

# GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

## Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)

VI– Semester

Course Title: Microcontroller Applications

(Course Code: 4366404)

<b>Diploma programmer in which this course is offered</b>	<b>Semester in which offered</b>
Renewable Energy Department	Six

### 1. RATIONALE

The microcontroller is at the heart of all embedded electronic devices and is widely used across various fields of electronics. These applications range from small consumer electronics to complex industrial process controllers. It is essential for diploma engineers to understand and maintain such systems. Developing programming skills will enable students to create their own microcontroller-based applications. This course is designed to equip students with the knowledge and skills needed to achieve these goals.

### 2. COMPETENCY

The purpose Students will develop the ability to understand and apply microcontroller concepts for embedded systems. They will gain proficiency in microcontroller architecture, programming, and interfacing techniques, enabling them to design, implement, and troubleshoot microcontroller-based applications. This competency will prepare students to:

1. Analyze and select suitable microcontrollers for various applications.
2. Write and debug efficient code to control microcontroller functions.
3. Interface microcontrollers with external devices and sensors.
4. Troubleshooting of microcontroller-based systems.

### 3. COURSE OUTCOMES (COs)

The theory should be taught, and practical exercises conducted, in a way that enables students to achieve learning outcomes across cognitive, psychomotor, and affective domains, allowing them to demonstrate the following course outcomes(Cos):

- a) Demonstrate and understanding of microcontroller architecture, operation, and key features.
- b) Able to Select appropriate microcontroller for different application
- c) Interface microcontroller with hardware for given application
- d) Write and execute assembly language programs(software) for given application
- e) Develop small microcontroller based applications.

### 4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
L	T	P		Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	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

The following practical outcomes (PrOs) 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’.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use 8051 Simulation tool	I	2
2	Test and verify the features of 8051 Trainer Kit	I	2
3	Write and execute assembly language programs based on Data transfer Instructions	II	2
4	Write and execute a simple program to understand microcontroller basics, including input and output operations.	II	2
5	Develop assembly language programs based on Arithmetic Instructions (e.g. 8 bit Addition , Subtraction, Multiplication, Division)	II	2
6	Develop Assembly Language Programs based on Logical Instructions (And, Or etc.)	II	2
7	Develop Assembly Language Programs based on Branch Instructions	II	2
8	Develop Assembly Language Programs to introduce delay (e.g. 1ms Delay) using Timer/Counter	III	2
9	Develop Assembly Language Programs for Interrupts	III	2
10	Develop Programs for serial communication	III	2
11	Develop a program to control LEDs and switches using digital input and output pins on the microcontroller.	III	2
12	Develop a program to interface LED with 8051	IV	2
13	Program the microcontroller to display numbers or characters on a seven-segment display.	IV	2
14	Develop a program to Interface 8 bit DAC with 8051	IV	2
15	Connect analog sensors (e.g., temperature sensor) to the microcontroller and read data using ADC.	IV	2
16	Develop a program to interface a DC Motor with 8051	IV	2
17.	Develop a program to interface LCD Module with 8051	V	2
18.	Develop a program to interface a Stepper Motor with 8051	V	2
19.	Develop a 4 bit binary counter with 8051 and display out put on LCD	V	2

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
20.	Develop a program to interface a Stepper Motor with 8051	V	2
	Minimum 10 Practical Exercises		28

**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.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Preparation and experimental setup	20
2	Setting and operation	20
3	Safety measure	10
4	Observation and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample question	10
7	Timely completion of term work	10
<b>Total</b>		<b>100</b>

## 5. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practicals in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	<b>8051 Microcontroller Development Board</b> <ul style="list-style-type: none"> <li>• <b>Microcontroller:</b> AT89S52 or AT89C51 (or compatible 8051 family microcontroller)</li> <li>• <b>Clock Frequency:</b> 11.0592 MHz crystal oscillator</li> <li>• <b>Memory:</b> 8 KB Flash memory, 256 bytes RAM</li> <li>• <b>Power Supply:</b> 5V DC, onboard voltage regulator (7805 IC)</li> <li>• <b>I/O Ports:</b> 32 general-purpose I/O pins, accessible via header connectors</li> <li>• <b>Programming Interface:</b> ISP (In-System Programming) using USB or serial interface</li> </ul>	ALL
2.	<b>Power Supply Unit</b> <ul style="list-style-type: none"> <li>• <b>Input:</b> 220V AC</li> <li>• <b>Output:</b> 5V DC regulated, 500mA–1A (for powering the development board)</li> <li>• <b>Voltage Regulation:</b> 7805 voltage regulator IC</li> <li>• <b>Protection:</b> Short circuit and overload protection</li> </ul>	ALL

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
3	Desktop PC with microcontroller simulation software	ALL
4	ADC 0808 Trainer Board	15
5	DAC 0808 Trainer Board	14
6	DC Motor setup ( <b>Motor Type:</b> 5V/12V DC motor, <b>Driver:</b> L293D or H-Bridge motor driver IC)	16
7.	Stepper Motor setup ( <b>Motor Type:</b> Unipolar or Bipolar stepper motor (5V or 12V), <b>Driver:</b> ULN2003A or L293D motor driver IC for interfacing)	18
8.	LCD Trainer Board ( <b>Display Type:</b> 16x2 LCD (HD44780-compatible) <b>Voltage:</b> Operates on 5V)	17
9.	Seven segment LED Display (0.56 in 1 digit common anode/cathode)	11
10.	<b>Breadboard and Connecting Wires</b> <ul style="list-style-type: none"> <li>• <b>Breadboard:</b> 830-point solder less for circuit prototyping</li> <li>• <b>Wires:</b> Male-to-male, male-to-female jumper wires for connections</li> </ul>	ALL

## 6. 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 course competency.

- a) Work as a leader/a team member (while doing a micro-project)
- b) Follow safety practices while using Electrical supply and electrical equipment.
- c) Follow ethical practices.
- d) Practice environmental friendly methods and processes. (Environment related)

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 1<sup>st</sup> year
- ii. 'Organization Level' in 2<sup>nd</sup> year.
- iii. 'Characterization Level' in 3<sup>rd</sup> year.

## 8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such 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 different levels)	Topics and Sub-topics
<b>Unit -I</b> <b>Introduction to microcontroller</b>	<b>1a.</b> Describe functions of each Block. diagram of generic digital computer <b>1b.</b> Describe common features of Microcontrollers <b>1c.</b> Differentiate between microprocessor & microcontroller <b>1d.</b> Describe Evolution of Microcontrollers <b>1e.</b> Explain various architectures of microcontroller <b>1f.</b> Describe applications of microcontrollers	<b>1.1</b> Block diagram of microcontroller : CPU, input device, output device, memory and buses <b>1.2</b> function of following parts of Microcontrollers : IO pins, On-chip Oscillator, program and data memory, I/O Ports, Watchdog- timer reset, SFRs, Timers, Counters, Interrupts, ADC, PWM <b>1.3</b> comparison between microprocessor and microcontroller <b>1.4</b> Hierarchy of microcontrollers <b>1.5</b> Applications: House hold , Communication, Office equipment and industrial automation
<b>Unit-II</b> <b>8051 Hardware</b>	<b>2a.</b> Explain functions of each block of 8051 microcontroller <b>2b.</b> Explain Pin Diagram of 8051 <b>2c.</b> Distinguish of clock, reset and machine cycle of 8051 with the help of relevant waveform <b>2d.</b> Explain Memory organization of 8051 <b>2e.</b> Differentiate Stack , Stack Pointer and stack operation <b>2f.</b> Describe modes of operation of Timers/Counters <b>2g.</b> Explain function and structure of I/O Ports <b>2h.</b> Describe Serial Communication <b>2i.</b> Explain various controlling modes of 8051	<b>2.1</b> Blocks of Microcontroller 8051: ALU, PC, DPTR, PSW, Internal RAM, Internal ROM, Latch, SFRs, General purpose registers, Timer/Counter, Interrupt, Ports. <b>2.2</b> Functions of each pin of 8051 <b>2.3</b> Clock circuit, reset Circuit ,phase and state in machine cycle of 8051 <b>2.4</b> Memory organization of 8051: Program and Data memory Map, External Memory Addressing and Decoding Logic of 8051 <b>2.5</b> Stack, Stack Pointer and Stack operation. <b>2.6</b> Timers/Counters logic diagram and its operation in various modes. <b>2.7</b> I/O Ports structure: Port 0, Port 1, Port 2, Port 3. <b>2.8</b> Serial Communication in various modes <b>2.9</b> Modes of operation: Power down and idle mode

<b>Unit</b>	<b>Unit Outcomes (UOs)</b> (4 to 6 UOs at different levels)	<b>Topics and Sub-topics</b>
<b>Unit-III</b> <b>8051</b> <b>Programming</b>	<p><b>3a.</b> Classify addressing modes of 8051 with example</p> <p><b>3b</b> Arrange the collection of 8051a instructions according to the tasks they carry out.</p> <p><b>3c</b> Describe the looping, counting, and indexing programming concepts.</p> <p><b>3d.</b> Create basic programs to carry out the following tasks: Data processing, masking, stacking</p> <p><b>3e</b> Explain functions of Timer/ Counters and its application and mode of timers.</p> <p><b>3f.</b> Explain I/O Port Programming</p>	<p><b>3.1</b> Addressing Modes: Immediate, Register, Direct, Indirect, Indexed Relative and bit addressing.</p> <p><b>3.2</b> Instruction set: Data Transfer, Arithmetic, Logical, Branching, and Machine Control.</p> <p><b>3.3</b> Looping, counting, sorting and indexing.</p> <p><b>3.4</b> Data manipulation, Masking, Stack operation.</p> <p><b>3.5</b> Configuration and programming of Timer/Counter using SFRs: TMOD, TCON</p> <p><b>3.6</b> Configuration and programming of I/O Port : P0,P1,P2,P3</p>
<b>Unit-IV</b> <b>8051</b> <b>Interfacing</b>	<p><b>4a.</b> Interface Input and Output Devices with 8051 microcontroller</p> <p><b>4b.</b> Interface ADC and analog input device with 8051 microcontroller</p> <p><b>4c.</b> Interface DAC and analog output device with 8051 microcontroller.</p> <p><b>4d.</b> Interface actuator with 8051 microcontroller</p>	<p><b>4.1</b> Interface below IO device with 8051 <b>Input Device</b> : Switch: Pushbutton, DIP, Thumbwheel, Tilt <b>Output Device</b> : Relay,LED,7 segment LED,LCD</p> <p><b>4.2</b> ADC0804 and Temperature sensor LM35</p> <p><b>4.3</b> DAC0808 and Damper Control, Hoper Control</p> <p><b>4.4</b> Speed control of DC Motor, Stepper motor</p>
<b>Unit-V</b> <b>8051</b> <b>Applications</b>	<p><b>5a.</b> Enumerate Different 8051 Use Cases</p> <ul style="list-style-type: none"> <li>✓ Temperature Monitoring and Control</li> <li>✓ Battery voltage logging system (BMS)</li> <li>✓ GSM based Security Application.</li> <li>✓ Solar tracker system</li> </ul>	<p><b>5.1</b> Temperature control using LM35, ADCC0804, Microcontroller, 7 segment LED</p> <p><b>5.2</b> BMS system using Analog Multiplexer4051,ADC0804,Microcontroller, 7 segment LED,MAX232</p> <p><b>5.3</b> Security system using GSM Modem, Microcontroller, Relay, Switches.</p> <p><b>5.4</b> Solar tracker using Microcontroller, 7 Segment LED and Stepper motor.LDR.</p>

## 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 of Microcontrollers	9	4	6	4	14
II	8051 Hardware	11	8	6	4	18
III	8051 Programming	10	6	5	4	15
IV	8051 Interfacing	7	4	5	4	13
V	8051 Applications	5	2	2	6	10
Total		42	24	24	22	70

**Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

**Note:** This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to 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 slightly vary 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 perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

- Present seminar on various topics from course content.
- Present seminar on latest controller used in modern machinery.
- Create and present posters on architecture of various microcontroller and its applications.
- Prepare general comparison table among various microcontroller version 8051,8052,8031
- Implement a simple traffic light controller using the 8051.

The student should be encouraged to get their work assessed by the concerned teacher progressively during the term and at the end of the term the whole work should be submitted to the concerned teacher.

## 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:

- Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
- Guide student(s) in undertaking micro-projects.
- 'L' in section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- Show animation/ video related to course content.
- Co-relating the importance of content of this course with other courses and practical applications.
- Organize a visit to a PCB or embedded system manufacturing or design related company

## 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-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, 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 duration of the micro project should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students 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:

### 1. LED Blinking and Pattern Display

Objective: Learn how to control basic output devices like LEDs using the 8051 microcontroller.

- Activity: Write a program to blink an LED connected to a GPIO pin of the 8051. Expand the activity to create different LED patterns (e.g., running lights, wave patterns).
- Skills: GPIO programming, basic logic, delay routines.

### 2. Traffic Light Controller Simulation

Objective: Implement a simple traffic light controller using the 8051.

- Activity: Use the 8051 to control the sequence of traffic lights (Red, Yellow, Green). Students can simulate these using LEDs to represent the traffic lights.
- Skills: Timing, control logic, sequencing.

### 3. 7-Segment Display Driver

Objective: Interface a 7-segment display with the 8051 to show numeric values.

- Activity: Write a program to display digits 0-9 on a 7-segment display. Students can expand this to show hexadecimal values or create a clock-like display.
- Skills: Binary-to-decimal conversion, I/O control, hardware interfacing.

### 4. Temperature Sensing with LM35

Objective: Interface a temperature sensor (e.g., LM35) with the 8051 microcontroller.

- Activity: Design a project where the 8051 reads temperature data from an LM35 sensor and displays the temperature on a 7-segment display or LCD screen.
- Skills: ADC conversion (simulated) sensor interfacing, analog-to-digital conversion.

### 5. Serial Communication (UART)

Objective: Learn the basics of serial communication and how to transmit data between the 8051 and a computer.

- Activity: Use the UART feature of the 8051 to send data to a PC through a serial interface (e.g., using a USB-to-serial adapter).

- Skills: Serial communication, baud rate settings, data transmission/reception.

## 6. Automatic Fan Speed Control

Objective: Use the 8051 to control a fan's speed based on temperature readings.

- Activity: Interface a temperature sensor with the 8051 and control the fan's speed using PWM based on the temperature input.
- Skills: PWM control, temperature sensing, automation.

## 13. SUGGESTED LEARNING RESOURCE

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	"8051 Microcontroller: Architecture, Programming, and Applications"	Kenneth J. Ayala	<b>Publisher:</b> Penram International Publishing (India) Pvt. Ltd. <b>Edition:</b> 3rd Edition (2004) <b>ISBN-13:</b> 978-0763740715 <b>ISBN-10:</b> 0763740716
2	"The 8051 Microcontroller and Embedded Systems"	Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay	<b>Publisher:</b> Pearson Education <b>Edition:</b> 2nd Edition (2006) <b>ISBN-13:</b> 978-0131181404 <b>ISBN-10:</b> 0131181403
3	"8051 Microcontroller: Internals, Instructions, Interfacing, Programming & Applications"	Dhanraj Bhosale	<b>Publisher:</b> Pearson Education India <b>Edition:</b> 1st Edition (2014) <b>ISBN-13:</b> 978-9332515307 <b>ISBN-10:</b> 933251530X
4	"8051 Microcontroller: An Application-Based Introduction"	J. B. Dixit	<b>Publisher:</b> Wiley India Pvt. Ltd. <b>Edition:</b> 1st Edition (2012) <b>ISBN-13:</b> 978-8126537116 <b>ISBN-10:</b> 8126537113

## 14. SOFTWARE/LEARNING WEBSITES

### Software Tools for 8051 Microcontroller:

#### 1. KEIL $\mu$ Vision (IDE and Compiler)

- **Description:** KEIL  $\mu$ Vision is a widely used integrated development environment (IDE) for 8051 microcontroller programming. It provides a powerful debugger and supports assembly language and C programming for 8051-based systems.
- **Website:** [KEIL  \$\mu\$ Vision](#)
- **Features:**
  - ✓ C, C++, and assembly programming
  - ✓ Integrated debugger and simulator
  - ✓ Supports hardware debugging via JTAG

#### 2. Proteus (Simulation Software)

- **Description:** Proteus is a simulation tool for embedded systems, where you can design circuits and simulate the 8051 microcontroller along with other peripherals (like LCDs, motors, sensors). It's widely used for testing and validating embedded designs.
- **Website:** [Proteus](#)
- **Features:**
  - ✓ Circuit simulation and PCB design
  - ✓ Support for embedded programming (8051, PIC, AVR, ARM)

### Learning Websites for 8051 Microcontroller

- TutorialsPoint - 8051 Microcontroller
- Coursera - Embedded Systems

- All About Circuits - 8051 Microcontroller

**Video link for 8051 microcontroller:**

- **Great Learning:** [Great Learning - 8051 Tutorials](#)
- **Electronics Projects:** [Electronics Projects YouTube](#)
- **Learning Points:** [Learning Points - 8051 Projects](#)

**15. PO-COMPETENCY-CO MAPPING:**

Semester IV	Microcontroller and its Applications (Course Code: )						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solution	PO4 Engineering Tools, Experimentation Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
<b>Competency</b>	<i>The purpose Students will develop the ability to understand and apply microcontroller concepts for embedded systems.</i>						
<b>Course Outcomes</b>							
CO1 Demonstrate an understanding of microcontroller architecture, operation, and key features	2	--	--	--	--	--	1
CO2 Able to Select appropriate microcontroller for different application	2	--	--	--	--	--	2
CO3 Interface microcontroller with hardware for given application	--	1	--	2	--	1	--
CO4 Write and execute assembly language programs (software) for given application	2	--	1	--	--	--	1
CO5 Develop small based microcontroller applications.	--	1	--	1	--	--	--

*Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.*

**16. COURSE CURRICULUM DEVELOPMENT COMMITTEE**

**GTU Resource Persons**

S. No	Name and Designation	Institute	Contact No.	Email
1.	Kirit M. Hothi Lecturer Electrical Engg.	AVPTI, Rajkot	7779081811	kmh.avpt@gmail.com