

Programme Name/s	: Mechatronics
Programme Code	: MK
Semester	: Fourth
Course Title	: EMBEDDED SYSTEM USING 'C'
Course Code	: 314338

I. RATIONALE

Embedded system has become an integral part of various mechatronics systems such as robotics, industrial automation, smart appliances etc. This course will make students proficient and enable them to develop and maintain various embedded systems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Develop various embedded system applications in mechatronics.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Classify the different types of embedded systems.
- CO2 - Use embedded 'C' language for programming 8051 microcontroller.
- CO3 - Interpret the communication protocols of embedded systems.
- CO4 - Develop embedded 'C' programs for Input/Output devices.
- CO5 - Develop basic embedded system applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Paper Duration	Assessment Scheme										
				Actual Contact Hrs./Week			SLH	NLH			Theory			Based on LL & TL			Based on SL	Total Marks			
				CL	TL	LL					FA-TH	SA-TH	Total	FA-PR	SA-PR	SLA					
				Max	Max	Max/Min	Max/Min	Max/Min			Max/Min	Max/Min	Max/Min								
314338	EMBEDDED SYSTEM USING 'C'	ESC	AEC	3	-	4	1	8	4	3	30	70	100	40	25	10	-	-	25	10	150

Total IKS Hrs for Sem. : 0 Hrs

Abbreviations: CL- Classroom Learning, TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA - Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain the block diagram of embedded system with it's characteristics. TLO 1.2 Classify the Embedded Systems. TLO 1.3 Distinguish between Von-Neumann and Harvard architecture. TLO 1.4 Explain the features and pin configuration of 8051 microcontroller. TLO 1.5 Explain power-saving options of 8051.	Unit - I Overview of Embedded System 1.1 Block diagram of embedded system with hardware components 1.2 Characteristics of Embedded System: Processor power, memory, operating system, reliability, performance, power consumption, NRE cost, unit cost, size, flexibility, time-to-prototype, time-to-market, maintainability, correctness and safety 1.3 Classification of Embedded System: Small scale, medium scale, sophisticated, stand-alone, reactive /real time (soft and hard real time) 1.4 Von-Neumann and Harvard architecture 1.5 8051 microcontroller: Features, pin configuration 1.6 8051 as a Boolean processor, Power-saving options- Idle and power down mode	Lecture using Chalk-Board Presentations Video Demonstrations
2	TLO 2.1 List the various datatypes in Embedded 'C'. TLO 2.2 Develop embedded 'C' program for arithmetic, logical and data transfer operations. TLO 2.3 Develop embedded 'C' program using timer. TLO 2.4 Develop embedded 'C' program for serial transmission and reception. TLO 2.5 Explain the 8051 interrupts.	Unit - II 8051 Programming using Embedded 'C' 2.1 Embedded C: Data types, decision control and looping 2.2 8051 Microcontroller programming in embedded C: Arithmetic and logical operations, data transfer on Input/ Output ports 2.3 Timer/Counters: TMOD, TCON, Timer/Counter modes and 'C' programs for Timer/Counter 2.4 Serial communication: SCON, SBUF, modes of serial communication, 'C' programs for serial communication 2.5 Interrupts: 8051 interrupts, IE and IP SFRs	Lecture using Chalk-Board Presentations Video Demonstrations
3	TLO 3.1 Compare serial vs. parallel communication and synchronous vs. asynchronous communication. TLO 3.2 Explain the serial communication protocol. TLO 3.3 Describe the important features of advanced serial protocols.	Unit - III Communication Standards and Protocols 3.1 Modes of data communication: Serial, parallel, synchronous and asynchronous communication 3.2 Serial communication standard RS232 (DB9) 3.3 Serial communication protocols: I2C, CAN, Serial Peripheral Interface (SPI) 3.4 Features of advanced serial protocols: IrDA, Bluetooth, Zigbee	Lecture using Chalk-Board Presentations Video Demonstrations
4	TLO 4.1 Develop 'C' program for interfacing switch and LED. TLO 4.2 Develop 'C' program for interfacing a relay. TLO 4.3 Develop 'C' program for interfacing 7-segment LED display. TLO 4.4 Explain interfacing of 16X2 LCD with 8051. TLO 4.5 Explain interfacing of ADC 0808 with 8051. TLO 4.6 Develop 'C' program for generating square wave and triangular wave.	Unit - IV Interfacing of Input and Output Devices with 8051 4.1 Interfacing of switch, LED and it's programming in 'C' 4.2 Interfacing of relay and it's programming in 'C' 4.3 Interfacing and 'C' programming of single 7-segment LED display 4.4 16 x 2 LCD interfacing with 8051 and it's programming in 'C' 4.5 Interfacing of ADC 0808. 'C' program to convert analog signal into digital 4.6 Interfacing of DAC 0808 and 'C' program to generate square wave and triangular wave	Lecture using Chalk-Board Presentations Video Demonstrations Demonstration

Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Develop 'C' program for rotating DC motor and servo motor interfaced with 8051. TLO 5.2 Develop 'C' program for rotating stepper motor in clockwise and anticlockwise direction. TLO 5.3 Develop 'C' program for obstacle detection using IR sensor. TLO 5.4 Develop 'C' program for motion detection using PIR sensor.	Unit - V Applications of 8051 Microcontroller 5.1 Interfacing of DC motor and servo motor, its programming in 'C' 5.2 Interfacing of stepper motor and 'C' program to rotate the stepper motor 5.3 Interfacing of IR sensor and simple 'C' program for obstacle detection 5.4 Interfacing of PIR sensor and simple 'C' program for motion detection	Lecture using Chalk-Board Presentations Video Demonstrations Demonstration

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify various blocks of 8051 microcontroller development board. LLO 1.2 Connect the development board to PC.	1	*Identification of various blocks of 8051 microcontroller development board	2	CO1
LLO 2.1 Install Integrated Development Environment (IDE) tool for 8051 microcontroller. LLO 2.2 Use IDE tool.	2	*Integrated Development Environment tool for 8051 microcontroller	2	CO2
LLO 3.1 Develop C program for input/output operation over port pins. LLO 3.2 Simulate the program.	3	*Development of embedded 'C' program to accept data from P1 pins and send it out on P2 pins	2	CO2
LLO 4.1 Develop C program for various arithmetic operations. LLO 4.2 Simulate the program for arithmetic operations.	4	*Development of embedded 'C' program for various arithmetic operations	2	CO2
LLO 5.1 Develop 'C' program for various logical operations. LLO 5.2 Simulate the program for logical operations.	5	Development of embedded 'C' program for various logical operations	2	CO2
LLO 6.1 Develop 'C' program for port operations. LLO 6.2 Simulate the program port operations.	6	Development of embedded 'C' program to accept number from P1 and P2 pins and send out greater number on P3 pins	2	CO2
LLO 7.1 Develop 'C' program for block transfer. LLO 7.2 Simulate the program for block transfer.	7	*Development of embedded 'C' program for block transfer	2	CO2
LLO 8.1 Develop 'C' program for generation of square wave without using timer over port pin. LLO 8.2 Simulate the program for square wave generation.	8	Development of embedded 'C' program for generation of square wave over port pin without using timer	2	CO2
LLO 9.1 Develop 'C' program for generation of square wave using timer over port pin. LLO 9.2 Simulate the program for square wave generation.	9	*Development of embedded 'C' program for square wave generation over port pin using 8051 timer	2	CO2
LLO 10.1 Develop 'C' program to transmit a character 'Y' on TxD pin. LLO 10.2 Simulate the program for transmitting a character.	10	Development of C program to transmit a character 'Y' on TxD pin	2	CO2
LLO 11.1 Develop 'C' program for transmitting the message. LLO 11.2 Simulate the program for transmitting the message.	11	*Development of 'C' program for transmitting the message "WELCOME" on serial port	2	CO2
LLO 12.1 Identify the pins of DB9 connector. LLO 12.2 Connect DB9 connector to PC using MAX232 IC.	12	*Interfacing of RS232 (DB9) connector to PC using MAX232 IC	2	CO3
LLO 13.1 Develop 'C' program for LED blinking. LLO 13.2 Execute the above program to demonstrate on hardware.	13	Interfacing of LED with 8051 and development of 'C' program for LED blinking	2	CO4
LLO 14.1 Develop 'C' program to turn ON the LED by pressing a switch. LLO 14.2 Execute the above program to demonstrate on hardware.	14	*Development of 'C' program for turning ON the LED by pressing a switch	2	CO4
LLO 15.1 Develop 'C' program for toggling 8 LEDs. LLO 15.2 Execute the above program to demonstrate on hardware.	15	Interfacing of eight LEDs with 8051 and development of 'C' program for toggling them continuously	2	CO4
LLO 16.1 Develop 'C' program for controlling a lamp interfaced with 8051 microcontroller through a relay. LLO 16.2 Execute the above program to demonstrate on hardware.	16	*Development of 'C' program for controlling a lamp interfaced with 8051 microcontroller through a relay	2	CO4
LLO 17.1 Develop 'C' program for 7-segment LED display. LLO 17.2 Execute the above program to demonstrate on hardware.	17	*Development of 'C' program for single digit up-counter (0-9) using 7-segment LED display	2	CO4
LLO 18.1 Develop 'C' program for 7-segment LED display. LLO 18.2 Execute the above program to demonstrate on hardware.	18	Development of 'C' program to display characters 'A','B','C','D','E','F' on 7-segment LED display	2	CO4
LLO 19.1 Develop 'C' program for displaying a message on the 16 x 2 LCD. LLO 19.2 Execute the above program to demonstrate on hardware.	19	*Development of 'C' program for displaying a message "Welcome" on the 16 x 2 LCD	2	CO4
LLO 20.1 Develop 'C' program to check the occurrence of an external interrupt 0. LLO 20.2 Execute the above program to demonstrate on hardware.	20	Development of 'C' program to turn 'ON' the LED when an external interrupt 0 occurs	2	CO4
LLO 21.1 Develop 'C' program for square waveform generation using DAC. LLO 21.2 Execute the above program to demonstrate on hardware.	21	*Development of 'C' program for generation of square waveform using DAC	2	CO4
LLO 22.1 Develop 'C' program for triangular waveform generation using DAC. LLO 22.2 Execute the above program to demonstrate on hardware.	22	Development of 'C' program for generation of triangular waveform using DAC	2	CO4
LLO 23.1 Develop 'C' program for ADC. LLO 23.2 Execute the above program to demonstrate on hardware.	23	Development of 'C' program for converting the analog signal into digital form using an ADC	2	CO4
LLO 24.1 Develop 'C' program for DC motor to rotate the motor in clockwise direction. LLO 24.2 Execute the above program to demonstrate on hardware.	24	*Development of 'C' program to rotate the DC motor in clockwise direction	2	CO5
LLO 25.1 Develop 'C' program for DC motor to rotate in anticlockwise direction. LLO 25.2 Execute the above program to demonstrate on hardware.	25	Development of 'C' program to rotate the DC motor in anticlockwise direction	2	CO5
LLO 26.1 Develop 'C' program for stepper motor to rotate in clockwise and anticlockwise direction. LLO 26.2 Execute the above program to demonstrate on hardware.	26	Development of 'C' program to rotate the stepper motor in clockwise and anticlockwise direction	2	CO5
LLO 27.1 Develop 'C' program to rotate the stepper motor by 180 degrees. LLO 27.2 Execute the above program to demonstrate on hardware.	27	*Development of 'C' program to rotate the stepper motor by 180 degrees	2	CO5
LLO 28.1 Develop 'C' program to rotate servo motor by specified angle. LLO 28.2 Execute the above program to demonstrate on hardware.	28	Development of 'C' program for rotating the servo motor by specified angle	2	CO5
LLO 29.1 Develop 'C' program for IR sensor. LLO 29.2 Execute the above program to demonstrate on hardware.	29	*Development of 'C' program to turn on the LED when an obstacle is detected by IR sensor	2	CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 30.1 Develop 'C' program for PIR sensor. LLO 30.2 Execute the above program to demonstrate on hardware.	30	Development of 'C' program to turn on the LED when motion is detected by PIR sensor	2	CO5
Note : Out of above suggestive LLOs - <ul style="list-style-type: none"> *Marked Practicals (LLOs) Are mandatory. Minimum 80% of above list of lab experiment are to be performed. Judicial mix of LLOs are to be performed to achieve desired outcomes. 				

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Build a circuit to blink LEDs in different patterns.
- Build 8051 based system for speed control of DC motor.
- Build a circuit using LCD to display name in rolling fashion.
- Build 8051 based product counter.
- Build an automated door controlled system.
- Build a countdown timer using LED 7-segment display.

Activities

- Prepare a report on different sensors used in mechatronics industry.
- Write a report on different types of robots.
- Conduct an internet survey on different Arduino boards and prepare a report on it.
- Prepare a report on different motors used in mechatronics industry.
- Prepare a chart on applications of embedded system in mechatronics.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	8051 Microcontroller Development Board- single board system with 8K RAM, ROM/Flash memory with battery backup, 16x2 LCD display, RS-232/USB interfacing facility with built in power supply	1,12,13,14,15,17,18,19,20,21,22,23,24,25,26,27,28,29,30
2	LED	13,14,15,20,29,30
3	Switch	14,20
4	+5V Relay	16
5	7-Segment LED display	17,18
6	16 x 2 LCD Module	19
7	DAC 0808/0809 Module, CRO- Bandwidth AC 10Hz ~20MHz, DC ~20MHz	21,22
8	ADC 0808/0809 Module	23
9	+5V DC motor with driver	24,25
10	+5V stepper motor with driver	26,27
11	Servo motor: +5V, Torque: 2.5kg/cm, Rotation : 0°-180°	28
12	IR sensor Module	29
13	PIR sensor Module	30
14	PC with IDE and program uploading software for 8051	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Overview of Embedded System	CO1	8	4	4	6	14
2	II	8051 Programming using Embedded 'C'	CO2	14	4	6	8	18
3	III	Communication Standards and Protocols	CO3	6	2	4	4	10
4	IV	Interfacing of Input and Output Devices with 8051	CO4	11	4	6	6	16
5	V	Applications of 8051 Microcontroller	CO5	6	2	4	6	12
Grand Total				45	16	24	30	70

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- FA-TH represents average of two class tests of 30 marks each. FA-PR represents continuous assessment based on process and product related performance indicators. Each practical will be assessed considering 60% weightage to process 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester theory examination of 70 marks

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO- 1	PSO- 2	PSO- 3
CO1	2	2	1	-	1	1	2			
CO2	2	3	2	2	1	1	2			
CO3	2	1	1	1	1	1	2			
CO4	3	3	3	2	2	2	2			
CO5	3	3	3	2	2	3	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -

*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay	The 8051 Microcontroller and Embedded Systems using Assembly and 'C'	Pearson, 2007 ISBN -13: 978-0199681273
2	Kenneth J. Ayala	The 8051 Microcontroller: Architecture, Programming and Applications	Penram International Publishing, 1996 ISBN -13: 978-0314201881
3	Raj Kamal	Embedded Systems	McGraw Hill, 4th Edition, 2020 ISBN -13: 978-9353168025
4	Ajit Pal	Microcontrollers: Principles and Applications	PHI Learning Pvt. Ltd.,2011 ISBN -13: 978-8120343924
5	Ajay V. Deshmukh	Microcontrollers: Theory and Applications	McGraw-Hill Education (India) Pvt. Ltd., 2005 ISBN - 13: 978-0070585959

XIII. LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.keil.com/demo/eval/c51.htm	Keil IDE download
2	https://www.engineersgarage.com/timers-8051-timer-programming/	8051 timer programming
3	https://www.tutorialspoint.com/embedded_systems/es_io_programming.htm	8051 I/O programming
4	https://electrosome.com/interfacing-relay-8051-keil-c/	Relay interfacing and programming
5	https://www.javatpoint.com/embedded-system-7-segment-display	7-segment-display interfacing and programming
6	https://www.javatpoint.com/embedded-system-lcd-programming	LCD interfacing and programming
7	https://www.elprocus.com/embedded-system-programming-using-keil-c-language/	Embedded 'C' programming
8	https://www.electronicwings.com/8051/dc-motor-interfacing-with-8051	DC-motor-interfacing-with-8051
9	https://electrosome.com/interfacing-stepper-motor-8051-keil-c-at89c51/	stepper motor interfacing and programming
10	https://circuitdigest.com/microcontroller-projects/servo-motor-interfacing-with-8051	Servo motor interfacing and programming
11	https://embetronicx.com/tutorials/microcontrollers/8051/ir-sensor-interfacing-with-8051/	IR sensor interfacing and programming
12	https://www.electronicwings.com/8051/pir-motion-sensor-interfacing-with-8051	PIR sensor interfacing and programming
13	http://vlabs.iitkgp.ac.in/rtes/index.html	Virtual Lab. for embedded system

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students