Electrical and Computer Engineering 4220/7220
Real Time Embedded Computing
Spring 2016

Prerequisite: ECE 3220

**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.

**Instructors:**
- Luis A. Rivera (ECE4220)
- G. DeSouza (ECE7220)

**Office Hours:**
- By appointment – EBW 18
- By appointment – EBW 325

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**Lab TA:**
- Tushar Kanta Das Nakini

**Office Hours:**
- To be announced

**E-Mail:**
- tnb88@mail.missouri.edu

**Course Texts:**

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

**Course Format:** Lectures will occur on Mondays and Wednesdays for students in 4220 and 7220 and a third day TBA for students in 7220. There will be one laboratory meeting per week, per section. There will be a total of two exams: one mid-term and one final exam. Also, there will be a final project for all students. Homework assignments will be handed out sporadically and collected in class. Quizzes may be given at the beginning of class sessions to test the students' readiness for the upcoming lecture.

**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 and other material will be made available on Blackboard [http://blearn.missouri.edu](http://blearn.missouri.edu) (for 4220 and 7220) and also at [http://vigir.ee.missouri.edu/~gdesouza/ece4220](http://vigir.ee.missouri.edu/~gdesouza/ece4220) (7220 only).
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. Introduction to local area network, controller area network

Labs:
1. Introduction to lab equipment, software development tools. Kernel modules.
2. Real Time modules, tasks, processes, threads, etc. Memory management.
4. FIFOS, semaphores, named pipes. Local inter-process communication and synchronization.
5. Sockets, Server-Clients: network inter-process communication and synchronization.
6. Interrupts. “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; 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>ECE4220</th>
<th>ECE7220</th>
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<tbody>
<tr>
<td>Mid-Term Exam</td>
<td>15</td>
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<tr>
<td>Final Exam</td>
<td>25</td>
<td>20</td>
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<td>Project</td>
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<td>25</td>
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<tr>
<td>Continuous Assessment</td>
<td>10</td>
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<tr>
<td>Laboratory Grade</td>
<td>35</td>
<td>30</td>
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<td><strong>Total Points</strong></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. Instructor observation during class and group work (preparation, participation, and process)
4. Submitted group work (product)
5. Peer assessment (prep. and participation)

Projects:
ECE4220: the project will consist of two different parts, to be submitted at different times in the semester. The second part includes a project report.

ECE7220: grad students must submit four components at different times in the semester: 1) a description of the problem to be addressed; 2) a formal project proposal; 3) a project presentation; and 4) a final project report. The topic of the project cannot be changed after the proposal is submitted.

All components will contribute to the final project grade.
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(s). Pseudo code should be structured and descriptive as well as technical.
   b. Other specific work assigned in the lab handout.
   c. The report must be turned in at the beginning of the lab period on which it is due.
   d. The report must be typed.

2. Lab Work:
   a. Your TA will check your program during the lab period.
   b. If the program works completely and following the program requirements, you will earn full credit.
   c. Partial credit will be earned based upon the work progress.

3. Post-lab Report:
   a. Due by next lab period.
   b. Lab report format:
      i. Objectives and Lab Description
      ii. Implementation (including, but not limited to diagrams, flowcharts, etc.)
      iii. Experiments and Results
      iv. Discussion and Post-lab Questions
      v. Code Section
   c. Reports must be clear and neat. Programs must be structured and commented adequately. Diagrams and flow charts SHOULD NOT be done by hand.
   d. The report must be submitted directly to the TA.
LAB GRADING:
1. Each lab assignment is worth 100 points, including Lab 1.
2. Lab assignments 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. Post-lab report grading guidelines:
         Objective and Lab Description: 5 points
         Implementation: 10 points
         Experiments and Results: 15 points
         Discussion and Post Lab Questions: 15 points
         Code Section: 5 points
      iii. There may be lab quizzes during the semester to check readiness and participation.

COMPUTER FACILITY:
The lab sessions will be held in C1246, in EBE (Lafferre Hall).

LAB REGULATIONS:
1. No food or drinks in the lab.
2. Do not leave your own software or programs on the computers in the lab.
3. Do not put backpacks etc. on the computer keyboards or mice.
4. You must be careful with the lab equipment, including the workstations, embedded boards, and auxiliary hardware.
5. You will have to work on your lab assignments and projects outside your lab sessions. You may use the lab at any time during its operating hours as long as there are no other labs in session (for this and other classes). You should inform yourself of these time schedules.
COURSE TIME / LAB SCHEDULE:

<table>
<thead>
<tr>
<th>SPRING 2016</th>
<th>Lab 1</th>
<th>Lab 2</th>
<th>Lab 3</th>
<th>Lab 4</th>
<th>Lab 5</th>
<th>Lab 6</th>
<th>Project ***</th>
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<td>Week 1</td>
<td>Introduction</td>
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<td>Week 11</td>
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<td>SPRING BREAK (March 28th – April 1st)</td>
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<td>Week 12</td>
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<td>Postlab</td>
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<td>Week 13</td>
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<td>Program</td>
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<td>Week 14</td>
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<td>Postlab</td>
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<td>Week 16</td>
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<td>Presentation/Report</td>
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FINALS WEEK (May 9th – 13th) **

* Mid Term Exam: Wednesday, March 9th, during class time.

** Final Exam: Friday, May 13th, 7:30 am – 9:30 am.

*** Project: submission due dates shown above are still tentative and they apply only to ECE4220 students. For ECE7220 students the requirements and deadlines will be discussed over the semester. ECE7220 students are the only ones required to give a project presentation.
From the Office of the Provost:

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.

If you anticipate barriers related to the format or requirements of this course, if you have emergency medical information to share with me, or if you need to make arrangements in case the building must be evacuated, please let me know as soon as possible.

If disability related accommodations are necessary (for example, a note taker, extended time on exams, captioning), please register with the Disability Center (http://disabilitycenter.missouri.edu), S5 Memorial Union, 573-882-4696, and then notify me of your eligibility for reasonable accommodations. For other MU resources for persons 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 (http://equity.missouri.edu), or by email at equity@missouri.edu. All students will have the opportunity to submit an anonymous evaluation of the instructor(s) at the end of the course.

Executive Order #38, Academic Inquiry, Course Discussion and Privacy: University of Missouri System Executive Order No. 38 lays out principles regarding the sanctity of classroom discussions at the university. The policy is described fully in Section 200.015 of the Collected Rules and Regulations. In this class, students may make audio or video recordings of course activity unless specifically prohibited by the faculty member. However, the redistribution of audio or video recordings of statements or comments from the course to individuals who are not students in the course is prohibited without the express permission of the faculty member and of any students who are recorded. Students found to have violated this policy are subject to discipline in accordance with provisions of Section 200.020 of the Collected Rules and Regulations of the University of Missouri pertaining to student conduct matters.

Those students who are permitted to record are not permitted to redistribute audio or video recordings of statements or comments from the course to individuals who are not students in the course without the express permission of the faculty member and of any students who are recorded. Students found to have violated this policy are subject to discipline in accordance with provisions of Section 200.020 of the Collected Rules and Regulations of the University of Missouri pertaining to student conduct matters.