through the library.

In addition to the online materials, you will need to have the following:

- A reliable home computer, meeting the requirements described in Lab 0.
- A kit of integrated circuits (logic chips), wires, a protoboard (breadboard), and other small electronics prototyping parts detailed on Canvas.
- A USB flash drive.

Your personal computer should be available for you to install software during the first week of class. The personal electronic hardware items and USB flash drive described above are needed for the second lab, done in the third week of classes (see the schedule on Canvas).

Instruction in Lecture and Lab

The lecture periods each week are usually used to elaborate on concepts that are introduced outside of class in asynchronous learning activities or background reading. This maximizes the chances of students being prepared to understand the laboratory assignments for the following week. The lecture period may include some review of prerequisite material in the context of the

laboratory environment. Some lectures also provide instruction on technical communication or related topics.

Lab work is entirely self-guided and is designed to allow students to work through design problems and get hands-on experience with prototyping and testing digital hardware. Teaching Assistants will be available at some times for assistance with lab steps.

Lecture Attendance Policy

The lectures will be remote synchronous. Recordings will be made available (as long as technical difficulties don't prevent it) but only for the purpose of later reference or catching up from excused absence.

Students will receive participation credit by answering Point Solutions questions synchronously in class or by completing other real-time tasks. We recommend accessing Point Solutions from Canvas to ensure that your login is associated with your school account.

Lab Attendance Policy

Lab is remote asynchronous; however, check-offs will need to be obtained by showing TAs the results of work at times when they are on duty.

Communication

Individual Communication

Individual communication will happen by email. Do not use Canvas's messaging feature to communicate with instructors. Do not use Piazza if a specific instructor needs to see something; send them an email directly.

Canvas

Canvas is the primary means of navigating the course content, using the Modules page. You may have already viewed some Canvas content, including announcements. If not, go to http://canvas.gatech.edu, log in with your Tech credentials, and you should see ECE 2031 as one of your courses.

We will make all important class-wide announcements via Canvas.

Online Discussion

Piazza is used as the primary online forum for this course and should be used for general questions. A link to the Piazza ECE 2031 course page is included within Canvas.

Acceptable questions include clarification of assignments, methods of problem solving, locations for additional information, tips for using the laboratory tools, deeper discussion on course topics, 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.

For sensitive questions, post visibility can be limited to faculty only; however, if it is determined that the question is both valid and general in nature, the post might be opened to the entire class.

Course Grade, Assessments, and Assignments

Letter-grade cutoffs use the following scale:

- A ≥90.0%
- B ≥80.0% and <90%
- C ≥70.0% and <80%
- D ≥60.0% and <70%
- F <60.0%

The course grade is determined according to the following weights:

- 44% two synchronous exams during the lecture period
- 20% eight structured labs
  - Completion of lab work (400 points)
  - Evaluation of results (400 points)
  - Evaluation of lab reports (150 points)
- 20% prepared work related to design project:
  - Design Logbook (50 points)
  - Proposal Presentation (200 points)
  - Technical Checkpoint (150 points)
  - Project Demonstration (200 points)
  - Project Files (300 points)
  - Project Summary (150 points)
- 6% one practical exercise
- 5% asynchronous learning activities
- 5% class participation

There is no exam during finals week. The project replaces the final exam, and some of the project-related assignments are due on the final instructional days of the semester.

The exams will be taken during lecture time on the days indicated on the semester calendar on Canvas. They will be proctored with Honor Lock or similar.

The practical exercise will be asynchronous, possibly proctored with Honor Lock or similar.

Completion of lab work is recorded via check-offs given in lab by UTAs. Each lab's check-offs are worth 50 points (400 points total).

Four of the eight labs require submission of collected results to be graded. Each submission is worth 100 points (400 points total). Submitted results are graded based on accuracy, good design, and effective presentation.

Four of the eight labs require submission of a lab report to be graded. The first lab report is ungraded and the remaining three are each worth 50 points (150 points total).

Online asynchronous quizzes associated with asynchronous learning activities will be given multiple times during the semester, related to some material that students are supposed to view outside of class, usually prior to a related lecture or lab.

Class participation includes credit for participating in lecture activities as well as completing surveys or other small tasks.

Extra credit

Offering a higher grade for additional work is not fair to students with a tight schedule, so there are no opportunities for extra credit in this class. There are many opportunities to get perfect scores simply by participating and being on time. These are the rewards to students who are diligent throughout the semester.

If your final grade is within 0.50 points of a higher letter grade boundary, your individual performance will be reviewed and may be adjusted if needed to match the official Institute descriptions of those letter grades.

- Consistently reading and making an effort to understand the material from the labs in a timely manner throughout the semester reflects positively on you. The lab manual has areas where you can submit responses to prompts, and you are encouraged to use those as you complete labs to build a history of your engagement with the material.
- The practical exercises and exams are the best indicators of your conceptual understanding of the course material. Lab work is akin to homework – it can be done in collaboration with TAs and peers, and so is not a good indicator of understanding.
- Your personal work during the project can be a good indicator of your understanding of course material. You are encouraged to use the logbook to record your individual achievements and progress throughout the project, as well as that of your team.
- Ultimately, grades are based on performance – understanding the material and being able to apply it to solving problems.

Absences and Late Work

Excused Absences

Specific procedures for excused absences are described in more detail on the "Handling Absences" page on Canvas. In general:

For excused absences falling under institute guidelines (school function, illness, injury, etc.; see http://www.catalog.gatech.edu/rules/4/), at the earliest opportunity, Kevin Johnson, Dr. Collins, and your GTA should be notified. In particular, both instructors should be contacted about making up assessments (tests, practical exercises, etc.), and the GTA should be contacted about lab-related work (lab reports, writing assignments, etc.).

For circumstances not specifically covered by institute policy (job interviews, transportation problems, personal crises, etc.), contact both instructors as soon as the situation is known. If it is deemed excusable, appropriate (perhaps partial) accommodation will be made.

Unexcused Missed Exams and Practical Exercises

In general, an unexcused missed exam will result in a grade of zero. However, it would be to the advantage of a student to discuss a missed exam at the first opportunity with Kevin or Dr. Collins.

Unexcused Missed Asynchronous Learning Activities

A penalty of 0.625% per hour will be applied for unexcused late online quizzes/activities. These quizzes are typically not difficult, so a student who completes all of them on time can easily end up with an average of 100%, whereas a student who completes all of them one day late will end up with an average of 85% at best.

Unexcused Participation Activities

At several times during the semester, including every lecture, there will be participation activities such as surveys or short-answer questions. This category can also include simple tasks done on time. Some credit for these activities is based on simply completing them, and some is based on correctly answering questions. There is no option for credit if an absence is unexcused. For excused absences, the assignment will be marked "excused" in Canvas, which effectively removes the assignment from your grade entirely.

Unexcused Late Lab Work

Completion of lab steps is recorded via check-offs, which are earned by showing or demonstrating the result of specific lab steps to a UTA.

Lab work has a soft deadline, after which the check-off credit is reduced by 15%, and a hard deadline, after which the check-off is not accepted.

Specific information about the current semester's deadlines is available on Canvas.

Late lab result submission will be penalized 0.625% per hour.

Unexcused Late Documents and Presentations

Unexcused late lab reports and most other communication assignments will be penalized 0.625% per hour. Missed presentations will be penalized 15% per day (starting as soon as they are late) and must be made up within the timeframe that presentations are occurring (usually a few days).

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. If the assignment was graded by your GTA, visit their office hours or make an appointment with them to discuss the grade. If you still have questions about your grade for a writing assignment, contact Kevin Johnson with a message that clearly and concisely explains the problem.
2. For questions about an exam or practical exercise, send an email to Kevin.
3. Sometimes the above may be enough to solve the problem, but either party may request an appointment to discuss the grade.
4. When course instructors become involved in re-grading an assignment, the entire assignment will be reviewed, not just the area questioned by the student.

All requests to change grades must be initiated within one week of receiving the grade.

Honor Code

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit

- http://www.policylibrary.gatech.edu/student-affairs/academic-honor-code
- http://honor.gatech.edu/

Plagiarism is the act of using work, ideas, or organizational patterns that are not your own and without giving credit to the source. It constitutes a serious offense and is a violation of the Academic Honor Code.

Any student suspected of cheating, plagiarizing, or receiving or giving inappropriate assistance will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations. Some key points follow.

Students may not discuss exams or practical exercises until grades have been released for that assessment.

Lab reports must be completed individually. External resources, tools, references, or collaboration with people other than the course GTAs or instructors is not allowed.

Students may discuss other assignments in general terms, but all work should be generated individually unless it is explicitly labeled as group work. Specifically related to lab work, using, in any way, work done by anyone or anything other than yourself is not allowed, as even viewing that work precludes the design and test process underpinning most of the lab work tasks.

Both receiving and providing inappropriate amounts of help are academic misconduct. Failing to properly secure one's own work is considered providing that work to others, and intentionally accessing work that is not your own, regardless of its source or location, is considered receiving that work.

External sources may be used during communication assignments, but you must cite the source(s), or the use of that information will be considered plagiarism. While properly citing an external source means that its use is not academic misconduct, its use may preclude receiving credit for the assignment if it undermines the purpose of you completing the assignment yourself.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See this catalog page for an articulation of some basic expectation that you can have of faculty in this course and that we have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, we encourage you to remain committed to the ideals of Georgia Tech while in this class.

Accommodations for Individuals with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/ as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter.

A survey early in the semester will gather basic information about your needs as they relate to most assignments. After taking that survey, email the instructors about anything not covered.

Note that accommodations are given per assignment. For example, as a lab exercise approaches where accommodations are needed, you must contact the instructors to arrange specific logistics. Having discussed accommodations at the start of the semester is not sufficient.