Unit 7: Neuroengineering and Brain-Computer Interface (BCI)

I. Pre-reading

A. New Vocabulary

Word / Term	Form	Definition / Synonym	Persian Translation
neuroengineering	n	applying engineering to the nervous system	مهندسی عصبی
neuron	n	nerve cell that transmits signals	نورون / سلول عصبی
cortex	n	outer layer of the brain	قشر مغز
decoding	n	interpreting or translating data	رمزگشایی
prosthesis	n	artificial device replacing a body part	پروتز
neural signal	n	electrical impulse from the nervous system	سیگنال عصبی
implant	n	device placed inside the body	ایمپلنت / کاشت
motor control	n	ability to direct muscle movement	کنترل حرکتی
noninvasive	adj	not involving surgery or entry into the body	غیرتهاجمی
synchronization	n	coordination between systems	همزمان‌سازی
adaptive	adj	able to adjust to changing conditions	تطبیقی
restoration	n	returning to normal function	بازیابی / بازگردانی

B. Pre-reading Questions

1. What is neuroengineering?
2. How do brain-computer interfaces (BCIs) work?
3. What are the applications of BCIs in medicine?
4. What challenges exist in developing neural interfaces?

II. Reading

Neuroengineering and Brain-Computer Interfaces

Neuroengineering is an interdisciplinary field that combines neuroscience, electrical engineering, and computer science to study and interact with the nervous system. One of its most advanced applications is the **Brain-Computer Interface (BCI)**, which enables direct communication between the brain and an external device.

A **BCI** detects **neural signals** using **electrodes** placed either on the scalp (noninvasive) or directly on the brain surface (invasive). These signals are **acquired**, **decoded**, and translated into commands that control devices such as robotic arms, computers, or prosthetic limbs. BCIs help individuals with paralysis or limb loss regain **motor control** and independence.

Biomedical engineers play a key role in **signal acquisition**, **feature extraction**, and **algorithm design** to interpret brain activity accurately. They also design **feedback systems** that allow users to receive sensory information from the controlled device, creating a closed-loop interaction.

Recent advances include **adaptive BCIs**, which learn from the user's neural patterns to improve performance over time. **Neural stimulation** techniques are also used for rehabilitation, helping restore movement or sensory function in patients with neurological injuries.

Despite major progress, BCIs face challenges such as signal noise, long-term stability, and **ethical** questions regarding privacy and cognitive influence. However, as technology evolves, neuroengineering promises to revolutionize healthcare by bridging the gap between the human brain and machines.

III. Post-reading

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

1. BCIs only work with invasive electrodes.
2. BCIs can control robotic limbs through brain signals.
3. Feedback allows users to feel or see device responses.
4. Neuroengineering ignores ethical issues.
5. Adaptive BCIs can learn from the user's brain patterns.
6. BCIs may help restore movement after injury.
7. Neural signals are recorded using electrodes.

B. Multiple Choice

1. BCIs are designed to:
   a) Stimulate muscles directly b) Connect the brain with external devices
   c) Record heart activity d) Replace neurons
2. Which process converts brain signals into device commands?
   a) Encoding b) Decoding c) Stimulating d) Synchronizing
3. What is a challenge in BCI research?
   a) Too many sensors b) Signal noise and instability
   c) Excessive muscle feedback d) Lack of electrodes

C. Fill in the blanks

1. Neuroengineering combines neuroscience, _____ engineering, and computer science.
2. A Brain-Computer Interface (BCI) enables direct _____ between the brain and an external device.
3. Noninvasive BCIs use electrodes placed on the _____.
4. Neural signals are acquired, _____, and translated into commands.
5. BCIs help individuals with _____ or limb loss regain motor control.
6. Biomedical engineers are responsible for _____ extraction and algorithm design.
7. Adaptive BCIs can _____ from the user's neural patterns over time.
8. Major challenges include signal _____, long-term stability, and ethical concerns about _____.