Reg. No.											

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

II SEM M.Tech (BME/MI) DEGREE END-SEMESTER EXAMINATIONS, APRIL/MAY 2024.

SUBJECT: NEURO ENGINEERING (BME 5215)
(REVISED CREDIT SYSTEM)
Tuesday, 07th May 2024, 9:30 AM to 12:30 PM

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to Candidates:

1. **Answer ALL questions.**
2. **Draw labelled diagrams wherever necessary**

1. A **A newly characterised cell in the human brain, Theta49, expresses a resting membrane potential (RMP) of $-110\ mV$.** The RMP of Theta49 is contributed to by three monovalent cations, A, B, and C, and a monovalent anion, D. **5 Marks**

The Nernst potentials of A, B, C, and D are $+70\ mV, -130\ mV, -72\ mV$ *and* $-92\ mV$ respectively. **Analyse the above information and answer the following questions:**

(i) Which of the ions present in Theta49 are in electrochemical equilibrium? Give reasons.

(ii) Theta49 cells are electrically excitable, i.e., they elicit an Action Potential (AP). Under the assumption that only ions A and B contribute to the AP, from the information supplied to you, what are the numerical bounds within which the membrane voltage can vary? Briefly explain your answer.

B Explain the mechanism of **excitation-contraction coupling** at the neuromuscular junction with the help of a flowchart. **2 Marks**

c) Explain the **three parameters that are used to tailor the stimulus protocol** in Function Electrical Stimulation (FES). **3 Marks**

2. a) **A description of EEG signals recorded from two patients, A and B, are mentioned below. Each patient's EEG was recorded using a different montage.** **5 Marks**

- **Patient A's EEG Description:** The EEG recording shows marked differences in wave amplitudes and frequencies between channels. Each channel represents the potential difference between two closely located electrodes placed over different brain regions.
- **Patient B's EEG Description:** The EEG recording exhibits relatively uniform waveforms across all channels, with variations primarily reflecting changes in amplitude and frequency relative to a stable, common baseline used for all channels.

Analyse the above description and determine which recording montage was used to obtain:

(i) Patient A's EEG
(ii) Patient B's EEG

Provide a rationale for your answer based on the characteristics described in each patient's EEG data.

b) Differentiate between **anterior-posterior bipolar montage and transverse bipolar montage** using a schematic diagram. **5 Marks**

3. a) **A sample arrangement of the 10-20 system for EEG recording is given in Fig. 1 below. Analyse the scenarios described below and answer the following questions with reference to Fig. 1.** **5 Marks**

(i) Given a scenario where a subject exhibits symptoms that suggest temporal lobe epilepsy, which electrodes in the 10-20 system would you primarily focus on to monitor the electrical activity in the temporal regions?

(ii) In order to evaluate sleep patterns and disturbances, which electrodes should you ensure are recorded to assess brain activity during sleep, and what areas of the brain do these electrodes monitor?

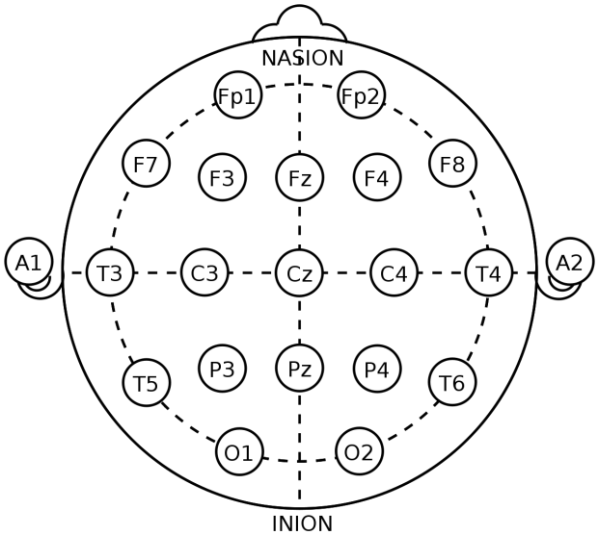

Fig. 1.

b) **In an EEG recording experiment which used bright lights as a stimulus, it was observed that the eyes of the subject rolled upwards in response to the stimulus.** Analyse the preceding statement and answer the following questions: **5 Marks**

(i) What kind of an artefact will be seen in the recorded EEG due to the upward movement of the eyeball, and on which electrodes?

(ii) Name and Explain this phenomenon (artefact) with the help of a schematic.

4. a) **Explain the three key components of time-domain analysis of an Event-Related Potential (ERP) in EEG Signal processing.** What would happen if an ERP is time-locked but not phase-locked, and how would this affect the quality of the ERP signal analysis? **5 Marks**

b) **Explain the following with respect to the frequency domain analysis of an EEG:** **5 Marks**

(i) Decomposition of an EEG using the 1D DFT.

(ii) Process of obtaining the power spectral density (static spectrum) of an EEG Signal

(iii) Process of obtaining the dynamic spectrum of an EEG Signal.

5. a) **A description of EEG readings from 5 subjects (A-E) is provided below. Each patient's EEG exhibits different patterns, which may indicate abnormal brain activity. Analyse the descriptions below, and match each patient to one of the five characteristics typically seen in an abnormal EEG and provide a typical sketch for each of these characteristic abnormalities.** **5 Marks**

The characteristics to consider are: *Sharp Waves, Spike-and-Wave Complexes, Slow-Wave Activity, Focal Asymmetry, and Paroxysmal Bursts.*

Patient A: The EEG shows periodic bursts of rapid spikes followed by a slow wave, occurring at regular intervals, especially noticeable during states of drowsiness.

Patient B: The EEG indicates a consistent presence of quicker, isolated waveforms that are distinctly pointed, appearing primarily in one hemisphere.

Patient C: Recordings display a continuous rhythm but significantly slower than the typical alpha waves, predominantly during wakeful periods.

Patient D: The EEG presents an uneven distribution of electrical activity, with the amplitude noticeably higher in the left frontal region compared to the right.

Patient E: The EEG captures sudden, brief clusters of rapid firings that seem to appear out of nowhere and resolve quickly.

b) **Explain the following two principles underlying functional MRI.** **5 Marks**

(i) Blood Oxygen Level Dependent (BOLD) Contrast

(ii) Magnetic Resonance Imaging (MRI)