



# GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Biomedical Engineering

Subject Code: DI04003011

Subject Name: Microcontroller in Medical Devices

w. e. f. Academic Year:	2025-26
Semester:	4 <sup>th</sup>
Category of the Course:	PCC

<b>Prerequisite:</b>	Basic knowledge of electronics, digital circuits, and biomedical sensors.
<b>Rationale:</b>	Microcontrollers are the core of modern biomedical equipment such as ECG machines, patient monitors, ventilators, infusion pumps, pulse oximeters, and digital thermometers. Diploma biomedical engineers must understand the fundamentals of microcontrollers, especially 8051, programming basics, sensor interfacing, and ADC and patient data acquisition principles. This course develops essential skills required to work with MCU-based medical devices in hospitals and clinical settings.

## Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level
1	Outline the fundamentals of microcontrollers and identify common applications of MCUs in biomedical devices.	Understand
2	Describe 8051 architecture & hardware features	Understand
3	Apply 8051 addressing modes and data-transfer instructions to write assembly programs for moving, storing, and handling data.	Apply
4	Implement arithmetic, logical, bit-level, branching, instructions of the 8051 to perform basic control and decision-making tasks.	Apply
5	Interface external peripherals with the 8051 and demonstrate simple biomedical applications.	Analyze

*\*Revised Bloom's Taxonomy (RBT)*



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### 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)	
2	0	4	4	70	30	20	30	150

### Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	<b>Introduction to Microcontrollers in Medical Devices</b>	04	
	1.1 Basic Concepts of microprocessor and microcontroller 1.2 Comparison of microprocessor and microcontroller 1.3 Features and selection factors for microcontroller 1.4 Advantages & Disadvantages of microcontroller 1.5 Types of buses 1.6 Applications in Medical Technology		18%
2	<b>8051 Architecture and Hardware Fundamentals</b>	10	
	2.1 Introduction 2.2 8051 block diagram Function of each block 2.3 Pin diagram of 8051 microcontroller and function of each pin 2.4 DPTR 2.5 Various registers 2.6 program status word PSW 2.7 Internal memory Internal RAM organization Internal ROM 2.8 Stack and stack pointer 2.9 Special function registers (list) 2.10 Difference between timer & counter 2.11 Define interrupt.		30%
3	<b>Addressing Modes and Data Handling Instructions</b>	05	
	3.1 Various Addressing Modes Of 8051. 3.2 External Data Moves.		15%



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	3.3 Push and Pop instructions. 3.4 Data exchanges. 3.5 Simple Example programs.		
4	<b>Processing and Control Instructions of 8051</b>	06	
	4.1 Introduction 4.2 Byte & Bit Level Logical Operation 4.3 Rotate and Swap Operation 4.4 Incrementing and Decrementing 4.5 Additions & Subtraction 4.6 Branch and Jump Instructions. 4.7 Logical operations such as AND, OR, XOR, NOT, CLR, CPL. 4.8 Simple Example Programs		20%
5	<b>8051 Interfacing for Medical Applications</b>	05	
	5.1 Interfacing of 8051 with output devices; LCD display 5.2 Interfacing of 8051 with A/D converter 5.3 Patient Data Acquisition System 5.4 Temperature Monitoring Using 8051		17%
	<b>Total</b>	<b>30 Hrs.</b>	<b>100 %</b>

**Suggested Specification Table with Marks (Theory):**

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
25 %	40 %	35 %	--	--	--

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

**References/Suggested Learning Resources:**

**(a) Books**

S. No.	Title of Book	Author(s)	Publication / Year
1	<i>The 8051 Microcontroller: Architecture, Programming and Applications</i>	Ayala, Kenneth J.	Wiley Eastern Ltd., New Delhi, Latest Edition
2	<i>Microprocessor and</i>	Singh, B. P.	Tata McGraw-Hill



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	<i>Microcontrollers</i>		(TMH), New Delhi, Latest Edition
3	<i>The 8051 Microcontroller and Embedded Systems: Using Assembly and C</i>	Muhammad Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay	Pearson Education India, New Delhi, Latest Edition
4	<i>8051 Microcontrollers: MCS-51 Family and Its Variants</i>	Shah, Satish	Oxford University Press, New Delhi, Latest Edition
5	<i>8051 Microcontroller: Internals, Instructions, Programming and Interfacing</i>	SubrataGhoshal	Pearson Education, New Delhi, Latest Edition
6	<i>The 8051 Microcontrollers: Architecture, Programming and Applications</i>	Rao, K. Uma; AndhePallavi	Pearson Education, New Delhi, Latest Edition
7	<i>Biomedical Instrumentation and Measurements (2nd Edition)</i>	Jog	PHI (Prentice-Hall of India), Latest Edition

### (b) Open-source Software & Websites

S. No.	Software / Website	Description / Use
1	Keil $\mu$ Vision	8051 assembly program development & debugging
2	EdSim51 Simulator	Free 8051 emulator for instruction-level execution
3	Proteus (Lite)	MCU interfacing simulation with LCD/ADC/sensors
4	Tinkercad Circuits	Basic electronic & controller practice
5	<a href="http://www.8051projects.net">www.8051projects.net</a>	Interfacing tutorials + sample projects
6	<a href="http://www.elprocus.com">www.elprocus.com</a>	Microcontroller explanations & circuit help
7	NPTEL Online Lectures	Embedded systems & microcontroller courses
8	GitHub 8051 repos	Open-source 8051 example codes

### Suggested Course Practical List: If any

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hours Required
1	Study Keil $\mu$ Vision / EdSim51 Simulator	3	4
2	Outline 8051 microcontroller architecture & pinout diagram	2	4
3	Learn 8051 microcontroller programming model	2	2
4	Execute assembly language programs using various addressing modes	3	4



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5	Execute assembly language programs to transfer data from source to destination location. (Internal/ External Memory)	3	2
6	Execute assembly language programs to perform arithmetic operations. e.g. addition, subtraction, multiplication, division	4	4
7	Execute assembly language programs to perform SWAP and Rotate instruction.	4	2
8	Execute assembly language programs to perform branching instructions.	4	4
9	Study of various timer modes (TMOD & TCON).		
10	Execute an assembly language program to generate delay using a timer.	3,4	4
11	Execute an assembly language program to generate pulse and square wave using timer.	4	4
12	Study of serial and parallel communication in 8051.	2	2
13	study of asynchronous and synchronous communication in 8051	2	2
14	Study of various serial control modes in 8051. (SCON/ SBUF)	2	2
15	Execute assembly language programs on serial transmission with different baud rates.	4	4
16	Study of various interrupts in 8051(IE & IP)	2	2
17	Execute assembly language programs on interrupts	4	4
18	Interface matrix keypad with microcontroller and display the key pressed.	5	4
19	Interface relay with microcontroller and turn it ON and OFF	5	4
20	Interface seven segment displays with microcontroller to display decimal number from 0 to 9.	5	4
21	Interface LCD with microcontroller to display the character and decimal numbers.	5	4
	Interface ADC with microcontroller to receive analog input data	5	4
22			
23	Interface temperature sensor with microcontroller to measure ambient temperature.	5	4



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24	Interface D to A converter using 8051.	5	4
25	Write assembly language program for the given application in bio medical instrumentation using 8051 and test	5	4
	<b>Total</b> (practical for 60 hours from above representing each unit may be selected)		80

### List of Laboratory/Learning Resources Required:

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

1. 8051 trainer kits or 8051 development boards
2. LM35 temperature sensor
3. Heartbeat (pulse) sensor module
4. ADC0804, DAC0808 modules
5. LCD 16×2, LEDs, buzzer modules
6. Keypad (4×3, 4×4)
7. Motor driver IC (L293D/L298)
8. Miniature DC/stepper motor
9. CRO/DSO and multimeters
10. Keil  $\mu$ Vision, EdSim51, Proteus simulation software
11. Breadboards, jumper wires, power supplies

### Suggested Project List:

The projects serve as practical learning experiences for students in the field of Biomedical Engineering. These projects integrate theoretical knowledge with hands-on application, fostering competency development across various Course Outcomes (COs). Below are guidelines for designing and executing projects:

- **Project Types:**
  - It can be industry-based, workshop-based, laboratory-based, or field-based.
  - Each project should align with specific COs and address real-world challenges.
- **CO Integration:**
  - It should encompass two or more COs.



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- Integration involves aligning Program Outcomes (PrOs), Unit Outcomes (UOs), and Assessment and Design Outcomes (ADOs).
- **Project Duration:**
  - Students are encouraged to maintain a dated work diary to document their individual contributions and sufficient engagement time for each project should be allocated by faculty during the course.
- **Project Demonstration:**
  - Before submission, students must give a project demonstration on their project.
  - The presentation should highlight the project's objectives, methodology, results, and relevance to industry-oriented COs.
- **Seminar Presentation:**
  - Before submission, students must give a seminar presentation on their project.
  - The presentation should highlight the project's objectives, methodology, results, and relevance to industry-oriented COs.

Following are suggestive projects, and additional ones can be tailored to specific course objectives. Encourage students to explore innovative solutions and apply their engineering skills effectively.

Using various fundamental knowledge of medical electronics engineering students may develop mini/micro projects based on team/individual basis which concrete their fundamentals of medical electronics hardware and can work as prototypic models in various societal applications. Following are the suggested list of projects:

- 1) LM35-based temperature monitoring system
- 2) Digital heartbeat counter (pulse sensor + 8051)
- 3) UART-based patient data logger (8051 → PC)
- 4) Mini infusion pump (stepper motor prototype)
- 5) Simple ECG acquisition block (front-end + ADC + MCU)
- 6) Alarm-based biomedical monitoring demo etc.

**Suggested Activities for Students: If any**



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In addition to classroom and laboratory learning, students are encouraged to engage in co-curricular activities that enhance their understanding and practical skills. These activities can be conducted in groups on breadboard or PCB should be used and it should be documented in 5-page reports. Collecting physical evidence of their work will also contribute to their portfolio, which can be valuable during placement interviews.

## **Hands-on Microcontroller Programming**

- **Activity:** Write and execute basic 8051 programs (MOV, ADD, logical ops, delay loops) on trainer kits or simulators.
- **Objective:** Strengthen understanding of instruction execution, register operations, and debugging.

## **Simulation-Based MCU Practice**

- **Activity:** Use Proteus, EdSim51, or Keil  $\mu$ Vision to simulate 8051 programs and peripheral interfacing (LED, LCD, ADC).
- **Objective:** Verify program logic and observe timing, port behaviour, and hardware response

## **Sensor Interfacing Challenge**

- **Activity:** Interface LM35, pulse sensor, or simple biomedical sensors with 8051 and display output on LCD.
- **Objective:** Apply sensor interfacing concepts in a real biomedical measurement scenario.

## **Troubleshooting & Debugging Practice**

- **Activity:** Provide students with incorrect or partially working 8051 codes/circuits and let them identify & fix errors.
- **Objective:** Develop debugging, logical reasoning, and error-tracing skills.

## **Mini-Project Group Activity**

- **Activity:** In small teams, build a working prototype (e.g., temperature monitor, heart-rate display, keypad-controlled device, or patient DAQ).
- **Objective:** Encourage teamwork, circuit-building, 8051 interfacing, and presentation skills.



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## Datasheet Interpretation

- **Activity:** Study datasheets of components such as 8051, ADC0804, DAC0808, LM35, LCD 16×2, L293D.
- **Objective:** Learn to extract pin configuration, timing diagrams, electrical characteristics, and interfacing guidelines.

## Expert Lecture or Hospital/Industry Visit

- **Activity:** Arrange a guest lecture by a biomedical engineer or visit a hospital/biomedical maintenance lab.
- **Objective:** Connect microcontroller applications with real-world medical devices and industry practices.

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