CPE555A Real-Time and Embedded Systems

Engineering/Computer Engineering
Fall 2021

Instructor: Dr. Jack Winters
Course Web Address: https://sit.instructure.com/courses/37824
Course Schedule: Thursday 6:30-9 pm, Peirce 120
Contact Info: jwinter1@stevens.edu 732 208-5568
Office Hours: Thursday 4:30-6:30pm, 9-10pm
Prerequisite(s): None (previous coursework in C programming and microcontrollers/assembly language strongly recommended)
Corequisite(s): N/A
Cross-listed with: N/A

COURSE DESCRIPTION

This course is a survey of many topics of interest to designers of real-time and embedded systems. This course will cover the definition of embedded systems, real-time systems, processor architecture, memory devices and architecture, embedded hardware devices and components, concurrent programming, real-time operating systems, real-time scheduling algorithms and analysis, application examples, and additional topics in real-time and embedded systems. This course will prepare students for careers and research positions in embedded systems design and real-time embedded software development.

STUDENT LEARNING OUTCOMES

After successful completion of this course, students will be able to…

- Define what real-time embedded systems are, and give examples of each
- Describe the difference between hard- and soft-real-time systems
- Describe the size, weight, and power requirements that constrain embedded systems
- Describe the differences between Harvard and Von Neumann machines and their benefits
- Describe how pipelining is used to improve processor performance
- List the types of memory devices used in embedded systems, and explain the benefits and drawbacks of each
- Describe the principles behind caching and the associated performance improvements
- Describe what purposes interrupts and timers serve in embedded system designs

- Determine what hardware interfaces should be used for different devices commonly used in modern embedded systems
- Describe common issues related to concurrent/multi-threaded programming and how to resolve them
- Develop simple multi-threaded applications in C
- Use common features of real-time embedded operating systems and develop simple applications in FreeRTOS
- Describe various scheduling algorithms used in real-time systems and analyze the feasibility of different schedules

COURSE FORMAT AND STRUCTURE

This course is held on-campus on Thursdays from 6:30 to 9:00 pm in Peirce 120. To access the course material, please visit stevens.edu/canvas . For more information about course access or support, contact the Technology Resource and Assistance Center (TRAC) by calling 201-216-5500.

Course Logistics

The course is held on Thursdays from 6:30 to 9:00 pm in Peirce 120 and assignments are due before 6:30 pm at the start of class on Thursday.

- When assignments are due, they are due by 6:30 pm EDT on the due date listed in the course schedule.
- Deadlines are an unavoidable part of being a professional and this course is no exception. Course requirements must be completed and posted or submitted on or before specified due date and delivery time deadline. Due dates and delivery time deadlines are defined as Eastern Daylight Time (as used in Hoboken, NJ). Please note, students living in distance time zones or overseas must comply with this course time and time and due date deadline policy. Avoid any inclination to procrastinate. To encourage you to stay on schedule, due dates have been established for each assignment; 20% of the total points will be deducted for assignments received 1-6 days late; assignments received more than 1 week late will receive 0 points.
- An assignment file should be appended by your username, such as “assignment1_kim53.doc”.
- The assignments will be graded a few days after the submission deadline of 6:30 pm Thursday.
- We will be using a mixture of textbook readings, slides, videos, discussions, homeworks, quizzes, exams, and an online book through ZyBooks.

Instructor’s Hours

My office hours are 2 hours before and 1 hour after class. As an Adjunct Professor, I am only on campus on Thursday after 4:30 pm. I am available via email and will respond as soon as I am available (generally within 24-48) hours. Email is preferred, but you can also call or text me at the above number (keep in mind that I may not always be able to immediately respond to calls or text messages).

Online Etiquette Guidelines

Your instructor and fellow students wish to foster a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to

comment, question, or critique an idea but you are not to attack an individual. Our differences, some of which are outlined in the University's inclusion statement below, will add richness to this learning experience. Please consider that sarcasm and humor can be misconstrued in online interactions and generate unintended disruptions. Working as a community of learners, we can build a polite and respectful course ambience. Please read the Netiquette rules for this course:

- Do not dominate any discussion. Give other students the opportunity to join in the discussion.
- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.
- Avoid using vernacular and/or slang language. This could possibly lead to misinterpretation.
- Keep an “open-mind” and be willing to express even your minority opinion.
- Think and edit before you push the “Send” button.
- Do not hesitate to ask for feedback.

TENTATIVE COURSE SCHEDULE

Changes to the below schedule will be given by email.
Homework assignments are due by 6:30 pm on the Thursday after the date that they are assigned in the Table below and are to be submitted via Canvas.

Tentative Course Schedule

Date	**Topic**	**Assignment (due at 6:30 pm)**	**Reading Assignment**	
Sept. 2	Introduction to Real-Time and Embedded Systems	Set up FreeRTOS simulation environment	Peckol Forward	
Sept 9	Embedded Processor Architecture	Homework # 1	Peckol Ch. 1	
Sept 16	Memory and Caching	Homework # 2	Peckol Ch. 4	
Sept 23	C Programming for Embedded Systems	Homework # 3	Peckol Ch. 6, 7.1-7.5	
Sept 30	Interrupts & Timers	Homework # 4	Peckol Ch. 7.6	
Oct 7	Communication Busses & I/O	Homework # 5	Peckol Ch. 16, 17, 18	
Oct 14	Hardware/Software Partitioning	Homework # 6	Peckol Ch. 14, 19	

Oct 21	**Midterm Exam**			
Oct 28	Real-Time Operating Systems	Homework # 7	Peckol Ch. 11	
Nov 4	Multitasking	Homework # 8	Peckol Ch. 12, 13	
Nov 11	RTOS Programming	Homework # 9 Presentation Topics		
Nov 18	Aperiodic Scheduling	Homework # 10		
Dec 2	Periodic Scheduling	Homework # 11		
Dec 9	Presentations			
Dec 16	**Final Exam (tentative date)**			

COURSE MATERIALS

Textbook(s): "Embedded Systems: A Contemporary Design Tool", Second edition, James K. Peckol, Wiley, ISBN 978-1-119-45750-3
Zybooks: Embedded Systems, zybooks.com
Other Readings: As posted on Canvas
Materials: "Computer Organization and Design, The Hardware Software Interface: ARM Edition" David Patterson and John L. Hennessy, Morgan Kaufmann, ISBN 9780128017333
"Modern Embedded Computing" Peter Barry and Patrick Crowley, Elsevier, ISBN 9780123914903
"Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications" George Buttazzo, Springer, ISBN 9781461406754

COURSE REQUIREMENTS

Participation: All students are required to read the assigned chapters in the textbook, skim the slides, and attend the class lectures. Interaction via discussion groups including text and occasionally audio is required. All students are also required to complete the weekly readings and online questions on Zybooks. For Zybooks:

- Click on your zyBooks link in Canvas under assignments for the week. (Do not go to the zyBooks website and create a new account)
- Subscribe

Note that a subscription is $58. Subscriptions will last until January 5, 2022.

Homework: Homework is submitted via Canvas prior to the start of lecture (by 6:30 pm on the Thursday after it is assigned). Word or pdf format is required.

Project(s): Presentation given by each student on a topic of interest (a list of topics will be provided). Presentation submitted via Canvas (PowerPoint slides) the day before per schedule. Length of presentation to be determined by the number of students. Grade based on:

- Presentation submitted on time (if later changes, state during talk).
- Presentation given within allotted time (I will provide 1-minute warning).
- Presentation style (should look adequately rehearsed).
- Content (appropriate level and interest).
- Response to questions asked.

Exams: A midterm and a final exam will be given on the tentative dates shown in the schedule. The exams are the entire 2.5 hour class time. The midterm exam will cover the first half of the course, and the final exam will cover the second half of the course (non-cumulative).

TECHNOLOGY REQUIREMENTS

Baseline technical skills necessary for online courses

- Basic computer and web-browsing skills
- Navigating Canvas.

Technology skills necessary for this specific course

- Live web conferencing using Zoom or Blackboard Collaborate

Required Equipment

- Computer: current Mac (OS X) or PC (Windows 7+) with high-speed internet connection
- Microphone: built-in laptop or tablet mic or external microphone

Required Software

- Microsoft Word
- Microsoft Excel
- Microsoft PowerPoint

GRADING PROCEDURES

Grades will be based on:

Participation	10%
Homework	30%
Presentation	20%
Midterm	20%
Final	20%

Late Policy

Course requirements must be completed and posted or submitted on or before specified due date and delivery time deadline. Due dates and delivery time deadlines are defined as Eastern Daylight Time (as used in Hoboken, NJ). Please note, students living in distance time zones or overseas must comply with this course time and time and due date deadline policy. Avoid any inclination to procrastinate. To encourage you to stay on schedule, due dates have been established for each assignment; 20% of the total points will be deducted for assignments received 1-6 days late and will require a makeup assignment; assignments received more than 1 week late may receive 0 points.

Academic Integrity

All students are expected to do their own work individually; however, students may occasionally assist one another to complete an assignment. If students collaborate on an assignment, this must be disclosed in the homework submission, and will not be considered a violation of academic integrity. “Assisting” each other does not mean that students each do a different part of the assignment – all students are expected to complete the entire solution they submit.

For programming assignments, students may use code found online or in sample or demo applications as a reference. All references and any re-used code must be disclosed. Follow all software licensing requirements (such as open source licensing requirements) – failure to do so would not only be an academic integrity violation, but may also be illegal, depending on the license.

Undergraduate Honor System

Enrollment into the undergraduate class of Stevens Institute of Technology signifies a student's commitment to the Honor System. Accordingly, the provisions of the Stevens Honor System apply to all undergraduate students in coursework and Honor Board proceedings. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. More information about the Honor System including the constitution, bylaws, investigative procedures, and the penalty matrix can be found online at http://web.stevens.edu/honor/

The following pledge shall be written in full and signed by every student on all submitted work (including, but not limited to, homework, projects, lab reports, code, quizzes and exams) that is assigned by the course instructor. No work shall be graded unless the pledge is written in full and signed.

"I pledge my honor that I have abided by the Stevens Honor System."

Reporting Honor System Violations
Students who believe a violation of the Honor System has been committed should report it within ten business days of the suspected violation. Students have the option to remain anonymous and can report violations online at www.stevens.edu/honor.

Graduate Student Code of Academic Integrity

All Stevens graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating this code shall be subject to discipline.

All graduate students are bound to the Graduate Student Code of Academic Integrity by enrollment in graduate coursework at Stevens. It is the responsibility of each graduate student to understand and adhere to the Graduate Student Code of Academic Integrity. More information including types of violations, the process for handling perceived violations, and types of sanctions can be found at www.stevens.edu/provost/graduate-academics.

Special Provisions for Undergraduate Students in 500-level Courses

The general provisions of the Stevens Honor System do not apply fully to graduate courses, 500 level or otherwise. Any student who wishes to report an undergraduate for a violation in a 500-level course shall submit the report to the Honor Board following the protocol for undergraduate courses, and an investigation will be conducted following the same process for an appeal on false accusation described in Section 8.04 of the Bylaws of the Honor System. Any student who wishes to report a graduate student may submit the report to the Dean of Graduate Academics or to the Honor Board, who will refer the report to the Dean. The Honor Board Chairman will give the Dean of Graduate Academics weekly updates on the progress of any casework relating to 500-level courses. For more information about the scope, penalties, and procedures pertaining to undergraduate students in 500-level courses, see Section 9 of the Bylaws of the Honor System document, located on the Honor Board website.

EXAM CONDITIONS

The following procedures apply to exams for this course. As the instructor, I reserve the right to modify any conditions set forth below by printing revised Exam Conditions on the exam.

1. Students may use the following materials during quizzes and/or exams. Any materials that are not mentioned in the list below are not permitted.

Material	Permitted?	
	Yes	No
Handwritten Notes Conditions: i.e. size of note sheet	X	
Typed Notes Conditions: i.e. size of note sheet	X	
Textbooks Conditions: i.e. specific books	X	
Readings Conditions: i.e. specific documents	X	

Other (specify)		

2. Students may access any online material except that they may not interact with any person other than the instructor of this course.

3. Students are/are not allowed to work with or talk to other students during exams.

LEARNING ACCOMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/office-disability-services. If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at pgehman@stevens.edu or by phone 201-216-3748.

Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies.

INCLUSIVITY

Name and Pronoun Usage

As this course includes group work and class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster

does not align with your name and/or pronouns, please inform the instructor of the necessary changes.

Inclusion Statement

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements.

You are expected to treat your instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and may result in disciplinary actions.

MENTAL HEALTH RESOURCES

Part of being successful in the classroom involves a focus on your whole self, including your mental health. While you are at Stevens, there are many resources to promote and support mental health. The Office of Counseling and Psychological Services (CAPS) offers free and confidential services to all enrolled students who are struggling to cope with personal issues (e.g., difficulty adjusting to college or trouble managing stress) or psychological difficulties (e.g., anxiety and depression). Appointments can be made by phone (201-216-5177).

EMERGENCY INFORMATION

In the event of an urgent or emergent concern about the safety of yourself or someone else in the Stevens community, please immediately call the Stevens Campus Police at 201-216-5105 or on their emergency line at 201-216-3911. These phone lines are staffed 24/7, year round. For students who do not reside near the campus and require emergency support, please contact your local emergency response providers at 911 or via your local police precinct. Other 24/7 national resources for students dealing with mental health crises include the National Suicide Prevention Lifeline (1-800-273-8255) and the Crisis Text Line (text "Home" to 741-741). If you are concerned about the wellbeing of another Stevens student, and the matter is *not* urgent or time sensitive, please email the CARE Team at care@stevens.edu. A member of the CARE Team will respond to your concern as soon as possible.