Electrical Engineering 4220-7220
Real Time Embedded Computing

Prerequisite: ECE 3220

G. DeSouza

Spring 2023

University of Missouri - Columbia
Electrical & Computer Engineering Department
Columbia, MO 65211
Description: The course covers both the practical and theoretical aspects of developing embedded systems with real time constraints. Topics include real time operating systems, task management and synchronization, real time scheduling algorithms, deadlocks, performance analysis and optimization, interfacing to external devices, and device drivers.

Instructor: Prof. Guilherme N. DeSouza
Lab TA: Ramy Farag

Course Material:

References: Various on Operating Systems, Embedded Devices, Manuals, Datasheets, etc.

G. DeSouza’s Office Hours: EBW 325
E-Mail: DeSouzaG@missouri.edu

Ramy Farag’s Office Hours: To be announced
E-Mail: rmf3mc@missouri.edu

Course Format: Lectures will occur on Mondays and Wednesdays, and laboratory meetings will be on Thursdays or Fridays (to be determined during the first week). There will be a total of two exams: one mid-term and one final exam. Also, there will be a final project for graduate students on a topic that will be chosen by the student. Students must submit a proposal for their project before the middle of the semester and that proposal is worth a reasonable amount of the project grade. The topic of the project cannot be changed after the proposal is submitted. Every project must have a hardware component added to it. Homework assignments will be handed out sporadically and collected in class.

Lecture Notes and Assignments: Students should NOT count on availability of lecture notes. That is, students should take their own notes. Lab and Homework assignments will be made available in advance on the web at http://www.missouri.edu/~desouzag (and look for the link to this course’s website).
Course Topics:

1. Introduction to real time embedded systems
2. Real time kernels and operating systems, including threads, memory management, task control blocks
3. Task communication, cooperation and synchronization
4. Real time scheduling algorithms
5. Deadlocks
6. Performance analysis and metrics
7. Optimizing performance
8. Introduction to inter-process communication
9. Local device model for inter-process communication and synchronization
10. Interrupts and polling
11. Remote device model
12. Interfacing to peripheral devices
13. Device drivers
15. Universal serial bus
16. Intro to local area network, controller area network

Labs:

1. Introduction to lab equipment, software development tools.
2. Real Time modules, tasks, processes, threads, etc... Memory management.
3. FIFOS, Semaphores: local inter process communication and synchronization.
5. Sockets, Server-Clients: network inter-process communication and synchronization.
6. “Putting it all together”.

ABET Course Learning Objectives. “By the end of the semester, students should be able to”

1. Explain the theoretical and practical differences between soft real time and hard real time.
2. Write real time applications – tasks and threads – for POSIX-compliant real time kernels and operating systems.
3. Explain concepts required in the design of real time operating systems, such as: scheduling mechanisms, interrupt handling, kernel preemption, etc.
4. Design multithread and multiprocess applications with the required interprocess synchronization, interprocess communication, server-client software architectures, etc.
5. Design Software-Hardware interfaces for real time performance: hardware interfacing, device drivers, pooling, interrupts, etc.
6. Explain the requirements for a network protocol stack – TCP/IP, etc. – for real time systems and applications.
Course Policies: Cheating is strictly prohibited. Cheating violates any concept of honesty, integrity, and engineering ethics and it shall not be tolerated. Any evidence of copying or plagiarism, partial or in full, is considered cheating. All parts caught cheating shall: 1) receive a score of 0 (“F”) in the course; 2) be turned over to the Department Chairman and the Academic Provost; and 3) face the appropriate penalties established by the University, including the possibility of being expelled.

Grade Construction

<table>
<thead>
<tr>
<th>GRADE COMPONENT</th>
<th>POINTS: ECE4220</th>
<th>POINTS: ECE7220</th>
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<tbody>
<tr>
<td>Exams</td>
<td>20 (midterm) &amp; 30 (final)</td>
<td>10 (midterm) &amp; 20 (final)</td>
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<td>Projects</td>
<td>0</td>
<td>25</td>
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<tr>
<td>Continuous Assessment</td>
<td>10</td>
<td>10</td>
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<td>Laboratory Grade:</td>
<td>40</td>
<td>35</td>
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<td>Total Points</td>
<td>100</td>
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Lab work: The laboratory experiments are assigned individually. Each student must develop and report his/her own lab experiment.

Continuous Assessment:
1. Attendance (participation)
2. Readiness tests (preparation)
3. Tutor observation during class and group work (preparation, participation, and process)
4. Submitted group work (product)
5. Peer assessment (prep. and participation)
ECE4220 LABORATORY RULES & GRADING

LAB ORGANIZATION:

1. Each student will perform the following tasks:
   a) Pre-lab report
   b) Lab work
   c) Post-lab report.

2. Each student should work independently and should NOT give their programs to others. Students are responsible for possible “proliferation” of their programs. Any violation will lead to penalty.

LAB TASKS:

1. Pre-lab Report:
   a) Write pseudo code or a flow chart for the program. Pseudo code should be structured and descriptive rather than technical.
   b) Other specific works assigned in the lab handout.
   c) The pseudo code or the flow chart must be turned in at the beginning of the lab period.
   d) The report must be typed.

2. Lab Work:
   a) Your T.A. will check your program during the lab period.
   b) If the program works completely following the program requirements, you will earn 40 points.
   c) Partial credits will be earned upon the work progress.

3. Post-lab Report:
   a) Due by next lab period.
   b) Lab report format:
      i. Objective (Lab Description)
      ii. Implementation (diagrams, flowcharts, etc.)
      iii. Results and Discussion
      iv. Post-lab Questions
      v. Code Section
   c) Report must be clear and neat. Programs must be structured and commented adequately.
   d) The report must be submitted directly to the TA.
LAB GRADING:

1. Each experiment is worth 100 points including LAB 1.

2. Experiments are graded as follows:
   a) Pre-lab: 10 points
   b) Program: 40 points
   c) Post-lab: 50 points (No credit for late report)

   i. For the lab work (Program):
      40 points, if completed before or by the due date
      20 points, if completed up to one week after the due date
      No credit for labs completed after one week.

   ii. Postlab report grading guidelines:
      Objective (Lab Description) – 5 points
      Implementation – 10 points
      Results and Discussion – 20 points
      Post Lab Questions – 10 points
      Code Section – 5 points.

   iii. There may be lab quizzes during the semester to check team participation.

COMPUTER FACILITY:

The lab sessions will be held in C1246, in EBE. The combination to the door will be given in class.

LAB REGULATIONS:

1. No food or drink in the lab.
2. Do not give lab combination to others.
3. Do not leave your own software or programs on the computers in the lab.
4. Do not put backpacks etc. on the computer keyboards or mice.
**COURSE TIME SCHEDULE:**

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<thead>
<tr>
<th>Week</th>
<th>Lab1</th>
<th>Lab2</th>
<th>Lab3</th>
<th>Lab4</th>
<th>Lab5</th>
<th>Lab6</th>
<th>Final Proj.</th>
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<td>Week 1</td>
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<td>Week 3</td>
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<td>PRELAB</td>
<td>PROGRAM</td>
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<td>Week 4</td>
<td>POSTLAB</td>
<td>PROGRAM</td>
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<td>Week 5</td>
<td>PROGRAM</td>
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<td>PRELAB</td>
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<td>Week 6</td>
<td>POSTLAB</td>
<td>PROGRAM</td>
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<td>Week 7</td>
<td>PROGRAM</td>
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**Mid-Term – Mar 8th**

| Week 8 | POSTLAB | PROGRAM |      |      |      |      |             |
| Week 9 | PROGRAM |      | PRELAB |      |      |      |             |
| Week 10|         |      |      |      |      |      |             |

**FINAL EXAM:** TBA

**Student Project Presentations**
Statement on Academic Honesty: Academic integrity is fundamental to the activities and principles of a university. All members of the academic community must be confident that each person's work has been responsibly and honorably acquired, developed, and presented. Any effort to gain an advantage not given to all students is dishonest whether or not the effort is successful. The academic community regards breaches of the academic integrity rules as extremely serious matters. Sanctions for such a breach may include academic sanctions from the instructor, including failing the course for any violation, to disciplinary sanctions ranging from probation to expulsion. When in doubt about plagiarism, paraphrasing, quoting, collaboration, or any other form of cheating, consult the course instructor.

Statement on ADA: If you need accommodations because of a disability, if you have emergency medical information to share with me, or if you need special arrangements in case the building must be evacuated, please inform me immediately. Please see me privately after class, or at my office.

Office location: __________ Office hours: __________

To request academic accommodations (for example, a notetaker), students must also register with the Office of Disability Services, (http://disabilityservices.missouri.edu), S5 Memorial Union, 882-4696. It is the campus office responsible for reviewing documentation provided by students requesting academic accommodations, and for accommodations planning in cooperation with students and instructors, as needed and consistent with course requirements. For other MU resources for students with disabilities, click on "Disability Resources" on the MU homepage.

Intellectual Pluralism: The University community welcomes intellectual diversity and respects student rights. Students who have questions or concerns regarding the atmosphere in this class (including respect for diverse opinions) may contact the Departmental Chair or Divisional Director; the Director of the Office of Students Rights and Responsibilities (http://osrr.missouri.edu/) or the MU Equity Office (equity@missouri.edu; http://equity.missouri.edu/) All students will have the opportunity to submit an anonymous evaluation of the instructor(s) at the end of the course.