Sana'a University
Faculty of Engineering
Electrical Engineering Department
B.Sc. of Computer and Control Engineering

44. Course Specification of Embedded Systems

I. Course Identification and General Information:

1.	Course Title:	Embedded Systems				
2.	Course Code & Number:	CCE334				
3.	Credit hours:	C.H				Total
		Th.	Tu.	Pr.	Tr.	
		2	-	2	-	3
4.	Study level/ semester at which this course is offered:	Fourth Level / First Semester				
5.	Pre –requisite (if any):	Microprocessors & Assembly Language (CCE214), Programming Language 2 (C/C++) (CCE143), Logic Circuits 2 (CCE112), Electronics 2 (PME214)				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered:	Computer & Control Engineering				
8.	Language of teaching the course:	English				
9.	Location of teaching the course:	Electrical Engineering Department Classes & Labs.				
10.	Prepared By:	Assoc. Prof. Dr. Farouk Al-Fuhaidy				
11.	Date of Approval	2020				

II. Course Description:

This course in an introductory course to Embedded Systems & Interfacing which become the next inevitable wave of technology, and finding application in diverse disciplines of engineering. The aim of the course is to provide students with the basic principles and concepts about embedded systems which can be defined as a control system or computer system designed to perform a specific task. It includes the theory and concepts of control system engineering, the basis of microcontrollers architecture and its assembly and/or Micro-

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C Programming within embedded systems, designing, programming, and implementing of embedded & interfacing systems based on microcontrollers, sensors and actuators for measuring and controlling different marketing and industrial environments. Laboratory work including, designing, simulating, and conducting practical control engineering experiments. Finally, this course is an introduction to robotics systems and advanced IoT.

	III. Course Intended learning outcomes (CILOs) of the course	**Referenced PILOs**
a1	Explain the principles and architectural hardware and software co-design issues related to embedded, interfacing, and control engineering systems.	A2
b1	Identify, formulate, and solve embedded & interfacing systems problems using suitable hardware equipment & software tools.	B1
b2	Construct embedded & interfacing systems considering economic, social, and industrial environments issues and constraints.	B4
c1	Design and interface advanced I/O features to embedded & control systems to meet desired specifications and constraints.	C2
c2	Conduct laboratory experiments and verify theoretical learned concepts of microcontroller-based systems.	C3
d1	Function effectively individually or within teams while designing, implementing, or communicating idea related to embedded systems.	D1, D4

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1- Explain the principles and architectural hardware and software co-design issues related to embedded,	▪ Lectures, ▪ Laboratory experimental work, ▪ Projects.	▪ Examinations, ▪ Homework ▪ Presentations,

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interfacing, and control engineering systems.	▪ Use of Information and Communication Technologies.	▪ Individual and group project reports

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1- Identify, formulate, and solve embedded & interfacing systems problems using suitable hardware equipment & software tools.	▪ Lectures, ▪ Laboratory Experimental work, ▪ Assignments, ▪ Seminars, ▪ Group work, ▪ Projects. ▪ Use of Information and Communication Technologies.	▪ Examinations, ▪ Homework, ▪ Laboratory reports presentations, ▪ Individual and group project reports
b2- Construct embedded & interfacing systems considering economic, social, and industrial environments issues and constraints.	▪ Lectures, ▪ Laboratory Experimental work, ▪ Assignments, ▪ Seminars, ▪ Group work, ▪ Projects. ▪ Use of Information and Communication Technologies.	▪ Examinations, ▪ Homework, ▪ Laboratory reports presentations, ▪ Individual and group project reports

© Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
c1- Design and interface advanced I/O features to	▪ Lectures,	▪ Examinations, ▪ Homework,

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embedded & control systems to meet desired specifications and constraints.	▪ Laboratory Experimental work, ▪ Assignments, ▪ Seminars, ▪ Group work, ▪ Projects. ▪ Use of Information and Communication Technologies.	▪ Laboratory reports presentations, ▪ Individual and group project reports
c2- Conduct laboratory experiments and verify theoretical learned concepts of microcontroller-based systems.	▪ Lectures, ▪ Laboratory Experimental work, ▪ Assignments, ▪ Seminars, ▪ Group work, ▪ Projects. ▪ Use of Information and Communication Technologies.	▪ Examinations, ▪ Homework, ▪ Laboratory reports presentations, ▪ Individual and group project reports

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1- Function effectively individually or within teams while designing, implementing, or communicating idea related to embedded systems.	▪ Seminars, ▪ Assignments, ▪ Laboratory Work, ▪ Projects, ▪ Use of Information and Communication Technologies.	▪ Presentations, ▪ Laboratory Reports, ▪ Individual and Group project Reports

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IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact hours
1.	Course Orientations and Introduction to Embedded Systems & Interfacing	a1	▪ Course Orientations ▪ Introduction to Embedded Systems, Definition, Components and Software Requirements, Importance & Applications fields, marketing, industrially, and different environments.	1	2
2.	Microcontroller Architectures	a1, b1	▪ Microcontroller Vs. Microprocessors, Architectures & Applications, High-level & Mid-Level Programming Techniques, ▪ PIC Microcontrollers Family, overview on PIC 16 family, different versions, their features & IC interfacing, ▪ Introduction to PIC16F84 Mc architecture and Features.	1	2
3.	PIC16 Microcontroller's Ports, Instruction Set, and	a1, b1	▪ PIC16F84 microcontroller IC & Pins functions & Interfacing,	3	6

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	Addressing Mode		▪ Parallel Input / Output Ports architectures design and their works as I/O ports, Ports configurations, and functioning, ▪ Different types of Switches & LEDs and their interfacing in CC/CA Connections. ▪ Different Memories On-Chip, Program Memory, Data Memories, RAM & EEPROM, architectures & Access, Memory Addressing, Direct and Indirect and Immediate operations, ▪ The PIC16 Family's Instruction Set, the 35-Assembly Instructions, Syntax & Functions illustrated using Examples. ▪ Layout of Assembly Program referenced to Program memory's organization, start point of program code, section of interrupts, initialization & Configuration of a system, main code and different		

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			user subroutines (functions), ▪ Simple I/O examples to interface LEDs & Switches with PIC16F84-Mc.		
4.	Embedded System's Design, Building, and programming using Structured Program Concepts	a1, b1, b2	▪ Introduction to the systematic Design concepts for Embedded Systems, brief Review on Structured Programming concepts, flow-char and state chart system-based design, ▪ Design & Implementation of Simple Embedded Systems using assembly structured programming concepts, building software delay Subroutine and Lookup tables in assembly, ▪ Simple embedded system examples for interfacing many LEDs (e.g., 8-Leds) and many Switches, hardware connection of elements to the PIC16F84, Building assembly program to function LEDs to work in variant fashions employing Delay subroutine and Lookup tables.	2	4

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5.	Control & Automation of Embedded Systems using Interrupt's Signals and Timers	a1, b1, b2, c1	▪ Introduction to Interrupts, definition, classifications and their automation of works in embedded system by their Self-Reaction-to-Events caused by external Hardware connected to an embedded system, ▪ PIC16F84-Mc Interrupts types, explanation the mechanism of operation & applications of these introduced types of interrupts, ▪ Interrupts Programming, demonstration of how-to assembly program embedded systems with single / multiple interrupts, interrupt programming conflicts and solving using different methods like context switching, ▪ Embedded Systems examples for illustration of interrupts ▪ PIC16F84 Timer0, block diagram for Timer0, applications, explanation its work as timers or as a counter, and example.	2	4

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6.	Embedded System Interfacing with Human Peripherals I/O Elements and Circuits	a1, b1, b2, c1	▪ Brief introduction to PIC16F877-Mc, additional features, On-chip Modules and I/O Ports, ▪ Inter of PIC16F877-Mc with Keypad, Seven-Segments and LCD, hardware design & connection of Keypad, 7-Segment and LCD, algorithms for reading & identifying Keypad's Keys and programming using interrupts, example illustrating the interfacing of Keypad, 7-Segment & LCD. ▪ PIC16F877-Mc interfacing with Motors & Actuators, starting by brief explanation on signal's problems like distortions, spikes, offsets...etc. then introduce dc motors and servo-motors and their applications and differences, use of power transistors to drive motors & actuators, and use of H-bridge drive circuits like L293D-IC.	2	4

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7.	More on PIC16F877-Mc On-Chip Modules, Timers and CCP Modules	a1, b1, b2, c1	▪ PIC16F877-Mc On-Chip Timers and CCP, their use and applications, ▪ Timers 1,2, and 3, their organizations, mechanism of operations, configurations, and applications, ▪ CCP Module, its internal organization, operation and configuration in Capture, Compare, or PWM modes of operations, applications of CCP illustrated with assembly programs.	1 1/2	3
8.	Embedded Systems and Acquisition & Communication with Peripherals	a1, b1, b2, c1, d1	▪ Introduction to Data Acquisition Systems elements and functions, ▪ Acquisition of analog signals, brief review on analog-to-digital and digital-to-analog electronics circuits and basic principles, Sample and Hold circuit use as ADC circuit, ▪ ADC Module in PIC16F877-Mc, hardware circuit, channels and pins associated with ADC, operations and	1 1/2	3

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			configuration with assembly programming, ▪ PIC16F877-MC Serial Communication Modules, serial communications vs. parallel communications, UART, SPI, and I2C serial communications between ICs, concept of operations, configuration, and programming. ▪ Brief introduction to new trends and smart embedded systems technologies.		
Number of Weeks /and Units Per Semester				**14**	**28**

B - Practical Aspect:

Order	Tasks/ Experiments	Number of Weeks	Contact hours	Learning Outcomes
1.	▪ Laboratory Equipment and Tools Orientations, Installing Microcontroller Development Tools	1	2	a1, b1, c2, d1
2.	▪ PIC16F84-Mc Assembly instructions Set using MPLAP Simulator to verify work of each instruction	1	2	a1, b1, d1
3.	▪ PIC16-Mcs Assembly structured programing, ▪ Generating software delay subroutine,	4	8	a1, b1, c1, c2, d1

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	▪ writing simple assembly program and debugging it through the simulator and downloading simple codes into the chip; ▪ writing simple assembly program and debugging it through the simulator and downloading simple codes into the chip to interface LEDs & Switches building different ideas of operation ▪ Design of a Microprocessor-based systems including RAM and EPROM interfacing and program memory lookup tables ▪ Parallel Ports Interfacing			
4.	▪ Installing a C Compiler, writing C code and debugging it using the simulator and the emulator	1	2	a1, b1, c2, d1
5.	▪ Interrupts, Timers hardware Interfacing and Programming using Assembly and MicroC	1	2	a1, b1, b2, c1, c2, d1
6.	▪ Keypad & 7-Segment Interfacing	1	2	a1, b1, b2, c1, c2, d1
7.	▪ Keypad & LCD Interfacing	1	2	a1, b1, b2, c1, c2, d1
8.	▪ Analog-Digital module configuration and programming	1	2	a1, b1, b2, c1, c2, d1
9.	▪ Serial communications (UART, SPI and I2C) and Low-Power Design	1	2	a1, b1, b2, c1, c2, d1
10.	▪ Review	1	2	a1, b1, b2, c2, d1
11.	▪ Project Presentation	1	2	a1, b1, b2, c1, c2, d1
Number of Weeks /and Units Per Semester		**14**	**28**	

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V. Teaching strategies of the course:

- Lectures,
- Laboratory experimental work,
- Projects works,
- Assignments,
- Seminars,
- Group work,
- Use of Communication and Information Technology.

VI. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1.	PIC Assembly, embedded Systems Development and Programming	a1, b1, b2, c1, c2, d1	3rd to 7th	3
2.	Interrupts and Timers	a1, b1, b2, c1, c2, d1	8th & 9th	3
3.	Human Interfacing	a1, b1, b2, c1, c2, d1	10th	3
4.	Timers and CCP	a1, b1, b2, c1, c2, d1	11th & 12th	3
5.	ADC and Serial Communications	a1, b1, b2, c1, c2, d1	13th to 15th	3
	Total			**15**

VII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1.	Assignments	3rd to 15th	15	10%	a1, b1, b2, c1, d1

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2.	Laboratory Experimental Works	3rd to 12th	15	10%	a1, b1, b2, c1, c2, d1
3.	Project Work & Presentation	14th	15	10%	a1, b1, b2, c1, c2, d1
4.	Mid-term Exam (Th.)	8th	15	10%	a1, b1, b2
5.	Final Exam (Pr.)	15th	15	10%	a1, b1, b2, c2, d1
6.	Final Exam (Th.)	16th	75	50%	a1, b1, b2, c1
	Total		**150**	**100%**	

VIII. Learning Resources:

- *Written in the following order: (Author - Year of publication – Title – Edition – Place of publication – Publisher).*

1- Required Textbook(s) (maximum two).

1- 1 -Tim Wilmshurst, 2010, Designing Embedded Systems with PIC Microcontroll Principles and applications, 2nd edition, Elsevier Ltd, USA

2- Park & Mackay, 2003, Practical Data Acquisition for Instrumentation and Control Systems, Newnes, ISBN 978-0750657969

3- Kevin James, 2000, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newnes**,** ISBN 0 7506 4624 1

2- Essential References.

1- 1-Steve Heath, 2002, Embedded Systems Design, (2nd ed.), Newnes, (ISBN:9780750655460)

2- Programming Embedded Systems in C and C++, Michael Barr, O'Reilly Media, (ISBN:9781565923546)

3- John Essick, 2008, Hands On Introduction to LabVIEW for Scientist and Engineers, 1ed, Oxford University Press

4- Muhamad Ali Mazidi, 2012, Embedded Systems Design Using PIC18", 1st , Pren Hall

3- Electronic Materials and Web Sites *etc*.

1- 1-http://www.ocw.mit.edu/courses.

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	2- Lecture notes prepared by the Lecturer.

IX. Course Policies:

1.	**Class Attendance:** A student should attend not less than 75 % of total hours of the subject; otherwise he will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic
2.	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in attending class he will be considered as absent.
3.	**Exam Attendance/Punctuality:** A student should attend the exam on time. He is Permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam-
4.	**Assignments & Projects:** The assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time-
5.	**Cheating:** For cheating in exam, a student will be considered as failure. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty-
6.	**Plagiarism**: Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proved a plagiarism of a student, he will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university.
7.	**Other policies:** - Mobile phones are not allowed to use during a class lecture. It must be closed, otherwise the student will be asked to leave the lecture room - Mobile phones are not allowed in class during the examination. Lecture notes and assignments my given directly to students using soft or hard copy

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Reviewed By	**Vice Dean for Academic Affairs and Post Graduate Studies: Asst. Prof. Dr. Tarek A. Barakat** **President of Quality Assurance Unit: Assoc. Prof. Dr. Mohammed Algorafi** **Name of Reviewer from the Department: Asst. Prof. Dr. Adel Ahmed Al-Shakiri**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

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