



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Automation and Robotics

Subject Code : DI04041011

Subject Name : Embedded Systems for Robotics

| | |
|--------------------------------|-----------------|
| w. e. f. Academic Year: | 2025-26 |
| Semester: | 4 th |
| Category of the Course: | PCC |

| | |
|----------------------|---|
| Prerequisite: | Fundamental of Electronics, Basic Programming Knowledge, Digital Techniques |
| Rationale: | The knowledge of embedded system and microcontrollers is essential in the field of Automation and robotics as the world is migrating towards automation rapidly in every field. By learning this course students can develop their own embedded system using microcontrollers which is application specific to solve given real time problems. Thus, this course is an important course for students who want to apply the skills and knowledge of automation using embedded technology in domestic, commercial, industrial and consumer goods from low end to high end applications. |

Course Outcome:

After Completion of the Course, Student will able to:

| No | Course Outcomes | RBT Level |
|-----|--|-----------|
| CO1 | Select appropriate microcontroller for given embedded system. | R, U, A |
| CO2 | Demonstrate architecture and working of AVR microcontroller | R, U, A |
| CO3 | Execute embedded C program of AVR microcontroller. | R, U, A |
| CO4 | Interface AVR microcontroller with input and output devices. | R, U, A |
| CO5 | Develop embedded industrial applications using AVR microcontroller.. | R, U, A |

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

| Teaching Scheme (in Hours) | | | Total Credits L+T+ (PR/2) | Assessment Pattern and Marks | | | | Total Marks |
|-------------------------------|---|----|------------------------------|------------------------------|--------|-------|----------------------|----------------|
| L | T | PR | | C | Theory | | Tutorial / Practical | |
| | | | ESE(E) | | PA(M) | PA(I) | ESE(V) | |
| 3 | 0 | 2 | 4 | 70 | 30 | 20 | 30 | 150 |



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Course Content:

| Unit | Topics and Sub-topics | No. Of Hrs. | % Weightage |
|---|--|-------------|-------------|
| Unit – I Introduction to Embedded System | 1.1 Embedded System definition, block diagram. 1.2 Embedded system architectures: Von Neumann vs Harvard. 1.3 Classification and characteristics of embedded systems. 1.4 Applications of embedded system. 1.5 Criteria for choosing microcontroller 1.6 Derivatives of microcontroller (from manufacturers Intel, Atmel, Microchip, Arduino). | 7 | 15 |
| Unit – II AVR Microcontroller Architecture | 2.1 History of the AVR microcontroller. 2.2 Features of AVR microcontroller 2.3 AVR family overview 2.4 Architecture of AVR microcontroller (ATmega32) 2.5 Data memory: General Purpose Registers, I/O Memory, Internal data SRAM, EEPROM Memory 2.6 Status register 2.7 Program Counter and memory 2.8 ATmega32 pin diagram 2.9 Input/ output ports pins, circuits & their alternate functions. 2.10 AVR fuse bits. 2.11 Clock and Reset Circuits 2.12 Operation of Timer/Counter in various mode. | 14 | 30 |
| Unit – III AVR Programming in C | 3.1 Data types and time delays in C. 3.2 I/O programming in C. (Byte size and bit size I/O) 3.3 Logic operations in C. (Bit-wise logic operators e.g. AND, OR, EX-OR, Inverter and shift operation. 3.4 Data serialization in C. 3.5 Memory allocation and programming in C. 3.6 Programming timers in C. 3.7 Interrupt programming in C. 3.8 AVR serial port programming in C. | 10 | 25 |
| Unit – IV AVR Interfacing | 4.1 LCD and Keyboard interfacing 4.2 ADC, DAC and sensor (LM 35) interfacing. 4.3 Relay, Opto-isolator and stepper-motor | 7 | 15 |



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|---|---|-----------|--------------|
| | interfacing 4.4 Interfacing of MAX7221 4.5 Basic c programs for above interfacing devices using Atmega32. 4.6 Working and programing in C for SPI. 4.7 functions of I2C-Two Wire Serial Interface (TWI) | | |
| Unit-V Embedded Robotic Applications | 5.1 Speed DC motor control and PWM 5.2 Line follower robot 5.3 Obstacle avoidance robot 5.4 Robotic arm control | 7 | 15 |
| | Total | 45 | 100 % |

Suggested Specification Table with Marks (Theory):

| Distribution of Theory Marks (in %) | | | | | |
|-------------------------------------|---------|---------|---------|---------|---------|
| R Level | U Level | A Level | N Level | E Level | C Level |
| 20 | 45 | 35 | - | - | - |

SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) that are the sub-components of the COs. *Some of the PrOs marked ‘*’ are compulsory, as they are crucial for that particular CO. These PrOs need to be attained at least at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.*

| Sr. No. | Practical Outcomes (PrOs) | Approx. Hrs. required |
|---------|---|-----------------------|
| 1 | Categorize the given microcontrollers based on architectures. | 2 |
| 2 | Compare architectures of embedded system. | 2 |
| 3 | Test AVR Micro-Controller Architecture. | 2 |
| 4 | Identify each block of ATmega32 with Pins. | 2 |
| 5 | Install Arduino IDE and its development tool. | 2 |
| 6 | Write ‘c’ program to perform logical operations. | 2 |
| 7 | Write ‘c’ program to generate different time delays. | 2 |
| 8 | Write ‘c’ program to transfer data serially. | 2 |



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| Sr. No. | Practical Outcomes (PrOs) | Approx. Hrs. required |
|---------|---|-----------------------|
| 9 | Identify the different blocks and pins on Arduino Uno and its functions. | 2 |
| 10 | Write 'c' program to write and read internal E ² PROM. | 2 |
| 11 | Write 'c' program to write and read external RAM. | 2 |
| 12 | Interface LCD to Atmega32 Microcontroller and Display message in scrolling or stationary mode. | 2 |
| 13 | Interface 4x4 matrix keypad to Atmega32 microcontroller and Display keys on LCD. | 2 |
| 14 | Interface ADC to Atmega32 microcontroller and display potentiometer voltage on LCD. | 2 |
| 15 | Construct circuit to interface DAC to Atmega32 microcontroller. Generate square/triangular wave and display on DSO. | 2 |
| 16 | Interface relay to Atmega32 microcontroller and control AC bulb ON/OFF using relay. | 2 |
| 17 | Interface DC motor to Atmega32 microcontroller and control the speed of DC motor. | 2 |
| 18 | Interface stepper motor to Atmega32 microcontrollers and Control speed/direction/ step angle of stepper motor. | 2 |
| 19 | Interface LM35 temperature sensor with Atmega32. | 2 |
| 20 | Interface DC motor using L293D Motor Driver. | 2 |
| 21 | Interface and control DC Motor Speed using Arduino Board. | 2 |
| 22 | Make Line-Follower Robot using Arduino. | 4 |
| 23 | Make Obstacle avoidance robot using Arduino. | 4 |
| 24 | Make Robotic arm control using Arduino. | 4 |
| | Total | 30 |

Note

- More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.
- The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency..



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| Sr. No. | Sample Performance Indicators for the PrOs | Weightage in % |
|--------------|--|----------------|
| 1 | Conceptual clarity | 20 |
| 2 | Experimental or Program Setup | 30 |
| 3 | Execution of Experiment or Program | 30 |
| 4 | Interpret the result and conclude | 20 |
| Total | | 100 |

MAJOR EQUIPMENT/ INSTRUMENTS AND SOFTWARE REQUIRED

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement of them by the administrators/management of the institutes. This will ensure conduction of practical in all institutions across the state in proper way so that the desired skills are developed in students.

| Sr. No. | Equipment Name with Broad Specifications | PrO. No. |
|---------|--|---|
| 1 | DC Power Supply | 3,4 |
| 2 | AVR Atmega32 Trainer Kit/ AVR Atmega32 Development Board | 3,4, 5, 6, 7, 8, 10,11, 12,13,14,15,16,17,18,19 |
| 3 | Atmel Studio (AVR) | 3,4, 5, 6, 7, 8, 10,11, 12,13,14,15,16,17,18,19 |
| 4 | Arduino IDE | 5, 6, 7, 8, 10,11, 21, 22, 23, 24 |
| 5 | Arduino Uno Board | 5, 9, 21, 22, 23, 24 |

AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfil the development of this competency.

- Work as a leader/a team member for assigned student activity.
- Follow safety practices and procedure in Lab.
- Realize the importance of engineering for societal development.
- Develop gradually the engineering mindset in day-to-day observation.
- Follow ethical practices.



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SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related *co-curricular* activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- a) Present seminar on various topics from course content.
- b) Prepare poster of embedded system application used for robotics.
- c) Prepare chart to represent the block diagram of different interfacing chips.
- d) Mini project for industrial application using ATmega32 Microcontroller.
- e) Prepare journals based on practical performed in laboratory.

SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Following Sample strategies teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- b) Guide student(s) in undertaking micro-projects.
- c) Some of the topics/sub-topics is relatively simple and very easy to the students for self-learning, but to be assessed using different assessment methods.
- d) Guide students for using latest Technical Magazine.
- e) Arrange visit to relevant industry.
- f) Show video lectures on Microcontroller Applications with help of internet.
- g) Programming practices on simulators (free downloadable).
- h) Inspire Student to read books on development and evolution networking, instruct them to take notes in form of summary
- i) Prepare a short note on applications of Embedded system for robotics.
- j) Guide students to make presentation on applications of robotics.
- k) Guide students Criteria for choosing microcontroller

SUGGESTED MICRO-PROJECTS

1. Prepare Specification Table for AVR microcontroller family.
2. Design a chart of ATmega32 Architecture.
3. Design minimum hardware system for ATmega32 circuit.
4. Develop ATmega32 based application board/circuit on PCB.
5. Design and Implement LED flasher circuit.
6. Design and Implement circuit for relay-based operation using switch.



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7. Design and Implement Room Temperature Monitor/Controller System
8. Design and Implement Water Level Indicator/controller circuit.
9. Build automatic door opening/ closing system.

SUGGESTED LEARNING RESOURCES

| Sr. No. | Title of Book | Author | Publication with place, year and ISBN |
|---------|--|--|--|
| 1 | The AVR microcontroller and Embedded System Using Assembly and C | Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naim | Pearson/ Prentice Hall, 1 st edition 2011, 978-0-13-800331-9 |
| 2 | Embedded C Programming and the Atmel AVR | Richard Barnett, Larry O'cull, Sarah Cox | Cengage Learning, 2 nd edition 2007, 978-1-4180-3959-2 |
| 3 | Programming and Interfacing ATMEL AVR Microcontrollers | Thomas Grace | Cengage Learning, Inc; 1 st edition 2015, 978-1305509993 |
| 4 | Introduction to Embedded Systems | Shibu K V | McGraw Hill Education India Private Limited; 2nd edition, 2017, 978-9339219680 |
| 5 | Embedded Systems | B Kanta Rao, | Prentice Hall (I), 1st edition, 2011, 978-8120340817 |
| 6 | Arduino for Beginners: Essential Skills Every Maker Needs | John Baichtal, | Que Publishing, 1st edition, 2013, 978-0789748836 |
| 7 | Introduction to Arduino: A piece of cake! | Alan G. Smith, | CreateSpace Independent Publishing Platform, 1st edition, 2011, 978-1463698348 |
| 8 | Getting Started with Sensors | Kimmo Karvinen and Tero Karvinen | Maker Media, 1st edition, 2014, 978-1449367084 |

SUGGESTED LEARNING WEBSITES

- i. <https://nptel.ac.in/courses/106105193>
- ii. <https://circuitstoday.com/program-and-upload-bootloader-in-new-atmega328p-ic-program-attiny25-45-85-atmega8-with-arduino-uno>
- iii. <https://www.mikroe.com/mikrocavr?srsId=AfmBOoo4oQycKvUuZCMtMz4j-PW8ByVelDswfVNB6qTowwj3iGqcTL6v>
- iv. https://www.mikroe.com/easyavr?srsId=AfmBOooaVq3uMUJY873BCoVdcKAG2BhHqyGpJ4eafQT_Or-n3iYpheqh



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- v. <https://www.intorobotics.com/>
- vi. https://www.tutorialspoint.com/embedded_systems/index.htm
- vii. <https://www.tutorialspoint.com/arduino/index.htm>

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