ECE 561 Course Syllabus

ECE 561 - Embedded System Optimization

Section 601
Spring 2020
3 Credit Hours

Special Notes
Distance education students (section 601) are not required to come to campus at any time. Any hardware distributed to on-campus students will be mailed to distance education students. All assignments are to be submitted electronically through the course's Moodle website.

Course Description
Analysis and optimization of embedded computer systems, covering speed, responsiveness, power, energy and memory requirements.

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

- Profile a program’s execution time distribution and identify hot functions.
- Analyze function object code to evaluate efficiency and compiler effectiveness and identify deficiencies.
- Improve program speed by tuning software toolchain, optimizing code and algorithms
- Profile a program's memory requirements and identify largest components.
- List, explain, apply, synthesize and evaluate methods to reduce program's memory requirements.

- List, explain and apply real-time system concepts.
- Analyze task response times and schedulability for a real-time system.
- List, explain, and apply different scheduling and prioritization methods to meet timing goals.
- List, explain and analyze impact of modern computer microarchitecture features on real-time performance.

- List, explain and apply power and energy concepts for digital, linear and power circuits.
- Analyze an embedded system’s power and energy consumption.
- Design and optimize an embedded system to meet low power or low energy requirements.
**Course Structure**

Two 75-minute meetings per week for lecture and discussion. Programming projects and lab assignments are completed on the student’s time and submitted online. There is no scheduled lab time.

**Instructors**

**Alexander Dean** (agdean) - *Instructor*

Email: agdean@ncsu.edu

Web Page: [http://people.engr.ncsu.edu/agdean](http://people.engr.ncsu.edu/agdean)

Phone: 919-513-4021

**Office Location:** 2004C EB2. Online students should contact the instructor by email (any time) or by telephone (during office hours listed below). They may also post on the online Moodle discussion forums.

**Office Hours:** Section 601: M/W 2:00 - 2:30 PM (Eastern Time Zone) and by appointment.

**Course Meetings**

**Lecture**

**Days:** MW  
**Time:** 11:45am (Eastern Time Zone) - 1:00pm (Eastern Time Zone)  
**Campus:** Centennial  
**Location:** 1230 EB2  
This meeting is required.

**Meeting Notes**

Lecture attendance is not required for distance students. Online videos will be available approximately 10 minutes after the conclusion of the campus class.

**Course Materials**

**Textbooks**

- **Better Embedded System Software** - Philip Koopman  
  **Edition:** 1st  
  **ISBN:** 9870984449002  
  **Web Link:** [http://betterembsw.blogspot.com](http://betterembsw.blogspot.com)  
  **Cost:** $50  
  This textbook is optional.

- **Embedded Systems Fundamentals with ARM Cortex-M Microcontrollers** - Alexander G. Dean  
  **Edition:** 1st  
  **ISBN:** 978-1911531036  
  **Cost:** $80  
  This textbook is required.

- **Embedded System Design, Analysis and Optimization** - Alexander G. Dean  
  **Edition:** 1st  
  **ISBN:** 978-1-935772-96-5  
  **Web Link:** [https://people.engr.ncsu.edu/agdean/Books/Dean_ESDAO_RL78_dist.pdf](https://people.engr.ncsu.edu/agdean/Books/Dean_ESDAO_RL78_dist.pdf)  
  **Cost:** $0  
  This textbook is required.

**Expenses**

None.

**Materials**

- **NXP FRDM-KL25Z MCU Development Board** - $15
This material is required.

**Electronic components** - Under $30

This material is required.


This material is required.

**Digital Multimeter** - $20

This material is required.

### Requisites and Restrictions

**Prerequisites**
C- or better in ECE 560 - Embedded Systems Architectures, or consent of instructor.

**Co-requisites**
None.

**Restrictions**
Credit will not be awarded for both ECE 461 and ECE 561.

### 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**

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projects</td>
<td>50%</td>
<td>Student completes projects involving hands-on microcontroller programming and analysis and submits online with Moodle. Grading will be based on demonstrations (in-person or recorded video) and/or lab reports. Student must work individually on projects. There will be up to four projects.</td>
</tr>
<tr>
<td>Lab Exercises</td>
<td>30%</td>
<td>Student completes lab exercises according to detailed instructions and submits report online with Moodle. Student must work individually on labs. There will be up to four labs.</td>
</tr>
<tr>
<td>Final Exam</td>
<td>20%</td>
<td>Student takes a comprehensive closed-book, closed-notes final examination on paper. One page (8.5&quot; x 11&quot;, both sides allowed) of notes and a calculator may be used.</td>
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Letter Grades

This Course uses Standard NCSU Letter Grading Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Minimum</th>
<th>Maximum</th>
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</thead>
<tbody>
<tr>
<td>A+</td>
<td>97</td>
<td>100</td>
</tr>
<tr>
<td>A</td>
<td>93</td>
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<td>C+</td>
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<td>60</td>
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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](http://policies.ncsu.edu/regulation/reg-02-20-04).

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](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/](http://www.fis.ncsu.edu/grad_publicns/handbook/).

Late Assignments

Late project submissions will be accepted until 72 hours before the final exam. 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 30% to encourage completion of the projects despite missing the deadline.

Attendance Policy

For complete attendance and excused absence policies, please see [http://policies.ncsu.edu/regulation/reg-02-20-03](http://policies.ncsu.edu/regulation/reg-02-20-03).

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
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](http://policies.ncsu.edu/policy/pol-11-35-01).

#### Academic Honesty
See [http://policies.ncsu.edu/policy/pol-11-35-01](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

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/](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/pp-04-25-05](http://policies.ncsu.edu/policy/pp-04-25-05) or [https://oied.ncsu.edu/divweb/](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.

### Course Schedule
**NOTE:** The course schedule is subject to change.

**Lecture MW 11:45am - 1:00pm — Introduction — 01/06/2020 - 01/07/2020**
Introduction to course. Microcontroller and peripheral overview. Development tool introduction.
### Lecture MW 11:45am - 1:00pm — Examining Object Code without Getting Lost — 01/08/2020 - 01/20/2020

### Lecture MW 11:45am - 1:00pm — Optimizing Speed — 01/22/2020 - 02/13/2020
Application profiling. Tuning the toolchain, low and high-level source code optimizations for speed. Polynomial approximations. Fixed-point math. SIMD programming concepts.

### Lecture MW 11:45am - 1:00pm — Optimizing Responsiveness — 02/17/2020 - 03/13/2020
Design and analysis of real-time systems. Use of preemptive real-time kernel. Leveraging hardware peripherals and DMA for responsiveness.

### Lecture MW 11:45am - 1:00pm — Optimizing Power and Energy Use — 03/16/2020 - 04/03/2020
Methods to measure energy or power use. Power and energy consumption models for digital CMOS logic. Methods for reducing power or energy use. Use of CPU stop and sleep modes, hardware peripherals (and sleep modes), DMA, voltage and frequency scaling, power supply options, other circuit design choices.

### Lecture MW 11:45am - 1:00pm — Optimizing Memory Requirements — 04/06/2020 - 04/30/2020
Methods for analyzing and reducing ROM and RAM size requirements for embedded systems.