

# CSE4354 Real-time Operating Systems CSE5354 Real-time Operating Systems Fall 2021

## Instructor Information

---

**Instructor:**

Jason Losh, Ph.D.

**Office Number:**

ERB 649

**Office Telephone Number:**

+1 817-272-3785 (CSE Department)

**Email Address:**

[jlosh@uta.edu](mailto:jlosh@uta.edu)

**Faculty Profile:**

<https://mentis.uta.edu/explore/profile/jason-losh>

**Office Hours:**

Office hours will be before and after class and by appointment for maximum flexibility.

**Grader:**

Doungpakanh Paige Keomaxay-Hampf, [doungpakanh.keomaxayhampf@uta.edu](mailto:doungpakanh.keomaxayhampf@uta.edu)

## Course Information

---

**Section Information:**

001

**Time and Place of Class Meetings:**

MW 4:00-5:20pm

ERB 130

**Description of Course Content:**

Implementation of a real-time operating system with cooperative and preemption context switching, priority scheduling, semaphores, message queues, and inter-process communications on bare metal microcontrollers. Prerequisite: C or better in both CSE 3320 and CSE 3442 or CSE 5400.

**Student Learning Outcomes:**

Upon successful completion of this course, students will have knowledge of:

- Real-time operation system design
- ARM M4F Architecture, NVIC, and MPU operation
- ARM 7 interrupts
- Service calls for OS services
- Task switching using non-deterministic pending service call
- Thread safety, critical sections and atomic operations
- Synchronization primitives, fences, and barriers
- Inter-thread/process communications
- Cooperative and preemptive OS design

- Priority scheduling, priority inversion, and priority inheritance
- Analysis of RTOS performance (deterministic limits, switching times)

### **Class Web Page:**

Additional files will be provided as needed on the course web site at <http://ranger.uta.edu/~jlosh/>.

### **Communication:**

All class-wide communication by the instructor, including distribution of homework sets, will occur via the class listserv. Please sign up for the CSE4354-L listserv by sending an e-mail from your UTA e-mail account to [listserv@listserv.uta.edu](mailto:listserv@listserv.uta.edu) from your UTA e-mail account (no subject line needed) and the command SUBSCRIBE CSE4354-L as the message body. You will then receive an e-mail from the listserv server to which you must acknowledge to join the listserv with "OK" in an e-mail. You must sign up to this listserv between the first and third day of class (it is part of your class grade).

Canvas will only be used for Echo360 access.

### **Textbooks and Other Course Materials:**

No textbook will be required for this course. Extensive references, datasheets, application notes, and class notes will be provided on the course web site at <http://ranger.uta.edu/~jlosh/>.

All students are required to have a TM4C123GXL evaluation kit. Information on this board is available at <http://www.ti.com/tool/EK-TM4C123GXL>. You can order from TI directly, mouser.com, or other parts distributors.

### **Major Assignments and Examinations:**

Shell Mini-project:	Monday, September 20
MPU Mini-project:	Monday, October 18
Test:	Wednesday, November 17
Final Project:	Wednesday, December 1

### **Technology Requirements:**

Students will need a computer capable of accessing Canvas and watching the Echo360 lectures. The computer and OS must be capable of running appropriate compiler tools for programming the microcontroller. Ubuntu and Windows OS are the ones used in the lab and class.

## **Grading Information**

---

### **Grading:**

- Grade scale: A (90-100), B (80-89), C (70-79), D (60-69), and F (0-59)
- Grade calculation: Shell Mini Project 1 (10%), MPU Mini Project 2 (25%), Project (35%), Test (30%)
- The instructor reserves the right to make reasonable changes in performance evaluation as needed.
- The instructor also reserves the right to make substantial changes in the structure of the course if the modality of the course must be changed.
- Any request for re-grading must be submitted to the Grader within one week of the completion of grading. If, after requesting a re-grade from the Grader and getting a response, you may refer the case to the instructor if you think further action is needed.

### **Test:**

- Test is on-campus
- Test is open-book, open-notes, calculators allowed.
- No makeup will be provided for any test missed. Generally, you can request an incomplete in the course and makeup the missed test in the following semester.

**Project:**

- The projects will consist of hardware construction and firmware development and it is expected that it will take approximately 80 hours to complete in total.
- Mini projects are individual assignments. Discussing mini project topics is allowed, but the submissions must be unique. Sharing of code is not allowed.
- Projects teams will consist of 1 or 2 students. Discussing project topics is allowed, but the submissions must be unique to the team. Sharing of code is not allowed.
- An interim deadline for hardware construction will apply.

**Course Schedule**

---

- Review of selected operating systems topics (3 hrs)
- Real-time operation system additional constraints vs multi-tasking operating systems (0.5 hr)
- Review of ARM M4F Architectural Basics (3 hrs)
- Review of TM4C123GXL GPIO and UART (1.5 hrs)
- Adding a shell interface with common OS commands (e.g., ps, ipcs, kill) (1.5 hrs)
- Detailed discussion of interrupt vectors and power-on initialization (1.5 hrs)
- Detailed discussion of stacks, heaps, code and other memory usage (1.5 hrs)
- Service calls / software interrupts (0.5 hr)
- The need for the non-deterministic pending service call (0.5 hr)
- Multithreading with single core affinity (1 hr)
- Thread safety, critical sections and atomic operations, reentrancy and static variables (1 hr)
- Synchronization primitives, fences, and barriers (3 hrs)
- Inter-thread communications (1 hr)
- Context switching overview and detailed application to M4F cores (1 hr)
- Cooperative and preemptive context switching (0.5 hr)
- Priority scheduling, priority inversion, and priority inheritance (1.5 hrs)
- Memory protection without virtualization techniques (1.5 hrs)
- RTOS performance evaluation, deterministic (bounded) timing constraints (1 hr)
- Overview of FreeRTOS solution (1 hr)
- CSE 6351 student demonstration (1 hr)
- Project support lecture content (7 hrs)
- Test (1.5 hrs)

The instructor reserves the right to make changes in the schedule as needed as the class progresses.

The official dates for registration, census, and dropping are available at [www.uta.edu/acadcal](http://www.uta.edu/acadcal).

**Academic Integrity**

---

This information is copied from <http://www.uta.edu/conduct/academic-integrity/index.php>.

The University of Texas at Arlington strives to uphold and support standards of personal honesty and integrity for all students consistent with the goals of a community of scholars and students seeking knowledge and responsibility. Furthermore, it is the policy of the University to enforce these standards through fair and objective procedures governing instances of alleged dishonesty, cheating, and other academic/non-academic misconduct.

Scholastic dishonesty includes, but is not limited to, cheating, plagiarism, and collusion on an examination or an assignment being offered for credit. Each student is accountable for work submitted for credit, including group projects.

- Cheating
  - Copying another's test or assignment (added note: remember this includes homework!)
  - Communication with another during an exam or assignment (i.e. written, oral or otherwise)
  - Giving or seeking aid from another when not permitted by the instructor
  - Possessing or using unauthorized materials during the test
  - Buying, using, stealing, transporting, or soliciting a test, draft of a test, or answer key
- Plagiarism
  - Using someone else's work in your assignment without appropriate acknowledgement
  - Making slight variations in the language and then failing to give credit to the source
- Collusion
  - Without authorization, collaborating with another when preparing an assignment

## **Safety Rules for ERB 121-127 and 132 Labs:**

---

### Scope:

- All UTA safety rules and regulations must be followed.
- These rules are in addition to UTA lab safety rules.
- In the event that a rule contained below is in conflict with UTA lab safety rules, the UTA safety rules shall supersede.

### General rules:

- Students can only be in the lab when a graduate teaching assistant (GTA), faculty member, or staff member is present.
- Students should be professional at all times in the lab.
- Food and drinks are not allowed in the lab at any time.
- When leaving the lab, all work surfaces and floors should be clear of breadboards, cables, wires, and tools prior to leaving.
- When leaving the bench, turn off all lab equipment and unplug soldering irons.
- When leaving the bench, make sure that all cables, tools, and soldering equipment are properly stored in the correct location.
- Please ensure that the lab is kept in a neat and tidy manner.
- Please pick up any loose wires or parts on the bench and floor before leaving the lab.
- Note any hazards observed in the lab to the TA, faculty, or staff member immediately.
- For test equipment incorporating multi-language menus, such as oscilloscopes, please return the language to English before leaving the bench.
- When returning parts that are not consumables, make certain that the parts are returned to the correct drawer. If you are not certain, please leave them with the GTA, faculty member, or staff member.
- Students should store backpacks and similar items in a way that does not create a trip hazard to others.

### Personal protective equipment (PPE):

- Safety glasses must be worn at all times when using the soldering irons or using cutting tools, such as diagonal cutters, in the lab.

### Soldering irons:

- Soldering must be performed in the labs only at the soldering benches.
- Soldering irons should be used with care, while wearing safety glasses, and only after receiving training.
- When soldering and removing parts, or reworking a board, please use special care to ensure that solder is not splattered.
- Soldering irons must be placed back in their soldering station holder when not soldering to prevent the chance of injury or fire.

- Please keep the soldering station sponges wet when cleaning the iron tip but ensure that water is not spilled on the floor creating a slip hazard.
- Use the soldering iron smoke absorber fan units when soldering. Use them in the horizontal position to prevent directing air flow across the table into the face of another user.
- Some solders can contain lead, so wash hands thoroughly after using the soldering irons. No eating or drinking is allowed in the lab, as previously stated.
- No self-contained butane soldering irons are permitted.

#### Hand tools:

- Hand tools must be used with care and only when safety glasses are being worn.
- Diagonal cutters in particular can create tension on the wires during the cutting process, ejecting the loose wire, so please use special care.

#### Small powered rotary tools:

- Short use of powered cutting tools such as “Dremel” or small drill/driver can only be used at the soldering tables using a backup board to prevent damage to the tables.
- Jewelry, necklaces, and lanyards should be removed.
- Long hair should be tied back to prevent being caught in the tool.
- For extended machining tasks, please use the designated Makerspace areas that are designed to handle the additional safety requirements and dust inhalation hazards instead.

#### Electrical hazards:

- The labs for these classes use voltages of 30V or less, but care must always be shown in using electrical circuits, regardless of the voltage.
- Do not use voltages of more than 30V unless approved in writing by the instructor.
- Do not modify the wiring or attempt repair of any lab equipment.
- Most of the lab equipment operates from 120V AC, which is a lethal voltage. Never pull on a cord to unplug it as this can cause damage to the strain relief and insulation, potentially resulting in exposed conductors.
- Please notify the GTA, faculty member, or staff member and stop using the equipment immediately if you see nicks or damage to a power cord.

#### Computers:

- Students should not install any software on the lab computers without approval of the GTA, faculty member, or staff member.
- Students should not remove any of the cables on the computer and the monitor on the bench.
- For external connection, an HDMI cable is provided at each workstation for configuring Raspberry Pi and similar computer hardware. This cable should not be disconnected from the monitor.

## Institution Information

---

UTA students are encouraged to review the below institutional policies and informational sections and reach out to the specific office with any questions. To view this institutional information, please visit the [Institutional Information](http://www.uta.edu/provost/administrative-forms/course-syllabus/index.php) page

(<http://www.uta.edu/provost/administrative-forms/course-syllabus/index.php>) which includes the following policies among others:

- Drop Policy
- Disability Accommodations
- Title IX Policy
- Academic Integrity
- Student Feedback Survey
- Final Exam Schedule

## Additional Information

---

### Face Covering Policy:

While the use of face coverings on campus is no longer mandatory, all students and instructional staff are strongly encouraged to wear face coverings while they are on campus. This is particularly true inside buildings and within classrooms and labs where social distancing is not possible due to limited space. If a student needs accommodations to ensure social distancing in the classroom due to being at high risk they are encouraged to work directly with the Student Access and Resource Center to assist in these accommodations. If students need masks, they may obtain them at the Central Library, the E.H. Hereford University Center's front desk or in their department.

### Attendance:

At The University of Texas at Arlington, taking attendance is not required but attendance is a critical indicator of student success. Each faculty member is free to develop his or her own methods of evaluating students' academic performance, which includes establishing course-specific policies on attendance. As the instructor of this section, However, while UT Arlington does not require instructors to take attendance in their courses, the U.S. Department of Education requires that the University have a mechanism in place to mark when Federal Student Aid recipients "begin attendance in a course." UT Arlington instructors will report when students begin attendance in a course as part of the final grading process. Specifically, when assigning a student a grade of F, faculty report must the last date a student attended their class based on evidence such as a test, participation in a class project or presentation, or an engagement online via Canvas. This date is reported to the Department of Education for federal financial aid recipients.

In this course, attendance in-class, on campus is expected.

### Emergency Exit Procedures:

Should we experience an emergency event that requires evacuation of the building, students should exit the room and move toward the nearest exit. When exiting the building during an emergency, do not take an elevator but use the stairwells instead. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist individuals with disabilities.

### Student Success Programs:

UT Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses. Resources include [tutoring by appointment](#), [drop-in tutoring](#), [etutoring](#), [supplemental instruction](#), [mentoring](#) (time management, study skills, etc.), [success coaching](#), [TRIO Student Support Services](#), and [student success workshops](#). For additional information, please email [resources@uta.edu](mailto:resources@uta.edu), or view the [Maverick Resources](#) website.

## Emergency Phone Numbers

---

In case of an on-campus emergency, call the UT Arlington Police Department at **817-272-3003** (non-campus phone), **2-3003** (campus phone). You may also dial 911. Non-emergency number 817-272-3381