FORMAN CHRISTIAN COLLEGE UNIVERSITY
CSCS306: Embedded Systems (2+2 Credit Hrs)
Course Outline and Lesson Plan

Instructor Information:
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Pre Requisites:

- Digital Logic Design
- Programming I
- Programming II
- Web Development (optional)
- Mobile Development (Optional)

Course Material:

1. Lecture Slides
2. Lab/Class Activity Handouts
3. Class Handouts
4. Reading Assignments
5. Video Lectures

Reference Books:

No **text book** for this course.
Students will be assigned reading material in the form of handouts / web links.

Programming Languages

- C / C++
- Java / App Inventor A2I (mobile application)
- Python
- HTML-5
- PHP
- JSON

Course Objectives:

The objective of this course is

- To emphasize on comprehensive treatment of embedded hardware using microcontrollers like Arduino UNO, ESP32, ARM Cortex M4 and PIC.
- To enable students to understand how to program different microcontrollers.
- To make students understand how to interface different sensors with microcontrollers.
- To make students learn different concepts of RTOS.
- To make students understand different ML algorithms and apply the knowledge to design intelligent embedded systems.

Course Learning Outcomes (CLOs)

CLO's	Description	Level
CLO:1	Describe the architecture, and functions of different components of a microcontroller	C1 (Remember)
CLO:2	Describe how an embedded program gets executed on a microcontroller and how to interface various sensors and actuators to a microcontroller.	C2 (Understand)
CLO:3	Interface hardware and write embedded software for the hardware.	C3 (Apply)
CLO:4	Design and implement different aspects of multi-threaded program on an embedded device. Apply different ML algorithms on edge devices.	C3 (Apply)
CLO:5	Integrate different concepts learnt and apply these to design and create a working model of the problem in hand.	C3 (Apply)
CLO:6	Differentiate, compare and analyze results of different software/hardware for a specific problem,	C4 (Analyze)

Mapping of CLO's to PLO's

PLOs	CLO:1	CLO:2	CLO:3	CLO:4	CLO:5	CLO:6
Computing Knowledge	√	√	√			
Problem Analysis				√	√	√
Design and development of solutions				√	√	
Investigation						√
Modern Tool Usage		√	√	√		

Week	Theory Session (1 Hr 50 Min)	Lab Session (1 Hr 50 Min)
1	Introduction to the course. Basics of Electronics (Optional) **The Arduino** • Pin out of an Arduino UNO board. • C for Arduino	**C for Arduino**
2	**The Arduino (cont …)** • C for Arduino • Digital IO and PWM for Arduino. • Interfacing LEDs and 7-segment displays with an Arduino	**Quiz 1** **Lab 1**
3	**The Arduino (cont …)** • Switch interface with Arduino • Key pad interface • Playing with analog sensors (LDR, LM35DZ).	**Lab 2**
4	**Sensors / Actuators** • LCD • Controlling DC and Servo motors • Using H-bridge IC.	**Lab 3**
5	**Sensors / Actuators** • Servo Motors and Joy stick interface • Enhancing IO functionality of a microcontroller with a shift register • Creating custom libraries in Arduino	**Quiz 2** **Lab 4** **Programming Assignment 1 Uploaded**
6	**Sensors / Actuators** • The I2C (Inter Integrated Circuit) bus interface. • The PIR motion sensor • The Blue tooth module.	**Lab 5**
7	**Arduino and timers** • Timers types • Timers registers • Implementing timers to create precise delays.	**Lab 6** **Quiz 3** **Programming Assignment 1 Due**

8	**Real Time Operating System RTOS on Arduino**
	• Introduction to FreeRTOS
	  ○ Creating a task
	  ○ Deleting a task
	  ○ Assigning priorities to a task
	  ○ Suspending a task
	  ○ Resuming a task
	  ○ Blocking a task
	• Communication between tasks.
		Lab 7

9	**Dual core functionality of ESP32** • Dual core Vs Single core	**Mid Exam (Course covered till end of week 8)**

	• Running two tasks on two different cores
	  ○ Defining task handle
	  ○ Creating task
	  ○ Defining task function	

10 - 11	**Understanding Internet of Things** • Storing sensor data to remote server. • Controlling a device remotely while updating its status on web server. • Storing sensor data to Google sheets. • Retrieving Google sheet data using python	**Lab Exam (Tentative)** **Lab 8** **Programming Assignment 2 Uploaded** **Quiz 4**

12 - 13	**Embedded machine Learning**
	• Naïve Baye's classifier
	  ○ Introduction to probability
	  ○ Bayes theorem
	  ○ Coding Bayes' theorem using C
	  ○ The Naïve Bayes' classifier (Coding the classifier from a to z)
	• Understanding sklearn
	  ○ Sikit-learn workflow
	  ○ Making your data ready for sklearn
	  ○ Dealing with missing data
	  ○ Choosing the right model for machine learning
	  ○ How to fit the model and making predictions
	• Gaussian Naïve Bay's classifier
	  ○ Understanding the math
	  ○ Implementing the classifier on an edge device (microcontroller)
		Lab 9
		Quiz 5
		Lab 10
		
		Programming Assignment 2 Due
		Class Project Uploaded

14 - 15	**Embedded machine Learning …**
	• Understanding Linear Regression
	  ○ From equation of a line to equation of a hyper plane.
	  ○ Derivative of a matrix
	  ○ Linear Regression in 2D
	  ○ Linear regression with multiple features.
	  ○ Gradient Desent inside out.
	• Understanding Logistic Regression
	  ○ The perceptron algorithm
	  ○ Problem with the perceptron algorithm
	  ○ Problem with sigmoid based results.
	  ○ Applying GD to Logistic Regression
	• Sky is the limit
		Lab 11
		Lab 12
		Quiz 6

16	• Cushion week • Revision • Class Project submission.	

Note that this outline is not carved on stone. Course staff / instructor reserves all rights to make appropriate changes as per needed.

Assessment Criteria

- In Class Quizzes 15%
- Home Work / Assignments 10%
- Labs 25%
- Mid Exam 15%
- Class Project 10%
- End Semester Exam (Comprehensive) 25%

NOTE:

- This is a lab course and we will conduct lab sessions almost every week.
- Labs will be conducted in class and hence only those students will perform lab who are present in the class.
- We may have 4 to 6 quizzes.
- Assignments/Home works will be uploaded and **MUST** be submitted within the deadline specified on handout.
- There will be **no retake for any instrument.**
- In case if any student under special circumstances is allowed to take entire course online, he/she will have to attempt the labs online within the given time frame.
- Mid Exams will be conducted face to face.
- Online students (if any) will have to go for an online mid exam followed by a viva.
- More details will be provided in the introductory lecture during first week of this semester.
- Online students should feel free to ask any query via email or we can have an online zoom meeting.
- **Students are advised to attend all assigned lectures**. It is entirely the students' responsibility to recover any information or announcements presented in lectures from which they were absent.
- **All work** that you submit in this course **must be your own**.
- **Unauthorized group efforts** are considered academic dishonesty.
- You may discuss homework in a general way with others, but you may not consult anyone else's written work. You are guilty of academic dishonesty if:
    - You **examine another's solution** to an assignment
    - You **allow another student to examine your solution** to an assignment
    - You fail **to take reasonable care to prevent another student from examining your solution** and that student does examine your solution.
- **Cheating, plagiarism and other forms of academic fraud** are taken very seriously. University Policy of plagiarism will be applicable in the case.
- **Attendance** does not carry any graded marks. It is necessary to maintain a minimum level of 70% attendance. Be very cautious as we may have pop up quizzes in class.