

**Western University  
Faculty of Engineering  
Department of Electrical and Computer Engineering**

**ECE 4460B: Real-Time Embedded Systems  
Course Outline 2021-2022**

**Description:** This course introduces the fundamentals of real-time embedded systems, including embedded hardware components, real-time operating system features, and task scheduling algorithms. It also presents approaches for modeling and designing real-time embedded systems. Upon completion of the course, students will have basic understandings of how to design, build, and integrate hardware and software for an embedded control application. Hands-on experience will be gained by studying practical examples and performing laboratory experiments.

**Instructor:** Dr. Mehdi Delrobaei, P.Eng.

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Consultation hours: By appointment or via email.

**Academic Calendar Copy:** Review of embedded processors, memory systems, basic peripherals; real-time kernel configurations, task control blocks, interrupt service routines, real-time clocks/timers, multi-tasking, schedulability analysis, inter-task communication, signals, message queues, cooperative/pre-emptive multi-tasking, priority scheduling, priority inversion problems, timing considerations, deadline handling, input-output handling; practical issues in computer control; design, development, and testing techniques.

**Contact Hours:** 3 lecture hours, 1.5 laboratory hours, 0.5 course.

**Pre-requisites:** Computer Science 1027A/B or Computer Science 1037A/B, ECE 3375A/B.

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

**CEAB Academic Units:** Engineering Science 60%, Engineering Design 40%.

**Required Textbook:**

Title: *Real-Time Embedded Systems*

Author: Jiacun Wang

Publisher: John Wiley & Sons

Edition: 1<sup>st</sup> (2017)

ISBN: 978-1-118-11617-3

## Recommended Reference:

Title: *Operating Systems: Internals and Design Principles*

Author: William Stallings

Publisher: Prentice Hall

Edition: 9<sup>th</sup> (2018)

ISBN: 978-0-134-67095-9

## General Learning Objectives (CEAB Graduate Attributes)

Knowledge Base	I	Use of Engineering Tools	D	Impact on Society and the Environment	
Problem Analysis	D	Individual and Team Work		Ethics and Equity	
Investigation		Communication Skills		Economics and Project Management	A
Design	I	Professionalism		Life-Long Learning	

Notation: I –The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. D – There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. A – It is expected that the student can apply the knowledge without prompting (e.g. no review).

## Course Objectives and Specific Learning Outcomes

## CEAB Graduate Attributes Indicators

### 1. Introduction to Real-Time Embedded Systems

At the end of this section, students will be able to:

- a. Illustrate the main objectives and elements of a real-time embedded system. Not Assessed
- b. Understand the concept of real-time response.

### 2. Hardware Components

At the end of this section, students will be able to:

- a. Differentiate between different types of processors and memories. KB3
- b. Identify I/O interfaces, sensors and actuators. KB3

### 3. Real-Time Operating Systems

At the end of this section, students will be able to:

- a. Understand the concept of process management, memory management, interrupt management, and I/O management. KB3, PA1
- b. Understand the concept of multitasking, scheduling, and sharing. PA1, PA2

### 4. Task Scheduling

At the end of this section, students will be able to:

- a. Identify task states and task scheduling. PA2, D1

b. Demonstrate scheduling algorithms. PA2, D2, ET1

## 5. Resource Sharing and Access Control

At the end of this section, students will be able to:

a. Understand the concept of resource sharing and critical section. KB3, PA1

b. Identify deadlock situations and possible solutions. D2

## 6. Concurrent Programming

At the end of this section, students will be able to:

a. Understand the mechanisms of inter-task synchronization and communication. D1

b. Understand the advantages of concurrent programming. D2, ET1

## 7. Finite-State Machines

At the end of this section, students will be able to:

a. Identify modeling and analysis techniques for real-time embedded systems. KB3, D1

b. Understand the fundamental concepts of Finite State Machines. ET1, D3

## 8. UML State Machines

At the end of this section, students will be able to:

a. Understand the fundamental concepts of Unified Modeling Language. KB3, D2

b. Demonstrate the application of UML state machines in real-world embedded system behavior modeling. ET1, D3

## 9. Practical Considerations

At the end of this section, students will be able to:

a. Understand the main practical issues with real-time embedded system design and development. EPM1

b. Differentiate between software reliability, aging, security, safety, and power consumption issues. EPM2

## Evaluation

Course Component	Weight
Homework Assignment	-
Quiz	30%
Laboratory	30%
Final Examination	40%

To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination as well as on the lab assignments. A final examination or lab assignments mark < 50% will result in a final course grade of 48% or less.

**Homework Assignments:** Assignments provide important information that complements the learning experience and enrich student's understanding of each topic. There will be up to three homework assignments. All assignments will be available on OWL but they will not be marked or be part of your course evaluation. The answers will be discussed during online tutorials.

**Laboratory:** The laboratory component consists of three exercises including pre-lab work that will be posted on OWL. A schedule of the laboratory sections as well as the instructions will also be posted on OWL. A student's laboratory mark is determined by the teaching assistant's evaluation of the written pre-lab work and a demonstration of the required results. The teaching assistants will be available during the lab hours for consultation. All the pre-lab reports must be submitted as soft copies on OWL.

**Quiz:** There will be up to three online quizzes throughout the semester. The quizzes will be held during the lecture hours. The date for the quizzes will be announced on OWL. The quizzes are online and include a mixture of multiple choice, true-false, and short answer questions. If a student misses any of the three quizzes, the quiz will not be rescheduled. The student who has missed a quiz must follow guidelines in Academic Consideration for Student Absence to provide necessary documentation. The department will decide whether to allow the reweighting of the quiz, where reweighting means the marks normally allotted for the quiz will be added to the final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the test.

**Final Examination:** The final examination will take place during the regular examination period. The exam is closed-book, and non-programmable calculators are allowed. More details will be available closer to the final exam date.

**Late Submission Policy:** There will be strict deadlines for the labs and the assignments. Late submissions will be penalized by 10% of the available mark per day, to a maximum of 3 days late.

**Use of English:** In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

**Online Activities:** A camera and microphone are required for online activities.

**Use of Recordings:** All of the remote learning sessions for this course will be recorded. The data captured during these recordings may include your image, voice recordings, chat logs and personal identifiers (name displayed on the screen). The recordings will be used for educational purposes related to this course, including evaluations. The recordings may be disclosed to other individuals under special circumstances. Please contact the instructor if you have any concerns related to session recordings. Participants in this course are not permitted to record the sessions, except where recording is an approved accommodation, or the participant has the prior written permission of the instructor.

**Online Tests and Examinations:** Tests and examinations in this course may be conducted using both Zoom and a remote proctoring service. When Zoom is used for exam invigilation, you will be required to keep your camera on for the entire session, hold up your student card for identification purposes, and share your screen with the invigilator if asked to do so at any time during the exam. The exam session using Zoom will **not** be recorded.

Remote proctoring service may require you to provide **personal information** (including some biometric data). The session will be **recorded**. By taking this course, you are consenting to the use of this software. More information about remote proctoring is available in the Online Proctoring Guidelines at the following link:

<https://www.uwo.ca/univsec/pdf/onlineproctorguidelines.pdf>.

Completion of this course will require you to have a reliable internet connection and a device that meets the system and technical requirements for both Zoom and remote proctoring service. Information about the system and technical requirements are available at the following links:

<https://www.proctortrack.com/tech-requirements/>,

### **Academic Consideration for Student Absence**

Students will have up to two (2) opportunities during the regular academic year to use an on-line portal to self-report an absence during the term, provided the following conditions are met: the absence is no more than 48 hours in duration, and the assessment for which consideration is being sought is worth 30% or less of the student's final grade. Students are expected to contact their instructors within 24 hours of the end of the period of the self-reported absence, unless noted on the syllabus. Students are not able to use the self-reporting option in the following circumstances:

- for exams scheduled by the Office of the Registrar (e.g., December and April exams)
- absence of a duration greater than 48 hours,
- assessments worth more than 30% of the student's final grade,
- if a student has already used the self-reporting portal twice during the academic year

If the conditions for a Self-Reported Absence are *not* met, students will need to provide a Student Medical Certificate if the absence is medical, or provide appropriate documentation if there are compassionate grounds for the absence in question. Students are encouraged to contact their Faculty academic counselling office to obtain more information about the relevant documentation.

Students should also note that individual instructors are not permitted to receive documentation directly from a student, whether in support of an application for consideration on medical grounds, or for other reasons. **All documentation required for absences that are not covered by the Self-Reported Absence Policy must be submitted to the Academic Counselling office of a student's Home Faculty.**

For Western University policy on Consideration for Student Absence, see [Policy on Academic Consideration for Student Absences - Undergraduate Students in First Entry Programs](#)

and for the Student Medical Certificate (SMC), see:

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/medicalform.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf).

### **Religious Accommodation**

Students should consult the University's list of recognized religious holidays, and should give reasonable notice in writing, prior to the holiday, to the Instructor and an Academic Counsellor if their course requirements will be affected by a religious observance. Additional information is given in the [Western Multicultural Calendar](#).

**Accommodation Policies:** Students with disabilities work with Accessible Education (formerly SSD) which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The accommodation policy can be found here: [Academic Accommodation for Students with Disabilities](#).

**Missed Quizzes:** If a student misses a quiz, the quiz will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests and provide documentation to their department within 24 hours of the missed test. The department will decide whether to allow the reweighting of the quiz, where reweighting means the marks normally allotted for the quiz will be added to the final exam. If no reasonable justification for missing the quiz can be found, then the student will receive a mark of zero for the quiz.

If a student is going to miss the quizzes for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the quiz date or they will be required to write the exam.

### **Course Delivery with Respect to the COVID-19 Pandemic:**

Although the intent is for this course to be delivered in-person, the changing COVID-19 landscape may necessitate some or all of the course to be delivered online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any assessments affected will be conducted online as determined by the course instructor.

When deemed necessary, tests and examinations in this course will be conducted using a remote proctoring service. By taking this course, you are consenting to the use of this software and acknowledge that you will be required to provide personal information (including some biometric data) and the session will be recorded. Completion of this course will require you to have a reliable internet connection and a device that meets the technical requirements for this service. More information about this remote proctoring service, including technical requirements, is available on Western's Remote Proctoring website at: <https://remoteproctoring.uwo.ca>.

**Cheating and Plagiarism:** Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (<http://www.turnitin.com>). Software code will also be check for plagiarism using different tools.

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:  
[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/scholastic\\_discipline\\_undergrad.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf)

**Use of Electronic Devices:** Use of electronic devices during lecture time should be limited to course

relevant material.

**Policy on Repeating All Components of a Course:** Students who are required to repeat an Engineering course must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment, or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted by the student for grading in subsequent years.

**Internet and Electronic Mail:** Students are responsible for regularly checking their Western e-mail and the course web site (<https://owl.uwo.ca/portal/>) and making themselves aware of any information that is posted about the course.

**Accessibility:** Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

**Support Services:** Office of the Registrar, <http://www.registrar.uwo.ca/>  
Student Development Centre, <http://www.sdc.uwo.ca/>  
Engineering Undergraduate Services, <http://www.eng.uwo.ca/undergraduate/>  
USC Student Support Services, <http://westernusc.ca/services/>

Students who are in emotional/mental distress should refer to Mental Health @ Western, [http://www.health.uwo.ca/mental\\_health/](http://www.health.uwo.ca/mental_health/), for a complete list of options about how to obtain help.

**Online Etiquette:** Some components of this course will involve online interactions. To ensure the best experience for both you and your classmates, please honour the following rules of etiquette:

- please “arrive” to class on time
- please use your computer and/or laptop if possible (as opposed to a cell phone or tablet)
- ensure that you are in a private location to protect the confidentiality of discussions in the event that a class discussion deals with sensitive or personal material
- to minimize background noise, kindly mute your microphone for the entire class until you are invited to speak, unless directed otherwise
- in order to give us optimum bandwidth and web quality, please turn off your video camera for the entire class unless you are invited to speak
- unless invited by your instructor, do **not** share your screen in the meeting

The course instructor will act as moderator for the class and will deal with any questions from participants. To participate please consider the following:

- if you wish to speak, use the “raise hand” function and wait for the instructor to acknowledge you before beginning your comment or question
- remember to unmute your microphone and turn on your video camera before speaking
- self-identify when speaking.
- remember to mute your mic and turn off your video camera after speaking (unless directed otherwise)

General considerations of “netiquette”:

- Keep in mind the different cultural and linguistic backgrounds of the students in the course.
- Be courteous toward the instructor, your colleagues, and authors whose work you are discussing.
- Be respectful of the diversity of viewpoints that you will encounter in the class and in your readings. The exchange of diverse ideas and opinions is part of the scholarly environment. “Flaming” is never appropriate.
- Be professional and scholarly in all online postings. Cite the ideas of others appropriately.

Note that disruptive behavior of any type during online classes, including inappropriate use of the chat function, is unacceptable. Students found guilty of Zoom-bombing a class or of other serious online offenses may be subject to disciplinary measures under the Code of Student Conduct.