Programme Name/s	**: Automation and Robotics/ Digital Electronics/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electronics & Communication Engg./ Electronics Engineering/ Industrial Electronics/ Electronics & Computer Engg./**
Programme Code	**: AO/ DE/ EJ/ EK/ ET/ EX/ IE/ TE**
Semester	**: Fifth**
Course Title	**: EMBEDDED SYSTEM**
Course Code	**: 315338**

I. RATIONALE

Embedded systems are designed for specific tasks to excel in real-time performance, resource utilization and reliability. These systems are playing vital role in modern technology, enabling sophisticated functionalities in a wide array of devices and applications. Embedded systems are integral to the advancement of technology across multiple sectors. By learning this course, students will develop skills to use embedded system for simple applications. It will also enable them to use open-source embedded system for solving real time problems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help students to attain the following industry/employer expected outcome through various teaching learning experiences:

"Develop simple applications based on embedded system."

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Select the relevant microcontrollers for various industrial applications.
- CO2 - Choose appropriate family of microcontroller for different applications.
- CO3 - Interpret the communication standards of embedded systems.
- CO4 - Analyze the features of Real Time Operating System.
- CO5 - Develop the basic applications using Arduino.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/ s	Learning Scheme					Credits	Assessment Scheme										
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315338	EMBEDDED SYSTEM	ESY	DSC	5	-	2	2	9	3	3	30	70	100	40	25	10	25#	10	25	10	175

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.* 10 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 Identify the components of the embedded system and their functions. TLO 1.2 Describe the given characteristic of the specified embedded system. TLO 1.3 Classify the embedded system. TLO 1.4 List the selection factors of the embedded systems.	**Unit - I Overview of Embedded Systems** 1.1 Embedded system, block diagram description, layered model 1.2 Characteristics of embedded system: CPU type, maximum CPU speed, processing power, memory, performance 1.3 Classification of embedded system: small scale, medium scale, sophisticated, stand-alone, reactive/real time (soft and hard real time) 1.4 Selection criteria of embedded system: operating system, reliability, NRE cost, unit cost, size, flexibility, time to prototype, time to market, maintainability, correctness and safety	Lecture using Chalk-Board Presentations
2	TLO 2.1 Compare different types of micro controllers used for embedded system designing. TLO 2.2 Describe AVR microcontroller with the help of block diagram. TLO 2.3 Sketch the block diagram of ATmega 8 and describe the functions of each block. TLO 2.4 Compare specifications of microcontrollers ATmega 8 and ATmega 328. TLO 2.5 List the features of Arduino specific microcontrollers.	**Unit - II Microcontroller Architecture** 2.1 Microcontroller Types: PIC, AVR, ARM, features and applications 2.2 AVR microcontroller: types , architecture 2.3 ATmega 8: features, internal architecture 2.4 Programming configurations of ATmega 8: I/O port, peripherals counter, timer 2.5 Comparison of ATmega 8 and ATmega 328 2.6 Features of Arduino specific AVR microcontroller ATmega 168/328	Presentations Lecture using Chalk-Board Site/Industry Visit

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.
3	TLO 3.1 Describe the given type of modes for communication. TLO 3.2 Describe the given communication protocol(s) with relevant sketches. TLO 3.3 Describe the given wireless serial communication interface. TLO 3.4 Differentiate between given protocols for given parameters.	**Unit - III Communication Standards and Protocols** 3.1 Modes of communication: serial, parallel, synchronous and asynchronous 3.2 Communication Protocols its types: Serial: I2C, CAN, USB 3.3 Serial peripheral interface (SPI), IEC 61850 GOOSE (Protocol for Electric power system applications) 3.4 Wireless protocol : IrDA, Bluetooth, Zigbee, WiFi, LORA, LoWPAN	Lecture using Chalk-Board Presentations
4	TLO 4.1 Describe the functions of the given operating system. TLO 4.2 Compare RTOS and general OS for the given parameters. TLO 4.3 Describe features of RTOS with neat sketch. TLO 4.4 Explain deadlock condition in RTOS with suitable sketch.	**Unit - IV Real Time Operating System** 4.1 Operating system: general and real time operating system 4.2 Characteristics of real time operating system: consistency, reliability, scalability, performance, predictability 4.3 Functions of RTOS, Task management: inter task communication and multitasking, Scheduling: scheduling algorithms, resource allocation and interrupt handling 4.4 Features of RTOS: watchdog timer, semaphore 4.5 Deadlock: reasons of occurrence, handling of deadlock	Lecture using Chalk-Board Flipped Classroom Presentations
5	TLO 5.1 Enlist the different types of Arduino boards and their major features. TLO 5.2 Describe the working of development board using block diagram. TLO 5.3 Describe the given Arduino functions. TLO 5.4 Write steps to interface the given peripheral with Arduino. TLO 5.5 Interface the given sensor with Arduino.	**Unit - V I/O Interfacing with Arduino** 5.1 Arduino Board: introduction, types: Arduino UNO, NANO, MEGA 5.2 Functional Block Diagram of Arduino, pin functions of Arduino 5.3 Functions used in Arduino: math, analog I/O, digital I/O, timer 5.4 Peripheral interfacing with Arduino: keyboard, LCD, seven segment LED, relay, stepper motor, DC motor 5.5 Sensor interfacing with Arduino: temperature sensor, ultrasonic sensor	Lecture using Chalk-Board Presentations

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 pins and functions of AVR and PIC microcontroller.	1	*Identification of pins of AVR and PIC Microrontroller	2	CO1 CO2
LLO 2.1 Use an Integrated Development Environment (IDE) tool for developing C Programs of ATmega 168/328.	2	Use an IDE for ATmega 168/328 programming	2	CO2
LLO 3.1 Develop AVR C program to perform addition, subtraction, and multiplication operations on two constant data and output the result to port with some delay between each output.	3	*Write C program to perform various arithematic operations	2	CO2
LLO 4.1 Interface 4 x 4 LED matrix with AVR. LLO 4.2 Develop C program to display various patterns.	4	*Interface LED matrix with AVR microcontroller	2	CO2
LLO 5.1 Configure USB protocol on PC .	5	Serial Communication using USB	2	CO3
LLO 6.1 Install Arduino IDE and its development tool for Windows/MacOS/Linux operating systems.	6	*Installation of Arduino IDE for Windows/MacOS/Linux operating Systems	2	CO5
LLO 7.1 Build the circuit using 4 switches and 4 LEDs to Arduino Board. LLO 7.2 Test the LED on/off as per switch positions.	7	Building and Testing switch and LED interface using Arduino	2	CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 8.1 Develop programs to perform arithmetic operation using math functions: constrain (), max (), min (), Pow(), sq(), sqrt() uisng Arduino.	8	*Programs to perfrom arithematic operations on Arduino	2	CO5
LLO 9.1 Interface two 16 x 2 LCD modules with Arduino using I2C serial communication protocol.	9	*LCD Interfacing to Arduino board	2	CO5
LLO 10.1 Develop program to read the data from the temperature sensor through Arduino and display on LCD.	10	Temperature sensor interfacing to Arduino board	2	CO5

Note : Out of above suggestive LLOs -

- '*' 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)

Assignment

- List different types of sensors and actuators used with embedded system and also write application of each sensor
- Create a program to control a DC motor using PWM (Pulse Width Modulation).
- Interface a temperature sensor with Arduino and display the readings on the serial monitor
- Develop a simple program to blink an LED using assembly language.
- Implement SPI communication to control an LED matrix display.
- Conduct a market survey for various types of Arduino boards available

Micro project

- Control the position of a servo motor using Arduino
- Control home appliances using Arduino and relays
- Design digital soil moisture meter using Arduino
- Implement a digital clock using an RTC (Real-Time Clock) module
- Create a digital thermometer using arduino and a temperature sensor
- Implement an RFID-based door lock system using Arduino
- Create a simple home automation system to control appliances using an AVR/PIC microcontroller
- Measure distances using an ultrasonic sensor and display the results on an LCD
- Interface any I/O deice to Raspberry pi development board

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	Components: AVR, PIC Microcontroller	1
2	PIC Microcontroller: 32.768 KHz and 20 MHz Crystal, On-Board Debugger, USB Powered or externally powered, Adjustable target voltage	1
3	Temperature sensors; range -55 to 125Â°C	10
4	Simulation softwares: Arduino IDE, Atmel studio, Microchip studio.	3,4,7,8,9,10
5	Microcontroller kit (AVR ATmega 168/328 board and PIC): single board systems with minimum 8K RAM, ROM memory with battery backup, 16 x 4 LCD display, seven segment display, PC keyboard interfacing facility, cross 'C' compiler, USB, interfacing facility with built in power supply.	4
6	Arduino board UNO/ Nano or available microcontroller: ATmega328P, operating voltage: 5V input voltage (recommended): 7-12V input voltage (limit): 6-20V digital I/O pins: 14 (of which 6 provide PWM output) analog input pins: 6 DC current per I/O Pin: 20 mA DC current for 3.3V pin: 50 mA flash memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader SRAM: 2 KB (ATmega328P) EEPROM: 1 KB (ATmega328P) clock speed: 16 MHz LED bulit in: 13 dimensions: 68.6 mm x 53.4 mm weight: 25 g	6,7,8,9
7	LCD 16x2 Modules	9
8	Desktop PC with mininum RAM 4GB, Windows OS	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 Systems	CO1	8	4	4	4	12
2	II	Microcontroller Architecture	CO2	12	2	6	8	16

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
3	III	Communication Standards and Protocols	CO3	8	2	4	8	14
4	IV	Real Time Operating System	CO4	10	4	6	2	12
5	V	I/O Interfacing with Arduino	CO5	12	2	6	8	16
Grand Total				**50**	**14**	**26**	**30**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit tests of 30 marks and average of two unit test marks will be consider for out of 30 marks.
  â€¢For formative assessment of laboratory learning 25 marks.
  â€¢Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment is of 70 marks.
  â€¢ End semester summative assessment is of 25 marks for laboratory learning.

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	2	1	1	-	2			
CO2	3	3	2	2	1	1	2			
CO3	2	2	2	2	1	-	2			
CO4	2	1	2	2	1	1	2			
CO5	3	3	2	3	1	1	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

Sr.No	Author	Title	Publisher with ISBN Number
1	Raj Kamal	Microcontroller Architecture Programming, Interfacing and System Design	Pearson Education India, Delhi, 2012 ISBN: 978-8131759905
2	Muhamed Ali Mazidi, Sarmad Naimi, Sepehr Naimi	AVR Microcontroller and Embedded Systems: Using Assembly and C	Pearson Education India, Delhi, 2013 ISBN: 978-9332518407
3	Dawoud Shenouda Dawoud, Peter Dawoud	Serial Communication Protocols and Standards	River Publishers, Denmark, 2020 ISBN: 978-8770221542
4	David E. Simon	An Embedded Software Primer	Addison-Wesley, Delhi, 2002 ISBN: 978-9332518407
5	J.M.Hughes	Arduino: A Technical Reference	O'REILLY, 2016 ISBN: 978-1491921760
6	Jeremy Blum	Exploring Arduino Tools and Techniques for Engineering Wizardry	John Wiley & Sons, 2019 ISBN: 978-1118549360
7	Michael McRoberts	Beginning Arduino	APRESS, 2011 ISBN: 978-1430232414
8	K. V. K. K. Prasad	Embedded Real â€“Time Systems concepts, Design & Programming Black Book	Dreamtech Press New Delhi, 2003 ISBN: 978-8177224610
9	Frank Vahid, Tony Givargis	Embedded System Design A Unified Hardware/ Software Introduction	Wiley India, New Delhi,2006 ISBN: 978-0471386780

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.microchip.com/en-us/tools-resources/develop/microchip-studio	Microchip Studio for AVRÂ® and SAM Devices is an integrated development platform from Microchip
2	http://arduino.cc/	Link for Arduino Related Hardware and Software Download and installation
3	https://learn.sparkfun.com/tutorials/what-is-an-arduino	Arduino Basics
4	https://onlinecourses.swayam2.ac.in/aic20_sp04/preview	Introduction and Concepts of Arduino
5	https://support.arduino.cc/	Tutorials, data sheets, guides and other technical documentation
6	http://vlabs.iitkgp.ac.in/rtes/	Virtual lab link for Microcontrollers
7	https://semiconductors.es/datasheet-pdf/219613/ATMEGA32.html	Datasheet for ATmega Microcontrollers
8	https://www.alldatasheet.com/datasheet-pdf/pdf/82338/MICROCHIP/PIC16F877A.html	Datasheet for PIC Microcontroller

Note :

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