(25)

B.Sc. Engg. in EE (7th Semester)
B.Sc. in TE (3rd Semester)

Date: 3rd October, 2023
Time: 2:30 pm – 4:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Mid-Semester Examination
Course No.: EEE 4763/EEE 4791
Course Title: Medical Electronics

Winter Semester, A. Y. 2022-2023
Time: 90 Minutes
Full Marks: 75

There are **4 (four)** questions. Answer **3 (three)** questions. **Question No. 1** and **Question No. 2** are compulsory. Answer **any 1 (one)** question from **Question No. 3** and **Question No. 4**. The symbols have their usual meanings. Marks of each question and corresponding COs and POs are written in the brackets.

---

1. a) Describe the action potential and its different states with the roles of the ion channels involved in the process. **12 (CO1, PO1)**

   b) For a neuron the ion concentrations at t_1 second are given as follows: **13 (CO2, PO2)**

ION	Extracellular	Intracellular
Na^+	100 mM	150 mM
Ca^{2-}	345 mM	280 mM
K^+	190 mM	200 mM
Cl^-	145 mM	145 mM

And at t_2 second the concentrations become: (where, $t_2 > t_1$)

ION	Extracellular	Intracellular
Na^+	95 mM	155 mM
Ca^{2-}	350 mM	285 mM
K^+	200 mM	190 mM
Cl^-	135 mM	155 mM

Determine the state of the action potential of the neuron between t_1 and t_2 time period by finding out the membrane potential, V_m at each time point.
Given, $P_{Cl} = 30\%$, $P_K = 40\%$, $P_{Na} = 45\%$, Gas Constant R = 8.31 J/mol/K, Faraday Constant F = 96500 C/mol and temperature is 35° C.

2. a) Define any two instrumentation terms (performance metrics) of a sensor with proper depiction. **6 (CO1, PO1)**

   b) Formulate the relation between Gauge Factor and Poisson's ratio for a strain gauge sensor. **9 (CO1, PO3)**

   c) For a metal $\mu = 0.3$ and this metal is attached as a strain gauge in a bridge circuit. Due to apply of some strain, the bridge is unbalanced and the output voltage $V_0 = 15.6$ mV. If, initial resistance $R_g = 100K\Omega$ and externally applied voltage, $V_{EX} = 20$ V, calculate: **10 (CO2, PO2)**
   i) The gauge factor of the metal.
   ii) Amount of strain applied on the strain gauge.
   iii) Determine whether the material is stretched or compressed.
   The strain-induced piezoresistive effect of the material can be ignored.

3. a) i) Define EPSP and IPSP.
ii) Differentiate between Action Potential and Synaptic Potential. 8 (CO1, PO1)

b) A capacitance sensor is added with a resistor of 80 MΩ. Calculate x, the distance between two parallel plates of the capacitor so that it only passes sound frequencies above 75 Hz. The height and width of the capacitor plates are 1 cm and 1.5 cm respectively. 9 (CO2, PO2)

c) Following chart shows the temperature difference between several junctions of thermocouple and emf induced in those junctions: 8 (CO1, PO3)

T1 & T2	T2 & T3	T3 & T4	T4 & T5
15 mV	17 mV	12 mV	5 mV

i) Determine the emf induced in a junction with temperature difference of **T1 & T4**
ii) Justify the answer with the appropriate thermocouple law.

Or,

4. a) Briefly describe the working principle of Photoplethysmography (PPG) and explain how it can be used in pulse oximeter to measure oxygen saturation in blood. 8 (CO1, PO3)

b) The frequency ranges of EMG signal varies from 50 to 3000 Hz and for EEG signal it varies between 0.1 to 80 Hz. Given, temperature T = 27° C and Boltzmann's constant **k = 1.38x10^(-23)** joules/K 9 (CO2, PO2)
i) Calculate the thermal noise present inside the bandwidth of EMG signal.
ii) If the EMG signal power is 0.1 mW, what is the SNR of the EMG signal?
iii) For the same signal power, determine which of the two abovementioned signal will have higher SNR.

c) Give examples of any two kinds of noise reduction techniques and justify their working principle. 8 (CO1, PO1)