

ECE 460/560 Course Syllabus

ECE 460/560 – Embedded System Architectures

Section 460-001

Sections 560-001/601

Fall 2025

3 Credit Hours

Special Notes

This is a dual level course. Students in ECE 560 will be required to develop more complex programs, perform more detailed system analysis and complete more challenging tests than those in ECE 460. Performance on tests and assignments will be evaluated more rigorously for ECE 560 students.

Course Description

Exploration of architectures and processes for implementing microcontroller-based embedded computer systems. Topics include hardware vs. software trade-offs, development processes (extracting architectures, debugging, planning, testing), concurrency and multithreading, and common architectures and design patterns. Strong hands-on component with use of oscilloscope and logic analyzer to understand system behavior.

Concepts of architectures for embedded computing systems. Emphasis on hands-on implementation. CPU scheduling approaches to support multithreaded programs, including interrupts, cooperative schedulers, state machines, and preemptive scheduler (real-time kernel). Communication and synchronization between threads. Basic real-time analysis. Using hardware peripherals to replace software. Architectures and design patterns for digital control, streaming data, message parsing, user interfaces, low power, low energy, and dependability. Software engineering concepts for embedded systems.

Students must have access to a logic analyzer/oscilloscope to complete the assignments for this course.

Learning Outcomes

By the end of this course, students should be able to:

- List, explain and apply software engineering concepts for embedded systems
- Analyze thread communication and synchronization patterns
- List, explain and apply thread synchronization and communication mechanisms
- Design multithreaded systems with cooperative or preemptive thread scheduling
- Evaluate cooperative and preemptive scheduling approaches for technical and non-technical characteristics
- Explain and apply CPU-independent peripheral features to improve performance
- List, explain, and apply architectures and design patterns to synthesize and evaluate multithreaded systems for specific applications

Course Structure

There are two scheduled 75-minute classes per week. The module schedule pages on the course's WordPress site indicate each day's activities.

- Most topics will be covered by a traditional lecture during the class time.
- A flipped approach may be used for a few topics. Before the scheduled class time, students will prepare by watching online videos or completing reading assignments. Some video lectures may have Panopto quizzes embedded, so be sure to watch those videos before class.
- The scheduled class time may also be used for discussions and demonstrations.
- Be sure to attend each class or watch the scheduled class recording promptly. Some critical information may be repeated as Moodle announcements for your convenience, but **it is your responsibility to keep up to date** on the class recordings (as well as other assignments).
- We will use Moodle forums for discussions.

Course Policies

All homework assignments and programming projects are completed on the student's time and submitted electronically via Moodle. There are no scheduled lab sessions.

The project will be posted by October 31 and is due by the end of the last day of classes.

EOL students (ECE 560-601) will take proctored exams.

There are two types of homework.

- **Theory homework** ("THW") evaluates your understanding of concepts combined with ability to navigate the documentation. These will typically be submitted using Google Forms.
- **Practical homework** ("PHW") is hands-on to teach you development processes and the use of software, hardware and test equipment. Responses will typically be submitted through Moodle and/or Google Forms.

Online class evaluations will be available for students to complete during the last 2 weeks of the semester. Evaluations then become unavailable at 8 am on the first day of finals for full semester courses and the last day of classes for shorter session courses.

Students will receive an email message directing them to a website where they can login using their Unity ID and complete evaluations. All evaluations are confidential; instructors will not know how any one student responded to any question, and students will not know the ratings for any instructors.

If at least 75% of the students in a section complete these evaluations, then all students in that section will receive **2 points of extra credit** for the final course grade.

Evaluation website: <http://go.ncsu.edu/cesurvey>

Student help desk: classeval@ncsu.edu

[More information about ClassEval](#)

Instructors

Alexander G. Dean - *Instructor*

Email: agdean@ncsu.edu

Web Page: <https://sites.google.com/ncsu.edu/agdean>

Phone: 919-513-4021

Office Location: 2104 EB2

Office Hours:

Note: you may also request an appointment by email.

ECE 460, 560-001: Tuesday/Thursday from after class (~1:15 PM) to 2:30 PM.

ECE 560-601 (Engineering Online): Tuesday/Thursday 4:00-5:00 PM by on-demand Zoom (<https://ncsu.zoom.us/j/94337188370>). Please notify me by email before 3:30 if you plan to attend. You may also contact me to arrange a different time.

Skieler Capezza - *Teaching Assistant for ECE 460/560*

Email: srcapezz@ncsu.edu

Office Hours: See post in Moodle Announcements forum

Caleb Readling - *Teaching Assistant for ECE 460/560*

Email: cmreadli@ncsu.edu

Office Hours: See post in Moodle Announcements forum

Course Meetings

Class

ECE 460

Days: Tu/Th

Time: 11:45 am - 1:00 pm

Campus: Centennial

Location: 2015 EB1

Class is face-to-face and recorded.

Final Exam: 12 – 2:30 PM Thursday 12/4/2025

ECE 560-001

Days: Mo/We

Time: 11:45 am - 1:00 pm

Campus: Centennial

Location: 2207 EB3

Class is face-to-face and recorded.

Final Exam: 12 – 2:30 PM Friday 12/5/2025

ECE 560-601

Online.

Final Exam: 48-hour time window TBD for 2½ hour exam.

Course Materials

Textbooks

Embedded Systems Fundamentals with ARM Cortex-M Microcontrollers - Alexander G. Dean

Edition: 1st (KL25Z). Be sure to check <https://embeddeddean.wordpress.com/errata-for-esf-textbook/> for corrections, updates and other information.

ISBN: 978-1911531036

Web Links:

- Downloadable pdf at <https://github.com/arm-university/Embedded-Systems-Fundamentals/releases/download/v1.0.0.ed1/Embedded.Systems.Fundamentals.1st.Ed.FRDM-KL25Z.pdf>
- Print version at https://www.amazon.com/Embedded-Systems-Fundamentals-Cortex-Microcontrollers/dp/1911531034/ref=sr_1_1?ie=UTF8&qid=1495211584&sr=8-1&keywords=9781911531036

Cost: Free pdf or \$40 for print version

This textbook is required.

Debugging: The 9 Indispensable Rules for Finding Even the Most Elusive Software and Hardware Problems - David J. Agans

Edition: 1st

ISBN: 9780814474570

Cost: \$15

This textbook is required.

Better Embedded System Software - Philip Koopman

Edition: 1st

ISBN: 9870984449002

Web Link: <http://betterembsw.blogspot.com>

Cost: \$50

This textbook is optional.

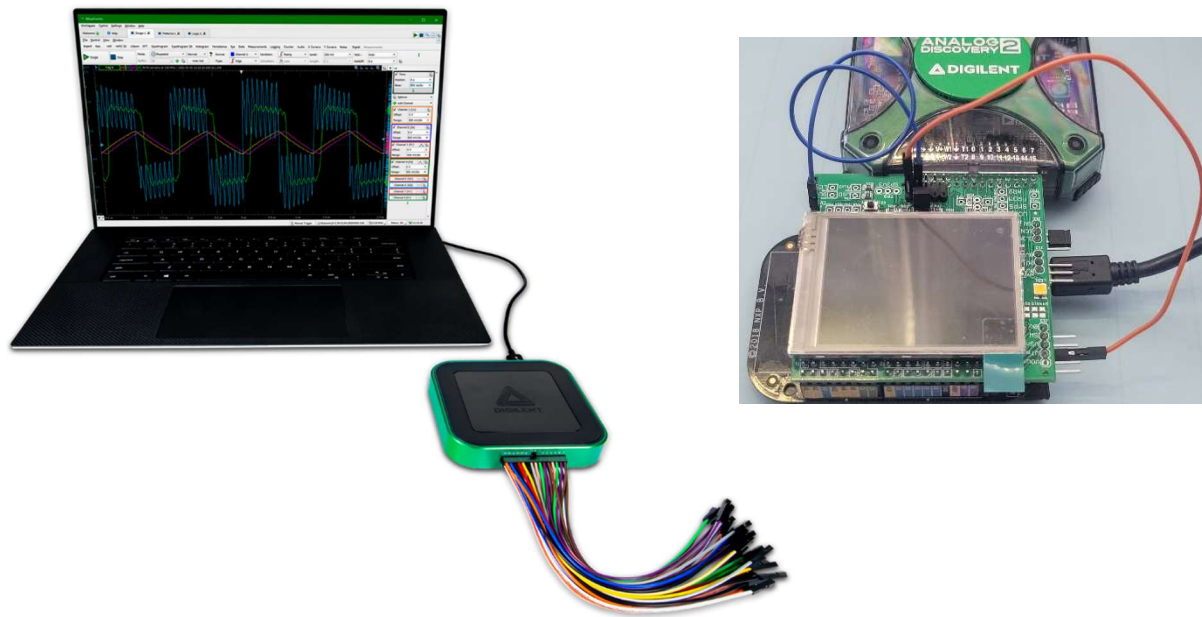
Expenses

None.

Materials

Logic Analyzer/Mixed Signal Oscilloscope with two analog and eight digital input channels. The class materials (assignments, instructions, hardware) target the USB-connected Digilent Analog Discovery 2 and 3 and its Waveforms application software. The [Digilent Analog Discovery 3](#) is recommended.

Our MCU development platform hardware includes an expansion board with a connector which plugs directly into an Analog Discovery. This eliminates the need to manually wire up signal connections for most common activities, saving time.



Digilent offers an academic price of \$249 after you complete [status verification](#) – scroll down on that web page to reach these steps:

All products on the Digilent store have special discounted pricing of 15% off for qualified academic customers. To purchase products at academic prices on our website:

1. Set up an account with Digilent.
2. **Verify** your academic credentials.
3. Once we verify your academic information, a confirmation email will be sent out and academic pricing will be applied automatically when you are logged into your Digilent account!

[Apply for Academic Pricing >>](#)

The [Digilent Analog Discovery 2](#) has been discontinued, but may still be available elsewhere. *This material is required but may be shared among students.*

Note: Further details appear on the course website on the page **Purchases**.

Requisites and Restrictions

Prerequisites

C- or better in ECE 306 - Introduction to Embedded Systems or equivalent. You should be comfortable with learning a new microcontroller and programming in C. In the projects you will be working with the NXP KL25Z microcontroller and you will be expected to learn how to program it without extensive hand-holding.

Co-requisites

None.

Restrictions

Credit will not be awarded for both ECE 460 and ECE 560.

General Education Program (GEP) Information

GEP Category

This course does not fulfill a General Education Program category.

GEP Co-requisites

This course does not fulfill a General Education Program co-requisite.

Transportation

This course will not require students to provide their own transportation. Non-scheduled class time for field trips or out-of-class activities is NOT required for this class.

Safety & Risk Assumptions

None.

Grading

Grade Components

Grade components include Theory Homeworks (THW), hands-on Practical Homeworks (PHW), a two-part Final Project (FP), two exams (MTX, FX) and attendance.

Component	Due Date	Description	Points
THW1	8/29/2025	Software and Hardware, Microseconds and Megahertz	7
THW2	9/14/2025	Race Conditions, Hardware Help for the Processing Chain	7
PHW1	9/21/2025	Get to Know the Toolchain	7
PHW2	9/28/2025	System Analysis and General Debugging	7
MTX	10/8-9/2025	Midterm Exam	14
THW3	10/5/2025	Response Time Analysis	7
PHW3	10/26/2025	Evaluating Mixed-Signal Closed-Loop Embedded Systems	7
THW4	11/2/2025	Using Schedulers and Services	7
FP.1	11/16/2025	Shields Up! Synchronization	7
FP.2	12/2/2025	Shields Up! Fault Tolerance	8
FX	12/4-5/2025	Final Exam	20
		Attendance	2
		Total Points	100

Note: Normally projects and homeworks will be graded based on **all questions**. However, time pressures may lead the instructor to **omit grading some questions** in an assignment. In this case, for fairness the same questions will be graded for all students in the class.

Letter Grades

This Course uses Standard NCSU Letter Grading:

97 ≤ **A+** ≤ 100

93 ≤ **A** < 97

90 ≤ **A-** < 93

87 ≤ **B+** < 90

83 ≤ **B** < 87

80 ≤ **B-** < 83

77 ≤ **C+** < 80

73 ≤ **C** < 77

70	≤	C-	<	73
67	≤	D+	<	70
63	≤	D	<	67
60	≤	D-	<	63
0	≤	F	<	60

Requirements for Credit-Only (S/U) Grading

Performance in research, seminar and independent study types of courses (6xx and 8xx) is evaluated as either "S" (Satisfactory) or "U" (Unsatisfactory), and these grades are not used in computing the grade point average. For credit only courses (S/U) the requirements necessary to obtain the grade of "S" must be clearly outlined.

Requirements for Auditors (AU)

Information about and requirements for auditing a course can be found at <http://policies.ncsu.edu/regulation/reg-02-20-04>.

Students must complete all homework assignments and the project with a passing grade on each to receive audit credit.

Policies on Incomplete Grades

If an extended deadline is not authorized by the Graduate School, an unfinished incomplete grade will automatically change to an F after either (a) the end of the next regular semester in which the student is enrolled (not including summer sessions), or (b) by the end of 12 months if the student is not enrolled, whichever is shorter. Incompletes that change to F will count as an attempted course on transcripts. The burden of fulfilling an incomplete grade is the responsibility of the student. The university policy on incomplete grades is located at <http://policies.ncsu.edu/regulation/reg-02-50-03>. Additional information relative to incomplete grades for graduate students can be found in the Graduate Administrative Handbook in Section 3.18.F at http://www.fis.ncsu.edu/grad_publicns/handbook/

Late Assignments

Late homework will be accepted until the solution is posted. There is an immediate 5% penalty for missing the deadline, and then an additional 2% penalty per 24 hours late (prorated). The maximum late penalty is capped at 20% to encourage completion of work despite missing the deadline.

Attendance Policy

For complete attendance and excused absence policies, please see <http://policies.ncsu.edu/regulation/reg-02-20-03>

Attendance Policy

Full participation in classes, assignments and examinations is expected of all students. Attendance will be taken each class, and will count for 2% of your grade.

Absences Policy

Excused absences are allowed as described in regulations at http://www.ncsu.edu/policies/academic_affairs/courses_undergrad/REG02.20.3.php. For other situations, please contact the instructor.

Makeup Work Policy

For expected absences, the student should contact the instructor at least a week before an absence to discuss scheduling how to make up missed work.

Additional Excuses Policy

None.

Academic Integrity

Academic Integrity

Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct found at <http://policies.ncsu.edu/policy/pol-11-35-01>

Academic Honesty

See <http://policies.ncsu.edu/policy/pol-11-35-01> for a detailed explanation of academic honesty.

Honor Pledge

Your signature on any test or assignment indicates "I have neither given nor received unauthorized aid on this test or assignment."

Electronically-Hosted Course Components

Students may be required to disclose personally identifiable information to other students in the course, via electronic tools like email or web-postings, where relevant to the course. Examples include online discussions of class topics and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

Electronically-hosted Components: Please be advised this course is being recorded for current and potential future educational purposes. By your continued participation in this recorded course, you are providing your permission to be recorded.

Accommodations for Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG02.20.01) (<https://policies.ncsu.edu/regulation/reg-02-20-01/>).

Non-Discrimination Policy

NC State provides equal opportunity and affirmative action efforts, and prohibits all forms of unlawful discrimination, harassment, and retaliation ("Prohibited Conduct") that are based upon a person's race, color, religion, sex (including pregnancy), national origin, age (40 or older), disability, gender identity, genetic information, sexual orientation, or veteran status (individually and collectively, "Protected Status"). Additional information as to each Protected Status is included in NCSU REG 04.25.02 (Discrimination, Harassment and Retaliation Complaint Procedure). NC State's policies and regulations covering discrimination, harassment, and retaliation may be accessed at <http://policies.ncsu.edu/policy/pol-04-25-05> or <https://oied.ncsu.edu/divweb/>. Any person who feels that he or she has been the subject of prohibited discrimination, harassment, or retaliation should contact the Office for Equal Opportunity (OEO) at 919-515-3148.