2020

Embedded Computing Systems Design

North Carolina Agricultural and Technical State University

NORTH CAROLINA AGRICULTURAL AND TECHNICAL STATE UNIVERSITY

COURSE SYLLABUS

College Name: College of Engineering

Department Name: Department of Electrical and Computer Engineering

Course Name: Embedded Computing Systems Design

COURSE INFORMATION

- Course Number/Section: ECEN 621
- Term:
- Semester Credit Hours: 3
- Times and Days:
- Class Location:

INSTRUCTOR CONTACT INFORMATION

- Instructor:
- Office Location:
- Office Phone:
- Email Address:

Faculty must notify students of the approximate time and method they can expect to receive an answer to all communications (e.g., email, phone, course messages). Excluding holidays, the response should be provided within 48 hours.

If there's a graduate teaching assistant assigned to work with this course, please include their names also.

STUDENT HOURS

These are times students may visit the professor without an appointment to request the assistance they need.

NOTE: Students are responsible for reading, understanding, and following the syllabus.

: AM ☐ / PM ☐ – : AM ☐ / PM ☐

Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☐

COURSE PREREQUISITES

None

COURSE DESCRIPTION

This course is a study of Embedded Computing System (a.k.a Embedded System) Design, which is the design of microprocessor-based, application specific systems. A popular contemporary high-level language is used for the majority of the software development, with some use of assembly language as well. An integrated development environment (IDE) popular in industry, along with a compatible hardware evaluation board, are utilized for practical experience. The core of the course material is organized using a data access hierarchy perspective. Other embedded computing topics covered include hardware/software co-design and debugging, real-time systems, digital/analog interfacing, low power modes, and firmware.

STUDENT LEARNING OBJECTIVES/OUTCOMES (SLO)

Learning outcomes should be specific, measurable, and focused on the content knowledge the students are expected to master and not what the faculty will teach.

If the course is a General Education Course, the SLO should be listed and labeled as "General Education."

SLO 1: Discuss the relevance of embedded systems in modern society
SLO 2: Program a microcontroller using both C and Assembly language with contemporary hw and IDE tools.
SLO 3: Utilize parallel ports on the MSP432 microcontroller
SLO 4: Use standard graphical languages to assist in development embedded systems.
SLO 5: Incorporate synchronous event handling into practical ES applications.
SLO 6: Schedule multiple periodic tasks of varying rates to run on a single processor.
SLO 7: Employ speed, power, and memory optimization techniques in developing practical embedded systems.
SLO 8: Incorporate asynchronous event handling into practical ES applications.
SLO 9: Implement a complex digital system with a combination of hardware and software components.
SLO 10: Utilize the Analog interface peripherals of an MCU in practical applications.
SLO 11: Schedule multiple periodic and non-periodic task to run on a single processors.
SLO 12: Utilize serial ports on the MSP432 microcontroller for practical applications.
SLO 13: Develop embedded systems applications using a real-time operating system (RTOS).
SLO 14: Develop practical Internet of Things (IoT)-related embedded system applications.

REQUIRED TEXTBOOKS AND MATERIALS

Any course-level subscriptions and tools linked in Blackboard Learn learning management system (LMS) should be listed here. The Blackboard LMS must have links to their student data privacy statement.

REQUIRED TEXTS:

Frank Vahid, Tony Givargis, Bailey Miller, (2016), *Programming in Embedded Systems,* zyBooks

REQUIRED MATERIALS:

SUGGESTED COURSE MATERIALS

SUGGESTED READINGS/TEXTS:

Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2017). *Programmable Microcontrollers: Applications on the MSP432 LaunchPad*. McGraw Hill Professional.

SUGGESTED MATERIALS:

GRADING POLICY

ASSIGNMENTS AND GRADING POLICY

94% and above	A		76% - 74%	C
93% - 90%	A-		73% - 70%	C-
89% - 87%	B+		69% - 67%	D+
86% - 84%	B		66% - 64%	D
83% - 80%	B-		63% - 0%	F
79% - 77%	C+			

For GRADUATE COURSES: See 2019-2020 Graduate Catalog p.38 for graduate grading scale and Non-Graded Courses

GRADING ALLOCATION

Course grades are based on a weighted grading scale of 100%. The breakdown for the course is as follows: *[Faculty, please adjust according to your course.]*

Category	# of Activities	Percentage Grade Weight
Discussion Boards	8	5%
Blackboard Live Sessions	15	3%
Homework	7	15%
Quizzes	7	15%
Exams	3	27%
Presentation	4	10%
Final Project Report	1	15%
Final Exam (based on Project)	1	10%
Total	**46**	**100%**

COURSE POLICIES

USE OF BLACKBOARD AS THE LEARNING MANAGEMENT SYSTEM

Blackboard is the primary online instructional and course communications platform. Students can access the course syllabus, assignments, grades, and learner support resources. Students are encouraged to protect their login credentials, complete a Blackboard orientation, and log in daily to the course.

Note: Uploading assignments through Blackboard presents a challenge for Chromebook users in locating the files for submission. If you use a Chromebook, please be sure you also have access to a Mac computer or Windows computer so you can fully participate in your Blackboard class. For more information about student computer recommendations, please visit https://hub.ncat.edu/administration/its/computer-recommendations.php.

MAKE-UP EXAMS

See << Update Academic Year >>*Undergraduate Bulletin:*

https://www.ncat.edu/provost/academic-affairs/bulletins/index.php

For GRADUATE STUDENTS: See 2019-20 Graduate Catalog p. 54

EXTRA CREDIT

LATE WORK

SPECIAL ASSIGNMENTS

For GRADUATE STUDENTS: FAILING TO MEET COURSE REQUIREMENTS (Graduate Catalog p.40)

For GRADUATE STUDENTS: CLASS ATTENDANCE (see 2019-20 Graduate Catalog p. 53-54)

Students are expected to attend class and participate on a regular basis in order to successfully achieve course learning outcomes and meet federal financial aid requirements (34 CFR 668.22). Class attendance in online courses is defined as active participation in academically-related course activities. Active participation may consist of course interactions with the content, classmates, and/or the instructor. Examples of academically-related course activities include, but are not limited to:

- Completing and submitting assignments, quizzes, exams, and other activities within Blackboard or through Blackboard (3rd-party products).
- Participating in course-related synchronous online chats, discussions, or meeting platforms such as Blackboard Collaborate in which participation is tracked.

CLASSROOM CITIZENSHIP

Courtesy, civility, and respect must be the hallmark of your interactions.

COMPLIANCE WITH THE AMERICANS WITH DISABILITIES ACT

North Carolina A&T State University is committed to following the requirements of the Americans with Disabilities Act Amendments Act (ADAAA) and Section 504 of the Rehabilitation Act.
If you need an academic accommodation based on the impact of a disability, you must initiate the request with the Office of Accessibility Resources (OARS) and provide documentation in accordance with the Documentation Guidelines at N.C. A&T. Once documentation is received, it will be reviewed. Once approved, you must attend a comprehensive meeting to receive appropriate and reasonable accommodations. If you are a student registered with OARS, you must complete the Accommodation Request Form to have accommodations sent to faculty.

OARS is located in Murphy Hall, Suite 01 and can be reached at 336-334-7765, or by email at accessibilityresources@ncat.edu. Additional information and forms can be found on the internet at https://www.ncat.edu/provost/academic-affairs/accessibility-resources/index.php.

Please note: Accommodations are not retroactive and begin once the Disability Verification Form is provided to faculty.

TITLE IX

North Carolina A&T State University is committed to providing a safe learning environment for all students—free of all forms of discrimination and harassment. Sexual misconduct and relationship violence in any form are inconsistent with the university's mission and core values, violates university policies, and may also violate federal and state law. Faculty members are considered "Responsible Employees" and are required to report incidents of sexual misconduct and relationship violence to the Title IX Coordinator. If you or someone you know has been impacted by sexual harassment, sexual assault, dating or domestic violence, or stalking, please visit the Title IX website to access information about university support and resources. If you would like to speak with someone confidentially, please contact Counseling Services at 336-334-7727 or the Student Health Center at 336-334-7880.

TECHNICAL SUPPORT

If you experience any problems with your A&T account, you may call Client Technology Services (formerly Aggie Tech Support and Help Desk) at 336-334-7195, or visit https://hub.ncat.edu/administration/its/dept/ats/index.php.

FIELD TRIP POLICIES / OFF-CAMPUS INSTRUCTION AND COURSE ACTIVITIES

If applicable:

Off-campus, out-of-state, foreign instruction, and activities are subject to state law and university policies and procedures regarding travel and risk-related activities. Information regarding these rules and regulations may be found at https://www.ncat.edu/campus-life/student-affairs/index.php.

STUDENT HANDBOOK

https://www.ncat.edu/campus-life/student-affairs/departments/dean-of-students/student-handbook.php

STUDENT TRAVEL PROCEDURES AND STUDENT TRAVEL ACTIVITY WAIVER

https://hub.ncat.edu/administration/student-affairs/staff-resources/studen_activity_travel_waiver.pdf

OTHER POLICIES *(e.g., Copyright Guidelines, Confidentiality, etc.)*

STUDENT HANDBOOK

https://www.ncat.edu/campus-life/student-affairs/departments/dean-of-students/student-handbook.php

Graduate Catalog

SEXUAL MISCONDUCT POLICY

https://www.ncat.edu/legal/title-ix/sexual-harassment-and-misconduct-policies/index.php

FAMILY EDUCATIONAL RIGHTS AND PRIVACY ACT (FERPA)

https://www.ncat.edu/registrar/ferpa.php

STUDENT COMPLAINT PROCEDURES

https://www.ncat.edu/current-students/student-complaint-form.php

STUDENT CONDUCT AND DISCIPLINE

North Carolina A&T State University has rules and regulations that govern student conduct and discipline meant to ensure the orderly and efficient conduct of the educational enterprise. It is the responsibility of each student to be knowledgeable about these rules and regulations.

Please consult the following about specific policies such as academic dishonesty, cell phones, change of grade, disability services, disruptive behavior, general class attendance, grade appeal, incomplete grades, make-up work, student grievance procedures, withdrawal, etc.:

- Undergraduate Bulletin
  https://www.ncat.edu/provost/academic-affairs/bulletins/index.php
- Graduate Catalog
  https://www.ncat.edu/tgc/graduate-catalog/index.php
- Student Handbook
  https://www.ncat.edu/campus-life/student-affairs/departments/dean-of-students/student-handbook.php

ACADEMIC DISHONESTY POLICY

Academic dishonesty includes but is not limited to the following:

1. Cheating or knowingly assisting another student in committing an act of cheating or other academic dishonesty;
2. Plagiarism (unauthorized use of another's words or ideas as one's own), which includes but is not limited to submitting exams, theses, reports, drawings, laboratory notes or other materials as one's own work when such work has been prepared by or copied from another person;
3. Unauthorized possession of exams or reserved library materials; destroying or hiding source, library or laboratory materials or experiments or any other similar actions;
4. Unauthorized changing of grades, or marking on an exam or in an instructor's grade book or such change of any grade record;
5. Aiding or abetting in the infraction of any of the provisions anticipated under the general standards of student conduct;
6. Hacking into a computer and gaining access to a test or answer key prior to the test being given. N.C. A&T reserves the right to search the emails and computers of any student suspected of such computer hacking (if a police report of the suspected hacking was submitted prior to the search); and
7. Assisting another student in violating any of the above rules.

A student who has committed an act of academic dishonesty has failed to meet a basic requirement of satisfactory academic performance. Thus, academic dishonesty is not only a basis

for disciplinary action, but may also affect the evaluation of a student's level of performance. Any student who commits an act of academic dishonesty is subject to disciplinary action.

In instances where a student has clearly been identified as having committed an act of academic dishonesty, an instructor may take appropriate disciplinary action, including loss of credit for an assignment, exam, or project; or awarding a grade of "F" for the course, **subject to review and endorsement by the chairperson and dean**.

For GRADUATE STUDENTS: Reference for academic dishonesty – 2010-2020 Graduate Catalog, p.58-59

For GRADUATE STUDENTS: STUDENT RELIGIOUS OBSERVANCE (see Graduate Catalog, p.55)

ASSIGNMENTS AND ACADEMIC CALENDAR

Include topics, reading assignments, due dates, exam dates, withdrawal dates, pre-registration and registration dates, all holidays, and convocations.*

THE WEEK OF MM/DD/YY	SUBJECT	UNIT LEARNING OUTCOMES (ULO)	READING IN TEXT, ACTIVITY, HOMEWORK, EXAM
	Unit 1 : Introduction to Embedded Systems Concepts	ULO 1: Identify several everyday products that are classified as embedded systems. (SLO 1) ULO 2: Discuss the advantages of using embedded system designs as compared to using fully custom or fully general-purpose systems. (SLO 1) ULO 3: Describe several different types of memory used by a microcontroller. (SLO 1) ULO 4: Discuss several computer engineering job categories that rely on embedded systems knowledge. (SLO 1)	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Chapter 1: Introduction to Embedded Programming 2) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 1: Introduction b) Chapter 2: Code Composer Studio and Energia 3) **Complete:** Discussion Board #1 (ULO 1-4)
	Unit 2 : Embedded Systems HW/SW Development Tools	ULO 1: Program embedded systems in C language. (SLO 2)	1) **Read Textbook: :** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in*

		ULO 2: Discuss the background of the MSP432 family of microcontrollers. (SLO 2) ULO 3: Utilize desktop and cloud-based IDE tools for developing embedded systems (IoT). (SLO 2) ULO 4: Utilize the serial monitor of the monitor for debugging. (SLO 2) ULO 5: Express feeling/thinking in text output. (SLO 2)	*embedded systems.* zyBooks. a) Chapter 1: Introduction to Embedded Programming 2) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 1: Introduction b) Chapter 2: Code Composer Studio and Energia 3) **Complete:** Homework #1 (ULO 1-5) 4) **Complete:** Quiz #1 (ULO 1-5)
	Unit 3 : Practical Parallel I/O in Embedded Systems	ULO 1: Write simple programs using switches and LEDs on the MSP432. (SLO 3) ULO 2: Handle switch bounce for push-button input. (SLO 3) ULO 3: Configure port data directions on the MSP432. (SLO 3) ULO 4: Configure port pull-up and pull-down resistors on the MSP432. (SLO 3)	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Chapter 3: State Machines 2) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 5: Digital Input and Output 3) **Complete:** Discussion Board #2 (ULO 1-4)
	Unit 4 : Modeling and Programming Embedded Systems	ULO 1: Explain and utilize a systematic process for modeling embedded systems. (SLO 4) ULO 2: Utilize UML activity diagrams to model embedded systems	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Chapter 3: State Machines 2) **Read Textbook:**Recommended

		software. (SLO 4) ULO 3: Utilize finite state machines to model embedded systems software. (SLO 4) ULO 4: Implement state machines in C language for embedded systems. (SLO 4)	Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 5: Digital Input and Output 3) **Complete:** Homework #2 (ULO 1-4) 4) **Complete:** Quiz #2 (ULO 1-4)
	Unit 5 : Periodic Event Handling for ES	ULO 1: Utilize the interrupt capability of the MSP432 microcontroller for practical ES system design. (SLO 5) ULO 2: Utilize the timer modules on the MSP432 microcontroller for practical ES system design. (SLO 5) ULO 3: Expressing and analyzing interactivity in text (based on button input frequency). (SLO 5)	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Section 4.5: Microcontrollers with timers 2) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 6: Exceptions and Interrupts.Chapter b) 7: Power Management and Timing Operations (Section 7.5) 3) **Complete:** Discussion Board #3 (ULO 1-3) 4) **Complete:** Exam #1 (ULO 1-3)
	Unit 6 : Basic Scheduling of Periodic Tasks: Cyclic Executive	ULO 1: Implement multiple computing threads modeled as FSMs on a single processor concurrently. (SLO 6) ULO 2: Enable communication between computing threads using shared variable. (SLO 6)	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Chapter 4: Synchronous SMs b) Chapter 5: Concurrent SynchSMs 2) **Complete:** Homework #3 (ULO 1-3)

		ULO 3: Enable communication between computing threads using messaging queues. (SLO 6)	3) **Complete:** Quiz #3 (ULO 1-3)
	Unit 7 : Analysis and Optimization for Embedded Systems	ULO 1: Analyze and Optimize code to improve speed. (SLO 7) ULO 2: Analyze and Optimize code to improve power consumption. (SLO 7) ULO 3: Analyze and Optimize code to improve memory utilization. (SLO 7)	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Section 9.1 thru 9.32. 2) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 6: Exceptions and Interrupts. 3) **Complete:** Discussion Board #4 (ULO 1-3)
	Unit 8 : Advanced Digital I/O and Asynchronous Event-Handling for ES	ULO 1: Utilize parallel port interrupt capability on the MSP432 microcontroller for asynchronous event handling. (SLO 8) ULO 2: Utitlize processor low-power states. (SLO 8) ULO 3: Utilize parallel port high drive capability on the MSP432 microcontroller for practical ES system design. (SLO 8)	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Section 9.1 thru 9.3 2) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 6: Exceptions and Interrupts. 3) **Complete:** Homework #4 (ULO 1-3) 4) **Complete:** Quiz #4 (ULO 1-3)
	Unit 9: Programmable Hardware in Embedded	ULO 1: Discuss the usage of fully programmable HW (FPGA's) in embedded systems.	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks.

	Systems	(SLO 9) ULO 2: Utilize the embedded systems design process to decide how to partition a design between hardware and software. (SLO 9) ULO 3: Describe various types of reconfigurable hardware included on microcontrollers. (SLO 9)	a) Section 14.1 thru 14.4 2) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Sections 1.2.3 thru Sections 1.2.7 3) **Complete:** Exam #2 (ULO 1-3) 4) **Complete:** Discussion Board #5 (ULO 1-3)
	Unit 10- Analog I/O for Embedded Systems	ULO 1: Utilize the ATD converter on the MSP432 microcontroller for practical ES design. (SLO 10) ULO 2: Utilize timing hardware on the MSP432 microcontroller for practical ES design. (SLO 10) ULO 3: Express the A/D and D/A conversion FSM. (SLO 10) ULO 4: Utilize the MSP432 launchpad and MKII to demonstrate audio and visual interaction for the microcontroller. (SLO 10)	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Section 7.1 and 7.3 2) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 8: Mixed Signal Systems 3) **Complete:** Homework #5 (ULO 1-4) 4) **Complete:** Quiz #5 (ULO 1-4)
	Unit 11: Intermediate Scheduling and Analysis	ULO 1: Calculate process utilization. (SLO 11) ULO 2: Implement a preemptive task scheduler. (SLO 11)	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Chapter 10:

		ULO 3: Calculate worst-case complexity. (SLO 11)	Utilization/Scheduling 2) **Complete:** Discussion Board #6 (ULO 1-3)
	Unit 12: Serial Communication for Embedded Systems	ULO 1: Utilize synchronous serial communication interface peripherals of an MCU for practical ES design. (SLO 12) ULO 2: Utilize asynchronous serial communication interface peripherals of an MCU for practical ES design. (SLO 12) ULO 3: Express operation of a standard serial communication protocols as FSMs. (SLO 12) ULO 4: Utilize the MSP432 launchpad and MKII to communicate audio and visual interactions between microcontroller. (SLO 12)	1) **Read Textbook:** Vahid, F., Givargis, T., & Miller, B. (2016). *Programming in embedded systems.* zyBooks. a) Section 7.2 2) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 9 Digital Communication 3) **Complete:** Homework #6 (ULO 1-4) 4) **Complete:** Quiz #6 (ULO 1-4)
	Unit 13: Real-time Operating Systems	ULO 1: Utilize a real-time operating system for implementing practical multithreaded system embedded systems. (SLO 13) ULO 2: Analyze performance of an ES using RTOS software tools. (SLO 13) ULO 3: Explain the characteristics of hard real-time, soft real-time, and safety-critical real-time environments. (SLO 13) ULO 4: Discuss tradeoffs	1) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 13: Real-time Operating System 2) **Complete:** Exam #3 (ULO 1-3) 3) **Complete:** Discussion Board #7 (ULO 1-3)

		among various RTOS options. (SLO 13)	4) **Complete:** Final Project (ULO 1-4)
	Unit 14: Internet of Things (IoT) Applications Embedded Systems	ULO 1: Describe the role of embedded systems in the 'Internet of Things'. (SLO 14) ULO 2: Implement an embedded system application which utilizes short-range wireless communication, such as Bluetooth. (SLO 14) ULO 3: Implement an embedded system applicationwhich utilizes long-range wireless communication, such as WiFi. (SLO 14)	1) **Read Textbook:** Recommended Textbook: Unsalan, C., Gurhan, H. D., & Yucel, M. E. (2018). *Programmable microcontrollers: Applications on the MSP432 LaunchPad*. McGraw-Hill. a) Chapter 10: Wireless Communication 2) **Complete:** Homework #7 (ULO 1-3) 3) **Complete:** Quiz #7 (ULO 1-3)
	Unit 15: Embedded Systems Project	ULO 1: Demonstrate the ability to design and implementa practical IoT-based embedded systems project. (SLO 14) ULO 2: Document the development and results of an embedded systems project. (SLO 14) ULO 3: Orally present the development and results of an embedded systems project. (SLO 14)	1) **Complete:** Final Project (ULO N/A)

** These descriptions and timelines are subject to change at the discretion of the instructor.*