Unit 2: Electroencephalography (EEG) Signals

I. Pre-reading

A. New Vocabulary

Word	Form	Definition / Synonym	Persian Translation
neuron	n	nerve cell that transmits impulses	نورون / سلول عصبی
cortex	n	outer layer of the brain	قشر مغز
brainwave	n	rhythmic electrical activity of the brain	موج مغزی
stimulus	n	something that causes a response	محرک
seizure	n	sudden abnormal brain activity	تشنج
signal processing	n	techniques used to analyze signals	پردازش سیگنال
synchronization	n	coordination of processes in time	هم‌زمان‌سازی
interface	n	point where two systems interact	رابط
cognitive	adj	related to thinking and mental processes	شناختی
sleep disorder	n	abnormal condition affecting sleep	اختلال خواب
rehabilitation	n	restoring health or ability after illness	توان‌بخشی / بازتوانی

B. Building Vocabulary

Root	Meaning	Example
neuro	nerve	neuron, neurology
encephalo	brain	encephalitis, electroencephalogram
signal	sign	signal, designate
analyze	examine	analysis, analytical
process	proceed	processing, processor
interface	connect	interface, interfacial
rehab	restore	rehabilitation, rehabilitative

C. Pre-reading Questions

1. What does an electroencephalogram (EEG) record?
2. How is EEG used to study brain function?
3. What are some biomedical applications of EEG?

4. Why must EEG signals be filtered before analysis?

II. Reading

Electroencephalography in Biomedical Engineering

Electroencephalography (EEG) is a key technique in biomedical engineering that measures and records the **electrical activity of the brain**. It provides insight into how the brain functions by detecting the tiny voltage changes produced by **neurons**. The recorded signal, known as an **electroencephalogram**, is represented as a series of waveforms that vary in **frequency** and **amplitude**.

To acquire EEG signals, **electrodes** are placed on the scalp using a standardized system such as the **10–20 electrode placement** method. Each electrode detects voltage fluctuations that reflect brain activity beneath that area of the cortex. Biomedical engineers work on developing precise **signal acquisition** systems that reduce **artifacts** caused by movement, eye blinks, or external electrical noise.

EEG waveforms are classified into several types according to frequency:

- **Delta (0.5–4 Hz):** deep sleep
- **Theta (4–8 Hz):** drowsiness or meditation
- **Alpha (8–13 Hz):** relaxed state
- **Beta (13–30 Hz):** alertness and mental activity
- **Gamma (>30 Hz):** cognitive processing and attention

Each type of brainwave indicates a different state of consciousness or brain function. Abnormal EEG patterns can help diagnose **epilepsy**, **sleep disorders**, **brain injuries**, and **neurological diseases**.

Modern EEG systems use **digital signal processing** and **machine learning algorithms** to automatically detect **seizures**, monitor sleep stages, and analyze cognitive states. Engineers also develop **brain-computer interfaces (BCIs)** that translate brain signals into commands to control external devices, such as wheelchairs or robotic arms. These technologies are vital in **neurorehabilitation** and assistive communication.

In clinical and research settings, EEG provides a non-invasive and cost-effective way to monitor brain activity. It plays an essential role in both **diagnosis** and **therapy**, contributing to advances in neuroscience, psychology, and biomedical engineering.

In conclusion, **electroencephalography** bridges the gap between engineering and neuroscience. By designing accurate acquisition systems and intelligent signal analysis tools, biomedical engineers enable deeper understanding of the brain and develop innovative solutions for neurological care.

III. Post-reading

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

1. EEG can accurately predict a person's emotions in real time.
2. EEG electrodes are placed directly inside the brain.
3. EEG can detect sleep-related disorders.
4. EEG electrodes must always be attached using conductive gel.
5. Delta waves are related to deep sleep.
6. EEG is used only for diagnosing epilepsy.

7. BCIs allow patients to control external devices using brain signals.

B. Multiple Choice

1. What does EEG measure?
   a) Brain mechanical activity b) Brain electrical activity
   c) Muscle contraction d) Heart rate
2. Which frequency range represents the alpha rhythm?
   a) 0.5–4 Hz b) 4–8 Hz
   c) 8–13 Hz d) >30 Hz
3. What is the main source of EEG artifacts?
   a) Eye movement or muscle activity b) High temperature
   c) Low blood sugar d) Oxygen level
4. What is one use of EEG in biomedical engineering?
   a) Blood oxygen analysis b) Brain-computer interface design
   c) Muscle force measurement d) Hearing aid development
5. Which of the following is a high-frequency brainwave?
   a) Theta b) Alpha
   c) Delta d) Gamma

C. Fill in the blanks

1. The EEG system records the electrical activity of the _____.
2. Electrodes are placed on the _____ to detect voltage changes.
3. Engineers develop filters to remove unwanted _____ from EEG signals.
4. Delta waves occur during _____.
5. EEG can help diagnose _____ and neurological disorders.
6. Brain-computer interfaces are based on analyzing _____ patterns.
7. The 10–20 system defines the standard _____ placement for EEG.
8. EEG signals are processed using _____ and machine learning algorithms.
