Unit 4: Microcontrollers in Biomedical Engineering

I. Pre-reading

A. New Vocabulary

Word	Form	Definition / Synonym	Persian Translation
microcontroller	n	a compact integrated circuit that controls a device	میکروکنترلر
embedded system	n	a computer system within a larger device	سیستم نهفته / تعبیه شده
processor	n	the component that executes program instructions	پردازنده
sensor	n	a device that detects or measures a physical property	حسگر
actuator	n	a device that converts electrical signals into motion	عملگر
analog	adj	relating to continuous electrical signals	آنالوگ
digital	adj	relating to discrete numerical signals	دیجیتال
automation	n	operation with minimal human control	خودکارسازی
feedback	n	information returned to control a process	بازخورد
prototype	n	an early model of a device	نمونه اولیه
integration	n	combining parts into a whole	یکپارچه‌سازی
reliability	n	ability to perform consistently and correctly	قابلیت اطمینان
optimization	n	making something as effective as possible	بهینه‌سازی

B. Building Vocabulary

Root	Meaning	Example
micro	small	microcontroller, microscope
auto	self	automatic, autonomy
sens	feel, detect	sensor, sensitive
act	do, move	actuator, action
embed	fix firmly	embedded, embedding

Root	Meaning	Example
proto	first	prototype, protocol
feed	supply	feedback, feeder
opti	best	optimize, optimal
med	heal	medical, medicine

C. Pre-reading Questions

1. What is a microcontroller, and how is it different from a computer?
2. Why are microcontrollers important in biomedical devices?
3. What kinds of sensors are commonly used with microcontrollers?
4. How do engineers test and optimize embedded systems in healthcare?

II. Reading

Microcontrollers in Biomedical Engineering

A **microcontroller** is a small computer on a single integrated circuit containing a **processor**, **memory**, and **input/output (I/O)** ports. It is designed to perform specific control tasks within larger systems, often as part of an **embedded system**. In biomedical engineering, microcontrollers are essential components of modern **diagnostic**, **monitoring**, and **therapeutic** devices.

Microcontrollers are used to control and process signals from various **biomedical sensors**, such as temperature sensors, heart rate monitors, and oxygen saturation probes. The collected data is processed and displayed in real time, allowing clinicians to make accurate and timely decisions. For example, a microcontroller in a **patient monitoring system** reads ECG or pulse data, converts it from **analog to digital**, and transmits it for further analysis.

Biomedical engineers use microcontrollers in **infusion pumps**, **ventilators**, **prosthetic limbs**, and **wearable health devices**. In prosthetics, for instance, the microcontroller interprets muscle or nerve signals and activates the **actuator** to move an artificial limb. In ventilators, it adjusts airflow and pressure based on patient feedback to maintain proper breathing support.

Programming is a crucial part of microcontroller design. Engineers write **embedded software** to define how the system responds to inputs and controls outputs. **Feedback loops** are used to maintain stability and precision — a key feature in critical medical systems. For example, in an insulin pump, the microcontroller continuously measures glucose levels and adjusts insulin delivery automatically.

Modern microcontrollers offer **wireless communication**, enabling **Internet of Medical Things (IoMT)** devices that send data to healthcare databases or cloud systems for remote monitoring. They must also meet strict standards of **reliability**, **safety**, and **power efficiency**, especially for life-support and implantable devices.

In conclusion, microcontrollers form the backbone of biomedical instrumentation. Their integration with sensors, actuators, and communication modules enables intelligent, efficient, and portable medical devices. Biomedical engineers play a vital role in programming, testing, and optimizing these systems to ensure patient safety and high performance.

III. Post-reading

A. True (T), False (F), or Not Given (NG)

1. Microcontrollers are used only in large hospital equipment.
2. Microcontrollers can process both analog and digital signals.
3. The first use of microcontrollers in medicine occurred in the 1980s.
4. Feedback control helps maintain system stability.
5. Microcontrollers are used in ventilators and infusion pumps.
6. IoMT refers to connecting medical devices through networks.

B. Multiple Choice

1. What is the main function of a microcontroller?
   a) To store large amounts of data b) To control and process signals in devices
   c) To replace sensors in medical systems d) To transmit electricity
2. Which component converts electrical signals into motion?
   a) Sensor b) Actuator
   c) Processor d) Display
3. In an insulin pump, the microcontroller's role is to:
   a) Display data b) Adjust insulin delivery automatically
   c) Store patient records d) Monitor air quality
4. Which of the following best describes an embedded system?
   a) A computer used for general tasks b) A device integrated into a larger machine for a specific function
   c) A communication network d) A type of biomedical sensor
5. What does IoMT stand for?
   a) Internet of Medical Tools b) International Organization of Medical Technology
   c) Internet of Medical Things d) Integrated Operation of Microcontrollers and Tools

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C. Fill in the blanks

1. A _______ controls the operation of small biomedical devices.
2. Engineers use _______ systems to embed controllers in medical instruments.
3. The ventilator's _______ adjusts airflow automatically.
4. A glucose monitor uses sensors to collect _______ data.
5. The first working version of a device is called a _______.
6. Engineers _______ code to control the device's behavior.
7. Reliable microcontrollers are essential for patient _______.
8. IoMT enables _______ communication between medical devices.
