TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

EMBEDDED SYSTEM

by

Dr. Prawitno Prajitno

Undergraduate Program in Physics
Faculty of Mathematics and Natural Sciences
Universitas Indonesia
Depok
November 2020

UNIVERSITAS INDONESIA
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
PHYSICS UNDERGRADUATE STUDY PROGRAM

TEACHING INSTRUCTIONAL DESIGN

Course Name	Embedded System	**Credit(s)**	**Prerequisite course(s)**	**Requisite for course(s)**	**Integration Between Other Courses**
Course Code	SCPH603712	2	Electronics 2	Laboratory Work of Embedded System	Laboratory Work of Embedded System
Relation to Curriculum	-				
Semester	5				
Lecturer(s)	Dr. Prwaito Prajitno				
Course Description	Giving the basic concepts about embedded systems, examples of embedded systems, microprocessors and microcontrollers, microcontroller architecture, memory organization, minimum systems based on microcontrollers, instruction sets, parallel inputs and outputs, interrupts, Counters and Timers, Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC), interfacing external memory, interfacing external peripherals and devices, serial data communication such as : USART, SPI, I2C, 1-Wire, and Real-time Operating Systems (RTOS)				

Program Learning Outcome (PLO)	
PLO	Applying the concepts of Embedded Systems

PLO	Formulating problems and solving Physics and its application, as well as interdisciplinary problems related to science and mathematics clusters critically, creatively, and innovatively.
PLO	Solving simple scientific problems and presenting them orally and in writing
Course Learning Outcome (CLO)	
CLO	Students are able to understand problems and apply interfacing and programming methods in embedded systems effectively and efficiently. (C3) (ELO 3, 5, 6, 7)
Sub-CLO	
Sub-CLO 1	Explaining the basic concepts of Embedded Systems, FPGA, Microprocessors and Microcontrollers (C2 and C3)
Sub-CLO 2	Explaining the basic concepts of Microcontroller Architecture, Program Memory (FlashROM), Data Memory (RAM), EEPROM and Assembly Programming (C2 and C3)
Sub-CLO 3	Explaining the basic concepts of I/O Port Configuration, Manipulating I/O Ports and Software-based time delay (C2 and C3)
Sub-CLO 4	Explaining the basic concepts of Polling, Interrupts from External Hardware and the difference between both concepts (C2 and C3)
Sub-CLO 5	Explaining the basic concepts of Programming Styles, Data Types, Variables, Constants, I/O Port Programming, and the Look-Up Table (C2 and C3)
Sub-CLO 6	Explaining the basic concepts of Programming External Interrupts, Procedure and Function, Alphanumeric LCD Interfacing and Programming (C2 and C3)

Sub-CLO 7	Explaining the basic concepts of Timer Configuration, Counter Configuration, Applications of Timers and Counters, PWM-based Motor Control, and the Watchdog Timer (C2 and C3)
Sub-CLO 8	Explaining the basic concepts of ADC Settings, Free-Running Mode, Single-Conversion Mode, and DAC Interfacing (C2 and C3)
Sub-CLO 9	Explaining the basic concepts of Asynchronized Communication for Serial Data, USART Polling Mode, and USART Interrupt Mode (C2 and C3)
Sub-CLO 10	Explaining the basic concepts of SPI based Data Communication, SPI Applications towards the ADC and DAC, and Real Time Clock units (C2 and C3)
Sub-CLO 11	Explaining the basic concepts of I2C based Data Communication, Applications of SPI towards the ADC and DAC, and Programming on peripheral Devices (C2 and C3)
Sub-CLO 12	Explaining the basic concepts of 1-Wire based Data Communication and 1-Wire Interfacing on the DS1820 Sensor (C2 and C3)
	Explaining the basic concepts of Real-Time Operating Systems (RTOS) and its Application on Embedded Systems
Sub-CLO 13	Designing simple Embedded Systems as a Group Task (C3)
Study Materials	• Embedded systems • Examples of embedded systems • Microprocessors and microcontrollers • M icrocontroller architecture • M emory organization • M inimum systems based on microcontroller and its instruction sets • Parallel inputs and outputs

	• Interrupts • Counters and Timers • Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC) • Interfacing external memory • Interfacing external peripherals and devices • Serial data communication such as : USART, SPI, I2C, 1-Wire, and Real-time Operating Systems (RTOS)
Reading List	• Mazidi, M.A, Naimi, S., *The AVR Microcontroller and Embedded Systems Using Assembly and C*, Prentice Hall, 2011. • Barnett, R.H, Cox, S, O'Cull, L, *Embedded C Programming and The Atmel AVR, 2nd edition*, Thomson Delmar Learning, 2007 • Maxim Integrated, *DS-1820 High-Precision 1-Wire Digital Thermometer*, Maxim Integrated Product, 2015. • Barrr, R, *Mastering the Free RTOS Real Time Kernel, A Hands-On Tutorial Guide*, Real Time Engineers Ltd. 2016

Teaching Plan

Week	Sub-CLO	Study Materials [with reference]	Teaching Method [with est. time]	Learning Experiences (*O-E-F)	Sub-CLO Achievement Indicator		Sub-CLO Weight on Course (%)
					General	Specific	
1	1	• Embedded Systems, FPGA, Microprocessors and Microcontrollers [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	Able to explain the basic concepts of: a) Embedded Systems b) FPGA c) Microprocessors d) Microcontrollers	Analyze and give feedback towards a) Embedded Systems b) FPGA c) Microprocessors d) Microcontrollers	%
2	2	• Microcontroller Architecture, Memory Organization, Minimum Systems, Assembly language and its sets of instructions	Lecturing classes and individual tasks	Orientation: Introduction to this week's topic	Able to explain the basic concepts of: a) Microcontroller Architecture	Able to analyze and give feedback towards the basic concepts of:	7%

		[Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	[Estimated time] 150 minutes	(50%) Exercise: Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	b) Program Memory (FlashROM), Data Memory (RAM), EEPROM c) Assembly Programming	a) Microcontroller Architecture b) Program Memory (FlashROM), Data Memory (RAM), EEPROM c) Assembly Programming	
3	3	• I/O Port Programming, Logic Instructions and Arithmetics [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%) Feedback: Question and answer	Able to explain the basic concepts of: a) I/O Port Configuration b) I/O Port Manipulation c) Software-based Delay Time	Able to analyze and give feedback towards the basic concepts of: a) I/O Port Configuration b) I/O Port Manipulation c) Software-based Delay Time	7%

				with the lecturer (40%)			
4	4	• External Hardware Interrupt [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150x2 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	Able to explain the basic concepts of: a) Polling and Interrupt b) Interrupt Settings and its Applications	Able to participate and analyze the basic concepts of: a) Polling and Interrupt b) Interrupt Settings and its Applications	7%
5	5	• Embedded C Language [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time]	Orientation: Introduction to this week's topic (50%) Exercise:	Able to explain the basic concepts of: a) Programming Styles b) Data Types, Variables and Constants	Able to participate and analyze the basic concepts of: a) Programming Styles b) Data Types, Variables and Constants	7%

			150x2 minutes	Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	c) I/O Port Programming d) Look-Up Table	c) I/O Port Programming d) Look-Up Table	
6	6	• External Interrupt Programming [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	Able to explain the basic concepts of: a) Programming External Interrupt b) Procedures and Functions c) Alphanumeric LCD Interfacing and Programming	Able to participate and analyze the basic concepts of: a) Programming External Interrupt b) Procedures and Functions c) Alphanumeric LCD Interfacing and Programming	7%

7	7	• Timers and Counters [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	Able to explain the basic concepts of: a) Timer Configuration b) Counter Configuration c) Applications of the Timer and Counter d) PWM-based Motor Control e) Watchdog Timer	Able to participate and analyze the basic concepts of: a) Timer Configuration b) Counter Configuration c) Applications of the Timer and Counter d) PWM-based Motor Control e) Watchdog Timer	7%
8	Mid Term Exam						
9	8	• The Analog to Digital Converter (ADC) and the Digital to Analog Converter (DAC) [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%)	Able to explain the basic concepts of: a) ADC setting, Free-Running Mode, and Single-Conversion Mode b) DAC Interfacing	Able to participate and analyze the basic concepts of: a) ADC setting, Free-Running Mode, and Single-Conversion Mode b) DAC Interfacing	7%

				Feedback: Question and answer with the lecturer (40%)			
10	9	• Asynchronized Serial Data Communication [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	Able to explain the basic concepts of: a) Asynchronized Serial Data Communication b) USART Polling Mode and USART Interrupt Mode	Able to participate and analyze the basic concepts of: a) Asynchronized Serial Data Communication b) USART Polling Mode and USART Interrupt Mode	7%
11	10	• Serial Peripheral Interface (SPI)-based Synchronous Data Communication	Lecturing classes and individual tasks	Orientation: Introduction to this week's topic	Able to explain the basic concepts of: a) SPI Bassd Data Communication	Able to participate and analyze the basic concepts of:	7%

		[Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	[Estimated time] 150x2 minutes	(50%) Exercise: Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	b) Applications of the SPI on ADC, DAC and the Real Time Clock Unit	a) SPI Bassd Data Communication b) Applications of the SPI on ADC, DAC and the Real Time Clock Unit	
12	11	• Inter Integrated Circuit (I2C)-based Synchronous Data Communication [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150x2 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%) Feedback: Question and answer	Able to explain the basic concepts of: a) I2C based Data Communication b) I2c Interfacing and Programming on Peripheral Devices	Able to participate and analyze the basic concepts of: a) I2C based Data Communication b) I2c Interfacing and Programming on Peripheral Devices	7%

				with the lecturer (40%)			
13	12	• 1-Wire Data Communication [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	Able to explain the basic concepts of: a) 1-Wire based Data Communication b) 1-Wire Interfacing on the DS1820 Sensor	Able to participate and analyze the basic concepts of: a) 1-Wire based Data Communication b) 1-Wire Interfacing on the DS1820 Sensor	7%
14	13	• Introduction to the Real-Time Operating System (RTOS) [Reference] Mazidi, M.A, Naimi, S., The AVR Microcontroller and Embedded Systems Using Assembly and C, Prentice Hall, 2011.	Lecturing classes and individual tasks [Estimated time] 150 minutes	Orientation: Introduction to this week's topic (50%) Exercise:	Able to explain the basic concepts of: a) Real-Time Operating System (RTOS) b) Applications of the RTOS on	Able to participate and analyze the basic concepts of: a) Real-Time Operating System (RTOS) b) Applications of the RTOS on	7%

				Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	Embedded Systems	Embedded Systems	
15	14	• Reviewing Final Exam Materials	Lecturing classes and individual tasks [Estimated time] 150 minutes	Orientation: Introduction to this week's topic (50%) Exercise: Listen to lecture (10%) Feedback: Question and answer with the lecturer (40%)	Students are able to participate in answering the exercises prepared by the lecturer to review the materials for the final exam	Students are able to solve and give feedback in answering the exercises prepared by the lecturer to review the materials for the final exam	9%
16	Final Exam						

Assignment Design

Week	Assignment Name	Sub-CLOs	Assignment	Scope	Working Procedure	Deadline	Outcome
Week	**Assignment Name**	**Sub-CLO**	**Assignments**	**Scopes**	**Working Procedure**	**Deadline**	**Outcome**
1-14	In-Class Quizzes, Homework and Simulations	1-13	Questions	Summarize the specific week's material and simulations	Individual Tasks	1 week	Quiz results in class and program design
15	Group Project	14	Final Project	Designing the equipment	Group Task	1 week	Student Power-point and results of the presentation

Assessment Criteria

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
In-class quiz	1-7 and 8-13	Evaluation Sheet	6	10
Homework and Simulations	2-13	Evaluation Sheet	12	10
Group Project	14	Evaluation Sheet	1	20
Mid-Term Exam	1-7	Essay Questions	1	30
Final Exam	8-13	Essay Questions	1	30
Total				**100**

Conversion of the students final score

Score	Grade	Equivalent
85—100	A	4,00
80—<85	A-	3,70
75—<80	B+	3,30
70—<75	B	3,00
65—<70	B-	2,70
60—<65	C+	2,30
55—<60	C	2,00
40—<55	D	1,00
<40	E	0,00

Rubric(s)

A. Criterions for the Group Project Presentation

Grade	Quality of Answer
85-90	If the group is able to present their materials logically, fluently and is able to finish their presentation on time while also being able to answer questions being given by other students or the teacher.
75-84	If the group is able to present their materials logically and fluently while also being able to answer questions being given by other students or the teacher but is not able to manage their time properly
65-74	If the group is able to present their materials logically but is not able to logically explain the process of their material
55-64	The group is not able to present their materials fluently nor logically and is not able to manage their time properly
<55	

B. Mid term exam and Final term exam

Grade	Quality of Answer
100	The answers are precise, every definition and main components are included
76-99	The answers precise enough, all definitions and main components that are needed to answer the question are almost precise
51-75	The answers are less precise, the definitions and main components that are needed to answer the question are less precise
26-50	The answers are very unprecise, the definitions and main components that are needed to answer the questions are missing a lot of details
<25	Wrong answer