GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-IV

Course Title: Microcontroller
(Course Code: 4342404)

Diploma programmer in which this course is offered	Semester in which offered
Power Electronics	4th semester

1. RATIONALE

Today embedded systems are replacing various systems that used to be designed with a set of complex electronic circuits. Usually the heart of the embedded system is a microcontroller. There are thousands of Microcontrollers are available in Commercial Market. One example of a microcontroller base platform is Arduino. Arduino is an open source based prototyping platform used to sense and control physical devices. The rapid growth in science and technology offers several advantages to learners for using integrated circuits/microcontrollers in designing electrical and electronics products by reducing their size, cost, and complexity with smart and enhanced features.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Develop basic embedded system programs with the use of Arduino Microcontroller Board.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

CO 1) Explain basics of Microcontroller and Arduino.

CO 2) Develop program to interface Display and Digital Input/output Devices

CO 3) Develop program to interface with Analog Devices.

CO 4) Develop program to interface with Motors/ Actuators.

CO 5) Develop program to interface with special output devices.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	2	4	30*	70	25	25	150

** Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.*

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination*

5. SUGGESTED PRACTICAL EXERCISES

*Following practical outcomes (PrOs) that are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	To study of connectivity and configuration of Arduino Board circuit.	1	2*
2	Built program to toggle LED state control by time delay.	2	2*
3	Built circuit and program to interface LCD for display message.	2	2
4	Built circuit and program to toggle LED with Push Button andLCD.	2	2*
5	Built circuit and program to interface fire sensor with LED and LCD.	2	2*
6	Built circuit and program to interface PIR sensor with LED and LCD.	2	2*
7	Built circuit and program to interface Alcohol Sensor with LED and LCD.	2	2*
8	Built circuit and program to interface Ultrasonic Sensorand LCD.	3	2
9	Built circuit and program to interface Temperature Sensorand LCD.	3	2*
10	Built circuit and program to interface Humidity Sensorand LCD.	3	2*
11	Built circuit and program to interface LDRand LCD.	3	2
12	Built circuit and program to interface DC Motor and LCD.	4	2*
13	Built circuit and program to interface Stepper Motor and LCD.	4	2
14	Built circuit and program to interface AC Motor and LCD.	4	2*
15	Built circuit and program to interface Speaker.	5	2*
16	Built circuit and program to interface Transistor Driver & Relay.	5	2*
	Total		**32**

Note

i. *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.*

ii. *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.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These are the major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Board Name Arduino® Mega 2560 Rev3 Microcontroller ATmega2560, USB connector: USB-B, Built-in LED Pin: 13, Digital I/O Pins: 54, Analog input pins: 16, PWM pins: 15, CommunicationUART, I2C, SPI, Power I/O Voltage:	2 to 16

S. No.	Equipment Name with Broad Specifications	PrO. No.
	5V, Input voltage (nominal): 7-12V, DC Current per I/O Pin: 20 mA, Supported battery: 9V, Clock speed: ATmega2560 16 MHz, USB-Serial ProcessorATmega16U2 16 MHz, Memory:ATmega2560 8KB SRAM, 256KB FLASH, 4KB EEPROM	
2	Board Name Arduino® Nano Microcontroller ATmega328, USB connectorMini-B USB, Built-in LED Pin13, Digital I/O Pins14, Analog input pins8, PWM pins6, CommunicationUARTRX/TX, I2C, SPI, PowerI/O Voltage5V, Input voltage (nominal)7-12V, DC Current per I/O Pin20 mA, Clock speed: ProcessorATmega328 16 MHz, Memory ATmega328P2KB SRAM, 32KB flash 1KB EEPROM	2 to 16
3	Board Name Arduino® Due Microcontroller: AT91SAM3X8E, USB connector: Micro USB, Built-in LED Pin13, Digital I/O Pins54, Analog input pins12, Analog output pins2, PWM pins12, Communication CAN, UART, I2C, SPI, Power I/O Voltage3.3V, Input voltage (nominal)7-12V, DC Current per I/O pin (group 1)9 mA, DC Current per I/O pin (group 2)3 mA, Clock speedProcessorAT91SAM3X8E 84 MHz, MemoryAT91SAM3X8E96KB SRAM, 512KB flash	2 to 16
4	Board Name Arduino® Portenta H7 Microcontroller: STM32H747XI dual Cortex®-M7+M4 32bit low power Arm® MCU, USB connector USB-C, Digital I/O Pins22, Analog input pins8, PWM pins10, Connectivity: Murata Type 1DX shielded ultra-small Wi-Fi® 11b/g/n + Bluetooth® 5.1 moduleSecure elementNXP SE050C2 and ATECC608, Communication: UART, I2C, SPI, PowerCircuit operating voltage3.3V, Input voltage (VIN)5V, DC Current per I/O Pin8 mA, Clock speed: Main core480 MHz, Second core240 MHz,MemoryST STM32H747XI2MB Flash, 1MB RAM	2 to 16
5	Board Name Arduino® Portenta X8 Microprocessor4x ARM® Cortex® -A53 core up to 1.8GHz 1x ARM® Cortex® -M4 core up to 400 MHz, Microcontroller1x ARM® Cortex® -M7 core up to 480MHz (for internal use) 1x ARM® Cortex® -M4 core up to 240MHz, USB connectorUSB-C, Digital I/O Pins22, Analog input pins8, PWM pins4, Connectivity: Radio moduleMurata 1DX dual WiFi 802.11b/g/n 65 Mbps and Bluetooth 5.1 BR/EDR/LESecure ElementNXP SE050C2 Crypto, Communication: UART, I2C, SPI, PowerCircuit operating voltage3.3V, Input voltage (VIN)5V, DC Current per I/O Pin8 mA, MemoryRAM2 GB of Low Power DDR4 DRAM, Flash16 GB of eMMCST STM32H747XI2MB Flash, 1MB RAM	2 to 16
6	Board Name Arduino® Edge Control MicrocontrollernRF52840 (64 MHz Arm® Cortex-M4F), Digital InputEdge sensitive wake up pins6, Digital Output Latching relay command outputs with drivers8, Latching relay command outputs without drivers8, Relays60V/2.5A galvanically isolated solid state relays, 4Analog Input, 4-20mA inputs4, 0-5V analog inputs 8, Hydrostatic watermark sensor input16, Terminal Block Connectors18 pin plug in terminal block connectors6, Power Supply12 V Acid/lead SLA Battery Supply (Recharged via solar panels), Power Consumption: Low power (up to 34 months on a 12V/5Ah battery) 200uA Sleep current, Connectivity (* Requires Arduino MKR board)Bluetooth® Wifi* 3G*NB-IoT* LoRaWAN®*, Peripherals: Full-speed 12 Mbps USB Arm CryptoCell CC310 security subsystem SPI/SPI/TWI/I²S/PDM/QDEC High speed 32 MHz SPI Quad SPI interface 32 MHz 12-bit 200 ksps ADC 128 bit AES/ECB/CCM/AAR co-processor ,Memory: Onboard Flash memory1 MB, Onboard QSPI Flash memory2 MB, Interface for SD Card connector (through expansion port only)	2 to 16
7	Board Name Nicla Sense ME MicrocontrollerCortex-M4 nRF52832, USB connector Micro USB (USB-B), Pins LED built-in1 RGB LED (I2C), Digital I/O Pins10 (of which 2 are shared with I2C and 4 are shared with SPI), Analog input pins2, both shared with PWM, PWM pins12 (of which 2 are shared with analog, 2 are shared with I2C and 4 are shared with SPI)External interrupts12, ConnectivityBluetooth®ANNA B112 Bluetooth® module, Communication:UART, I2C, SPI, PowerMicrocontroller operating voltage1.8V translated to 3.3V on external pins, Board Power Supply (USB/VIN)5V, Supported batteryLi-ion/Li-Po Single Cell, 3.7V, DC Current per I/O pin4.7mA, Clock speedProcessor64MHz, RTCOn board of the ANNA-B112, MemorynRF52832	2 to 16

<table>
<tr><th>S. No.</th><th>Equipment Name with Broad Specifications</th><th>PrO. No.</th></tr>
<tr><td></td><td>System-on-chip64kB SRAM, 512kB flash2x MX25R1635FZUIH02MB for data logging, 2MB storage for BHI260AP</td><td></td></tr>
<tr><td>8</td><td>Sensors compatible for Arduino:
<table>
<tr><td>1. Ultrasonic Module</td><td>2. Hall magnetic sensor module</td></tr>
<tr><td>3. IR Infrared Obstacle Avoidance sensor</td><td>4. Button switch</td></tr>
<tr><td>5. Soil Hygrometer Detection Module</td><td>6. Laser module</td></tr>
<tr><td>7. Soil Moisture Sensor</td><td>8. SMD RGB module and RGB module</td></tr>
<tr><td>9. Microphone sensor</td><td>10. Photo-interrupter module</td></tr>
<tr><td>11. Digital Barometric Pressure Sensor</td><td>12. Mercury switch</td></tr>
<tr><td>13. Photoresistor sensor</td><td>14. Tilt switch module</td></tr>
<tr><td>15. Digital Temperature sensor</td><td>16. Reed switch module</td></tr>
<tr><td>17. Rotary Encoder Module</td><td>18. Dual-color common-cathode led</td></tr>
<tr><td>19. MQ-2,3,4,5,6,7,8,9 Gas sensor</td><td>20. Knock sensor</td></tr>
<tr><td>21. SW-420 Motion sensor</td><td>22. Mental touch module</td></tr>
<tr><td>23. Humidity and Rain Detection sensor</td><td>24. Analog temp module</td></tr>
<tr><td>25. Passive Buzzer Module</td><td>26. Photoresistor module</td></tr>
<tr><td>27. Speed sensor Module</td><td>28. 7 color flash led module</td></tr>
<tr><td>29. IR Infrared Flame Detection sensor</td><td>30. High-sensitive voice</td></tr>
<tr><td>31. 5V 2,4,8- Channel Relay module</td><td>32. Magic light cup module</td></tr>
<tr><td>33. Breadboard Power Supply Module 3.3V</td><td>34. joystick module</td></tr>
<tr><td>35. Pyroelectric Infrared Sensor</td><td>36. Linear hall and analog hall module</td></tr>
<tr><td>37. Accelerometer Module</td><td>38. Tracking and avoidance module</td></tr>
<tr><td>39. Temperature and Humidity sensor</td><td>40. Rotary encoders module</td></tr>
<tr><td>41. RF 433MHz Transmitter/Receiver</td><td>42. Heartbeat module</td></tr>
<tr><td>43. Shock switch</td><td></td></tr>
</table></td><td>2 to 16</td></tr>
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7. 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 fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical instruments and tools.
c) Realize importance of sensors and transducers in electronic circuits.

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit –	1a. State the need of	1.1 Microcontrollers: need, generalized

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Introduction to Microcontroller & Arduino Board	microcontroller with examples of its applications. 1b. List various commercially available microcontrollers with their manufacturer names. 1c. Classify Arduino Boards. 1d. Compare technical parameters of Uno, Mega and Nano Boards. 1e. Troubleshoot IDE and Arduino for programming.	block diagram, features of microprocessor and microcontroller 1.2 Various available Commercial microcontroller devices. 1.3 Arduino: Advantages, Various available boards, Technical specifications of Uno, Mega, Nano 1.4 IDE: Steps to Install IDE, Connecting Arduino, uploading code to Arduino, Learning Arduino code basics, Code basics: Arduino C, Code Basics – Arduino pins
Unit– II Arduino &Display and Digital Input/output Devices	2.a Explain interfacing of LED and LCD using circuit diagram and write a necessary program. 2.b Explain interfacing of Push Button, Fire Sensor and Passive IR Sensor with Light Emitting Diode/Liquid Crystal Display using Block diagram, circuit diagram and write a necessary program.	2.1 Interfacing of LED & LCD: Device Parameter, Circuit Diagram and Program 2.2 Interfacing of Push Button, Fire Sensor, Passive IR Sensor and Alcohol Sensor with Light Emitting Diode/Liquid Crystal Display: Device Parameter, Block Diagram, Circuit Diagram and Program
Unit– III Arduino & Analog Devices	3a. Explain interfacing of Ultrasonic Sensor, Temperature Sensor, Humidity Sensor, LDR with Liquid Crystal Display using Block diagram, circuit diagram and write a necessary program.	3.1 Interfacing of Ultrasonic Sensor, Temperature Sensor, Humidity Sensor, LDR with Liquid Crystal Display: Device Parameter, Block Diagram, Circuit Diagram and Program
Unit– IV Arduino and Motors/Actuators	4a. Explain interfacing of DC Motor, Stepper Motor, AC Motors using Block diagram, circuit diagram and write a necessary program.	4.1 Interfacing of DC Motor, Stepper Motor and AC Motors: Device Parameter, Block Diagram, Circuit Diagram and Program.
Unit– V Special output device and Applications	5a. Explain interfacing of Speaker, Transistor Driver, Relay Driver, Optocoupler using Block diagram, circuit diagram and write a necessary program. 5b. Describe the working of special Application case studies.	5.1 Interfacing of Speaker, Transistor Driver, Relay Driver and Optocoupler. 5.2 Special Application Case Study: A Fire-Fighting Robot Using Arduino, PM2.5/Air Quality Monitor Using Arduino, Intelligent Lock System Using Arduino.

***Note**: The UOs need to be formulated at an 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I.	Introduction to Microcontroller & Arduino Board	06	6	4	2	12
II.	Arduino & Display and Digital Input/output Devices	10	2	4	10	16
III.	Arduino & Analog Devices	10	2	4	12	18
IV.	Arduino and Motors/ Actuators	08	2	4	8	14
V.	Special output device and Applications	08	2	4	4	10
Total		**42**	**14**	**20**	**36**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. 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) Compare and analyze any four Arduino boards with their technical specifications and features.
b) Compare Arduino board with other smart controller board available in market with their features.
c) Prepare Hazard Analysis report for various E-Waste generated from Waste circuit boards.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the 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) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Use video/animation films to demonstrate various interfacing and programming of Arduino.
g) Guide students for selecting proper controller to develop embedded system.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) **Make embedded system to control any one household application.**
b) **Demonstrate use of Arduino with Interfacing of at least 05 various sensors and transducers for display purpose.**

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Arduino-Based Embedded Systems Interfacing, Simulation, and LabVIEW GUI	Rajesh Singh Anita Gehlot Bhupendra Singh Sushabhan Choudhury	CRC Press ISBN: 978-1-1380-6078-4 ISBN: 978-1-315-16288-1 (eBook)
2	Arduino Cookbook	Michael Margolis	O'Reilly Media, Inc. ISBN: 978-0-596-80247-9
3	Learn Electronics with Arduino	Don Wilcher	Apress ISBN: 978-1-4302-4266-6 ISBN: 978-1-4302-4267-3 (eBook)
4	Beginning Arduino	Michael McRoberts	Apress ISBN: 978-1-4302-3240-7 ISBN: 978-1-4302-3241-4 (eBook)
5	Designing Embedded Systems with Arduino A Fundamental Technology for Makers	Tianhong Pan Yi Zhu	Springer ISBN 978-981-10-4417-5 ISBN 978-981-10-4418-2 (eBook)
6	Exploring Arduino Tools and Techniques for Engineering Wizardry	Jeremy Blum	John Wiley & Sons, Inc. ISBN: 978-1-118-54936-0 ISBN: 978-1-118-54948-3 (eBook)
7	Arduino Development Cookbook	Cornel Amariei	Packt Publishing ISBN 978-1-78398-294-3
8	Arduino Applied	Neil Cameron	Apres ISBN: 978-1-4842-3959-9 ISBN: 978-1-4842-3960-5 (eBook)

14. SOFTWARE/LEARNING WEBSITES

a) https://www.arduino.cc/
b) https://learn.sparkfun.com/tutorials/what-is-an-arduino/all
c) https://projecthub.arduino.cc/
d) https://www.hackster.io/arduino/projects
e) https://circuitdigest.com/arduino-projects
f) https://www.tutorialspoint.com/arduino/index.htm
g) https://spoken-tutorial.org/tutorial-search/?search_foss=Arduino&search_language=Englishb
h) https://onlinecourses.swayam2.ac.in/aic20_sp04/course

15. PO-COMPETENCY-CO MAPPING

Semester IV	Microcontroller (4342404) POs and PSOs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Develop basic embedded system programs with the use of Arduino Microcontroller Board						
Course Outcomes							
CO 1) Introduction to Microcontroller & Arduino Board	2	1	1	2	1	1	1
CO 2) Arduino & Display and Digital Input/output Devices	2	3	2	2	2	2	3
CO 3) Arduino & Analog Devices	2	3	2	2	2	2	3
CO 4) Arduino and Motors/ Actuators.	2	3	2	2	2	2	3
CO 5) Special output device and Applications	2	3	2	2	2	2	3

Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1.	Mr. Sunil A. Patel, Lecturer in Power Electronics	Dr. S. & S. S. Ghandhy College of Engineering & Technology, Surat	+91-9898073753	Patel_sunil5@gtu.edu.in
2.	Shailesh L. Dhoriyani Lecturer in Power Electronics	Dr. S. & S. S. Ghandhy College of Engineering & Technology, Surat	+91-9913776990	shailesh.dhoriyani@gmail.com