

COURSE SYLLABUS
EEL 4745C: Microprocessor Applications 2
Fall 2022

INSTRUCTOR

Dr. Md Jahidul Islam

Email: jahid@ece.ufl.edu

Office Hours: Friday 4:00 PM - 5:30 PM. @ LAR 339D

CLASS SCHEDULE

<u>Lecture</u> : M,W,F Period 6 MAEA 0303 12:50 PM - 1:40 PM	<u>Laboratory</u> : please check ONE.UF for the schedules of your section
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TEACHING ASSISTANTS

- **Xuanhao Shi**. xshi1@ufl.edu. OH: M/W 10:40-11:30 AM at NEB 281/222.
- **Kevin D Mcgrath**. kevin.mcgrath@ufl.edu. OH: Tu/Th 12:50-1:40 PM at NEB 281/222.

⇒ They will add you to a Teams group where you can communicate forum questions

⇒ Come to OHs and/or please contact through the Teams or Canvas.

COURSE DESCRIPTION

Implementation of a Real-Time Operating System on an ARM Cortex M4 processor to create more robust and complex microprocessor applications. Introduction to IoT applications.

COURSE PREREQUISITES

- ⇒ EEL 4744C with minimum grade of C
- ⇒ Fluent in C and assembly programming.
- ⇒ Proficiency in Python programming.

COURSE OBJECTIVES

The primary objective is to understand the basic concepts of RTOS (Real-Time Operating System) and apply that knowledge by programming a microcontroller. Towards this goal, students will learn about the architecture of ARM cortex M4-based processors and program important RTOS components such as implementing threads and thread schedulers as well as handling inter-process communication and synchronization/mutual exclusion via semaphores. Students will also learn how to design embedded C software driver libraries for peripherals such as I2C RGB LEDs drivers and a resistive, pixel-based LCD touchscreen. In the later part of this course, students will learn to interface a single-board mini computer in an embedded Linux environment to create various AI/IoT applications. Students will also learn on-device AI and TinyML concepts - to eventually develop several embedded AI/IoT projects.

MAJOR HARDWARE

- TI Tiva C Series LaunchPad
- TI SENSOR Booster Pack
- TI BeagleBone Black Board
- IoT Development Board (with LEDs, LCD touch display and joystick)

SOFTWARE

- TI Code Composer Studio 11
- Beagle-Board firmware image
- Some relevant libraries and source code (will be provided in class)

RELATION TO PROGRAM OUTCOMES (ABET):

Outcome	Coverage
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	Medium
3. An ability to communicate effectively with a range of audiences	Low
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Low
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	High
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	High

TEXTBOOK

- Real-Time Operating Systems for ARM Cortex-M Microcontrollers (4th Edition) By Jonathan W Valvano. ISBN-13: 978-1466468863, ISBN-10: 1466468866. (pdf available online)

RECOMMENDED HARD/SOFT MATERIALS

- Beagle-Board CookBook. Available online at: <https://beagleboard.org/cookbook>.
- The Digilent Analog Discovery 2 (DAD) board. Available from the UF Bookstore; also available at DigiKey, Adafruit, and other companies. *If you already have one from previous uP1/DSP courses - that will do! (*not a must have)*

LAPTOP & OS

You must have a personal laptop to interface with the devices and show your assignment/project progress. Our lectures/materials are based on Windows; however, Mac/Linux should also work with the standard driver-level adjustments. *Some rare Linux distributions or newer Mac-M1 chips might have some compatibility issues; in such cases, feel free to use virtual OS environments!*

ATTENDANCE, EXCEPTIONS, & MAKE-UP POLICY

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Follow this link to read the university attendance policies:

<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

COURSE GRADE BREAKDOWN

Item	Points	% of Final Grade
Hands-on Laboratory (lab1 - lab4)	4 x 10	40
Hands-on Laboratory (lab5 - lab6)	2 x 7.5	15
Mid-term	1 x 15	15
Milestone Quizzes (q1 - q3)	3 x 05	15
Final exam / project option	1 x 15	15
Total		100

GRADING POLICY

Grades are periodically posted online; please check your grades regularly. All grades are final after one week since posting. More information on the general UF grading policy can be found here: <https://catalog.ufl.edu/UGRD/academic-regulations/grades-grading-policies/>.

Percent	Grade	Grade Points
90 or More	A	4.00
86.0 - 89.9	A-	3.67
82.0 - 85.9	B+	3.33
79.0 - 81.9	B	3.00
76.0 - 78.9	B-	2.67
73.0 - 75.9	C+	2.33
70.0 - 72.9	C	2.00
66.0 - 69.9	C-	1.67
63.0 - 65.9	D+	1.33
60.0 - 62.9	D	1.00
55.0 - 59.9	D-	0.67
Below 55	E	0.00

LABORATORY SCHEDULE

Lab	Topic	Lab Timeline
0	Part A: Introduction and setup Part B: Blinking TIVA C on-board LEDs	Week 1
1	Basic Interfacing, Linking, and Communication <ul style="list-style-type: none"> Part A: Interfacing LED drivers, I2C communication Part B: ARM assembly checksums with the LED driver Part C: Basic UART with LED driver and console I/O 	Week 1-2 Demo Due: Week 2
2	G8RTOS Scheduler and Synchronizers <ul style="list-style-type: none"> Part A: Setting up support packages, drivers, & OS structure Part B: Implementing threads, exception handlers & schedulers Part C: Implementing semaphores & peripheral controls Part D: Adding threads to control LEDs via sensor feedback Part E: Putting it all together! 	Week 3-5 Demo Due: Week 5 In-lab Quiz #1: Week 5
3	Periodic Threads and Queueing <ul style="list-style-type: none"> Part A: Implementing Blocking, yielding, and sleeping Part B: Integrating periodic threads with background threads Part C: Enabling inter-process communication with FIFOs 	Week 6-7 Demo Due: Week 7
Mid-term	Quick recap of lab1 - lab3. Mid-term review and discussions.	Week 8
4	Dynamic Threads and LCD Interfacing <ul style="list-style-type: none"> Part A: Interfacing a touchscreen color LCD Part B: Incorporating aperiodic/dynamic threads in RTOS 	Week 9-10 Demo Due: Week 10 In-lab Quiz #2: Week 10
5	Incorporating AIoT with RTOS <ul style="list-style-type: none"> Part A: Interfacing and communication with a BeagleBoard Part B: Remote process handling 	Week 11-12 Demo Due: Week 12
6	On-device AI; Project Options: <ul style="list-style-type: none"> Handwritten zip code recognition Face or audio keyword detection Two-player tic-tac-toe or Security camera feature integration <i>Students may propose other options</i> 	Week 13-14 Demo Due: Week 14 In-lab Quiz #3: Week 14
Final	Final exam / project showcase	Week 15

COURSE MATERIALS BREAKDOWN

Week	Detailed Topics	Reference
1	Course Introduction <ul style="list-style-type: none"> ARM Architecture and OS overview CCS overview; contents of lab0 and lab1 	Lecture 1 Book Chapter 1 DataSheet Chapter: 1, 2
2-3	Diving Deeper Into ARM Cortex M4 <ul style="list-style-type: none"> Instruction set and memory model Board support packages; LED driver interfacing Thumb2 instruction sets; unified assembly programming TIVA C series overview; contents of lab 1 and lab 2 	Lecture 2,3 Book Chapter: 1, 2.5 DataSheet Chapter: 3, 14, 16
4-6	RTOS Components <ul style="list-style-type: none"> Threads, interrupts, and schedulers Locks and semaphores Avoiding deadlocks <ul style="list-style-type: none"> Yielding, blocking, sleeping, etc. Periodic and dynamic threads Contents of lab 2 and lab 3 	Lecture 4,5 Book Chapter 3 DataSheet Chapter: 10
8	Mid-term Exam	
9-10	Advanced RTOS Concepts <ul style="list-style-type: none"> More on dynamic and periodic threads Inter-process communication Thread priority: FIFO, round-robin LCD touch display drivers; content of lab 4 Aperiodic Event Threads Networking Basics: OSI model; IPv4/IPv6 and TCP/UDP 	Lecture 6,7 Book Chapter 4, 5 Materials provided in class
11-13	Real-time on-device AI/AIoT Topics <ul style="list-style-type: none"> Embedded AI and on-device ML/vision concepts Running AI inference models on Beagle boards Integrating RTOS and AIOT Sample projects and implementation do/donts 	Lecture 8,9 Book Chapter 9, 10 Materials provided in class
14	Specific project-based contents; recap	Lecture 10
15	Final Exam / Project Showcase	

LABORATORY GUIDELINES**Timeliness and participation**

- Do NOT miss any lab! If you cannot make it for appropriate health concerns or absolutely unavoidable circumstances, inform me and we will follow UF guidelines to make arrangements accordingly. See important guidelines at: [UF campus brief](#), [health guidelines](#), [UF DSO services](#).
- Be present at the lab 5-10 minutes earlier, keep the lab worksheet/manual/soft materials with you.
- Lab deadlines are hard deadlines; if you cannot finish (part of) a lab, you will have to demo/show it at the beginning of the immediate next lab (with a **-10% adjustment**). No submission will be accepted after that because we will publish the solutions by then.
- The milestone quizzes will be **in-lab**: second half of the specific labs. TAs will ask you to implement something or demonstrate something relevant to test your in-depth uP2 skills.

Honesty and integrity

- Do NOT cheat yourself! No place for any form of plagiarism in this course ([see UF guidelines](#)).
- Seek help and collaborate with integrity. We are here to help, we will walk you through your code/errors and provide hints and suggestions toward completing your assignments.
- We trust you, and we'll make sure nobody gets unfair/dishonest advantage

Safety and care

- Do NOT put yourself and others in danger! Take soldering measures you learned in uP1 laboratories!
- If you are not sure, ask - we are here to help!
- Report anything that needs attention

STUDENTS REQUIRING ACCOMMODATIONS

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center; visit this link for the details: <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

COURSE EVALUATION

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Moreover, the summaries of course evaluation results will be available to students at this link: <https://gatorevals.aa.ufl.edu/public-results/>.

IN-CLASS RECORDING

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code & Student Conduct Code.

UNIVERSITY HONESTY POLICY

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “In my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Conduct Code listed in this link (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

COMMITMENT TO A SAFE & INCLUSIVE LEARNING ENVIRONMENT

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

SOFTWARE USE

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

STUDENT PRIVACY

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

CAMPUS RESOURCES

Covid-19 Protocols: [UF campus brief](#), [UF health guidelines](#)

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS): Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.
E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Connections Center, Reitz Union, 392-1601. <https://career.ufl.edu>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. <https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. <https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>;
<https://care.dso.ufl.edu>.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.