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ECE 245: Microcontroller Applications with Internet of Things (IoT)
Fall Semester 2022

Course Description:
This course aims to introduce microcontrollers through theoretical and laboratory experiments along with projects and exams designed to introduce the concepts of microcontrollers at the system and sub-system level. Students will gain hands-on experience for assembling and testing devices which incorporate hardware such as sensors and actuators as well as software to program the microcontrollers. Students will learn how to achieve node to client communication, node to node communication, and peer to cloud communication through laboratory experiments and projects based on usage of microcontrollers.

Credit Hours: 3
Pre-requisites: ECE 111 (Introduction to C and C++ Programming) or Approval of the ECE Chair.

Course Outcomes:
1. Demonstrate an understanding of devices with microcontrollers.
2. Demonstrate microcontroller programming skills.
3. Demonstrate how to program, analyze, and test devices with microcontrollers.
4. Understand the appropriate security/privacy solutions for devices with microcontrollers.

Course Outline:

Theme	Session Number
Course Overview: Microcontrollers and IoT	1-3
Microcontrollers and Data Communication: SPI, UART, and UDP	4-6
	7-8
	9-10
	11-13
Midterm Exam	14-15
Microcontrollers and Encrypted Communication	16-17
Microcontrollers and Web-Server	18-19
IoT Data, Microcontrollers, and Cloud Computing	20-21
	22-23
Final Exam	24-28

Course Assessment Methods:

Assessment Methods	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Assignments	X	X	X	X
Examinations	X	X	X	X

1. Assignments:
The theoretical and laboratory assignments will test the knowledge and understanding of concepts related to microcontrollers and the IoT. The laboratory experiments will specify the requirements of the hardware implementation and the use of software tools to aid the design. Documentation of the design outcomes and demonstration of the design is required. The expected laboratory experiments are according to the following:

- Theoretical Assignment 1: Introduction to Microprocessors and Microcontrollers.
- Laboratory Assignment 1: Learning the Arduino Microcontroller.
- Laboratory Assignment 2: Communication with Xbee Wireless Modules.
- Laboratory Assignment 3: Communication with LoRa Packet Radios.
- Laboratory Assignment 4: Bluetooth Audio Transmission.
- Laboratory Assignment 5: Encrypted Communication with LoRa.

2. Exams:
The exam exercises will test the knowledge and concepts related to microcontrollers and the IoT.

Course Textbooks:
1. Computer Organization and Design: The Hardware and Software Interface, by David A. Patterson and John L. Hennessy, Fifth edition, Elsevier, ISBN: 978-0-12-407726-3, 2014.
2. Programming 32-bit Microcontrollers in C: Exploring the PIC32, by Lucio Di Jasio, Elsevier, ISBN: 978-0-7506-8709-6, 2008.

Course Laboratory Experiments: The Laboratory Manual - Introduction to IoT with microcontrollers, Steven Rowland, and Michael Eckels, ECE Dept., Gannon University, Erie, PA.

Course Policies:

- Integrity: Cheating in any form will not be tolerated. Willfully misrepresenting your work in this class may result in an "F" grade for the course. Please refer to the *Gannon University Code of Academic Integrity*.
- Testing: The test procedure will be announced prior to the examinations. Anyone violating the testing procedure will be dropped from class.
- Attendance: Three inadequately excused absences from class will result in a grade of **F.**
- Submission: Homework assignments are due before the class time of the due date. No late homework assignments will be accepted.
- Participation: Active participation in course meetings is expected of all students.
- Individual Assignments: Students are encouraged to discuss course topics and homework assignments with each other. However duplicate assignments are not allowed. All submissions must represent your own work.
- Group Assignments: Some of the work of this class may include the development of a group assignment. The work submitted must represent the work of the team.
- Resubmission of Key Assignments: Students may elect to resubmit *key assignments* that have already been graded. To resubmit a key assignment, the original graded assignment and the resubmission must be submitted together. Resubmissions may only receive 90% of the maximum grade allowable on the first submission. Assignments can only be resubmitted once. All assignments must be resubmitted prior to the final examination.
- Cell Phone**:** Use of a cellular phone for texting and/or voice calls is not allowed during the class time. All cell phones must be turned off or put in a silent mode of operation during the class time.

Grading Policy:
Course Outcomes Assessment Criteria: The course outcomes and the corresponding student outcomes are assessed by the construction of the **EAMU** vectors - Excellent (**E**), Adequate (**A**), Minimal (**M**), and Unsatisfactory (**U**). The construction of the EAMU vectors used for course assessment applies the following scoring in all cases and based on the **Accreditation Board for Engineering and Technology, Inc.** (**ABET**) criteria for accrediting engineering programs [Ref. 1]: **Excellent** (E) is scoring 90 or better of the total points possible, **Adequate** (A) is 75 or better, **Minimal** (M) is 60 or better, and **Unsatisfactory** (U) is anything below 60. The **PI** is an abbreviation for Performance Indicator and **SO** is an abbreviation for **Student Outcomes** in the following:

1. Demonstrate an understanding of devices with microcontrollers.
a. ECE: PI_1_4: *Analyze and design systems containing hardware and software components.*

Key Assignment: Laboratory Assignment 1.

Justification: Laboratory Assignment 1 requires the student to understand the use of the microcontroller in data collection using analog and digital temperature sensors. Lab Assignment 1 measures the ability to analyze and design systems containing hardware and software components (PI_1_4) and the ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (**SO_1**).

b. CYENG: PI_4_2: *Understand proper use of technology, its application, and potential consequences on legal, regulatory, privacy, and human behavior topics as part of the solution*.

Key Assignment: Laboratory Assignment 1.
Justification: Laboratory Assignment 1 requires the student to explain the role of the microcontroller in technological development, recognize the proper use of the microcontroller, and potential consequences on legal, regulatory, privacy, and human behavior topics as part of the solution (PI_4_2). Laboratory Assignment 1 measures the 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 (**SO_4**).

2. Demonstrate microcontroller programming skills.
a. ECE: PI_1_4: *Analyze and design systems containing hardware and software components*.

Key Assignment: Laboratory Assignment 2.
Justification: Laboratory Assignment 2 requires the student to (a) set up node-client communication, and (b) transmit the state of a sensor from the node to the client. Laboratory Assignment 2 measures the ability to analyze and design systems containing hardware and software components (PI_1_4), and the ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (**SO_1**).

b. CYENG: PI_1_4: *Select and implement the desirable solution and evaluate the results*.

Key Assignment: Laboratory Assignment 2.
Justification: Laboratory Assignment 2 requires the student to (a) set up node-client communication, and (b) transmit the state of a sensor from the node to the client. Laboratory Assignment 2 measures the ability to select and implement the desirable solution and evaluate the results (PI_1_4), and the ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (**SO_1**).

3. Demonstrate how to program, analyze, and test devices with microcontrollers.
a. ECE: PI_6_1: *Design and set up experiments to validate a given set of requirements*.

Key Assignment: Laboratory Assignment 3: Communication with LoRa Packet Radios - Sections 3.1.1, 3.2.1, and 3.3.1.
Justification: Laboratory Assignment 3 requires the student to implement secure peer to cloud data communication and evaluate the results. Lab experiment 3 measures the ability to design and set up experiments to validate a given set of requirements (PI_6_1). Therefore, Laboratory Assignment 3 measures the ability to develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions (**SO_6**).

b. CYENG:
PI_6_1: *Design and set up experiments to validate a given set of requirements*.

Key Assignment: Laboratory Assignment 3: Communication with LoRa Packet Radios - Sections 3.1.1, 3.2.1, and 3.3.1.

PI_6_2: *Conduct experiments, detect faults, troubleshoot, and perform measurements for analysis*.

Key Assignment: Laboratory Assignment 3: Communication with LoRa Packet Radios - Sections 3.1.2, 3.1.3, 3.2.2, 3.2.3, 3.3.2, and 3.3.3.

PI_6_3: *Analyze data and interpret results to draw conclusions.*

Key Assignment: Laboratory Assignment 3: Communication with LoRa Packet Radios - Section 4.

Justification: Laboratory Assignment 3 requires the student to implement secure peer to cloud data communication and evaluate the results. Lab experiment 3 measures the ability to design and set up experiments to validate a given set of requirements (PI_6_1), conduct the experiment, detect faults, troubleshoot, and perform measurements for analysis (PI_6_2), analyze data and interpret results to draw conclusions (PI_6_3). Therefore, Laboratory Assignment 3 measures the ability to develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions (**SO_6**).

4. Understand the appropriate security/privacy solutions for devices with microcontrollers.
a. ECE: PI_2_3: *Implement the designed solution to meet the specifications.*

Key Assignment: Laboratory Assignment 5.
Justification: Lab experiment 5 requires the student to design the microcontroller-based system which implements the designed solution to meet the specifications (PI_2_3). Laboratory Assignment 5 measures the 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 (**SO_2**).

b. CYENG: PI_4_2: *Understand proper use of technology, its application, and potential consequences on legal, regulatory, privacy, and human behavior topics as part of the solution*.

Key Assignment: Laboratory Assignment 5.
Justification: Lab experiment 5 requires the student to design the microcontroller-based system thereby understanding proper use of technology, its application, and potential consequences on legal, regulatory, privacy, and human behavior topics as part of the solution (PI_4_2). Laboratory Assignment 5 measures the 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 (**SO_4**).

Grading:
The following is the overall grading for the class.
- Exams: 60%
- Assignments: 40%

Letter Grade	Percentage
A+	100-97
A	96-90
A-	89-88
B+	87-85
B	84-80
B-	79-78
C+	77-75
C	74-70
C-	69-67
D	66-60
F	59 or Below

Relationship of Objective Evidence to ECE Performance Indicator, Student Outcome and Course Outcome:

Performance Indicator Met (Student Outcome)	Course Outcome	Objective Evidence
Analyze and design systems containing hardware and software components (**SO_1**)	1, 2	Lab. Assignment 1, Lab. Assignment 2
Design and set up experiments to validate a given set of requirements (**SO_6**)	3	Lab. Assignment 3 - Sections 3.1.1, 3.2.1, and 3.3.1
Implement the designed solution to meet the specifications (**SO_2**)	4	Lab. Assignment 5

Relationship of Objective Evidence to CYENG Performance Indicator, Student Outcome, and Course Outcome:

Performance Indicator Met (Student Outcome)	Course Outcome	Objective Evidence
Understand proper use of technology, its application, and potential consequences on legal, regulatory, privacy, and human behavior topics as part of the solution (**SO_4**)	1, 4	Lab. Assignment 1, Lab. Assignment 5
Select and implement the desirable solution and evaluate the results (**SO_1**)	2	Lab. Assignment 2
Design and set up experiments to validate a given set of requirements (**SO_6**)	3	Lab. Assignment 3 - Sections 3.1.1, 3.2.1, and 3.3.1
Conduct experiments, detect faults, troubleshoot, and perform measurements for analysis (**SO_6**)	3	Lab. Assignment 3 - Sections 3.1.2, 3.1.3, 3.2.2, 3.2.3, 3.3.1, and 3.3.3
Analyze data and interpret results to validate which requirements are met (**SO_6**)	3	Lab. Assignment 3 - Section 4

Accessibility Support Services:
The University will make reasonable accommodations for students with disabilities in compliance with Section 504 of the Rehabilitation Act and the Americans with Disabilities Act. The purpose of accommodations is to provide equal access to educational opportunities for eligible students with academic and/or physical disabilities. Gannon students who require accommodations due to a documented diagnosed physical, emotional or learning disability should contact Gannon's Office of Disability Services at extension 5522 or find more information at: https://mygannon.edu/studentresources/studentsuccesscenter/disabilitysupportservices/Page/default.aspx

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