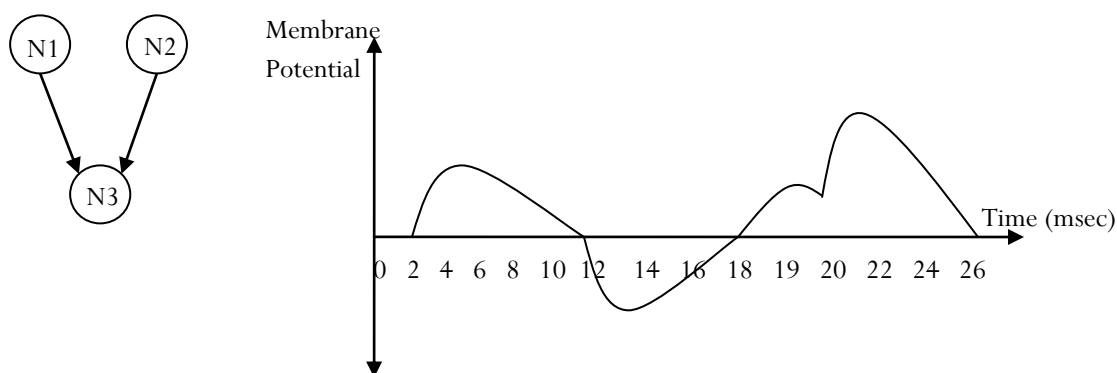


Sample Midterm Questions

Question 1

Consider the following diagram showing neurons connected to each other. The membrane potential of neuron N3 is given below versus time.



If you know that an action potential from neuron N1 causes Cl^- channels in N3 to open while an action potential from neuron N2 causes Na^+ channels to open in N3. Given that the concentrations for neuron N3 are given by:

- Na^+ : Intracellular = 30 mM	Extracellular = 125 mM
- Cl^- : Intracellular = 8 mM	Extracellular = 100 mM

- i – **What** is the type of the connection between N1 and N3, and between N2 and N3? **Explain** your answer.
- ii – From the membrane potential figure given above, determine **the number of action potentials** fired by neurons N1 and N2 and **the time** at which each action potential occurred.

Answer:

i – N1 \rightarrow N3: Inhibition since when Cl^- channels open, Cl^- will enter the cell since the extracellular concentration of Cl^- is larger than the intracellular concentration. Therefore, when Cl^- enters the cell, the membrane potential will decrease.

N2 \rightarrow N3: Excitation since when Na^+ channels open, Na^+ will enter the cell since the extracellular concentration of Na^+ is larger than the intracellular concentration. Therefore, when Na^+ enters the cell, the membrane potential will increase.

- ii – N1: 1 Action potential at 12 msec.
N2: 3 Action potentials at 2, 18, and 20 msec.

Sample Midterm Questions

Question 2

Why is the size of the left side of the heart needed to be larger in volume than the right side of the heart?

Answer:

Because the left pump is responsible for pumping the blood to the rest of the body while the right side pumps blood to the lungs which are close to the heart compared. Therefore, for the heart to be able to pump blood to every part of the body, the left side needs to be larger than the right side.

Question 3

Humans feel pain through pain receptors that are underneath the skin. Signals from pain receptors are sent through the spinal cord to the brain for sensation and perception. Consider a patient who has pain receptors working but signals do not reach the brain, **suggest** the design of a system that can help such patient.

Answer:

One possible solution is to attach electrodes in close proximity to pain receptors. The function of such electrodes is to record the activity of pain receptors. These signals will be then processed to determine if they exceed the pain threshold. The output can be sent to a screen to inform the patient that he is now feeling pain.

Question 4

Suggest the steps of an algorithm that can be used to determine movement direction from the activity of motor cortex neurons.

Answer:

- 1 – Determine the preferred direction of each neuron in a training session in which the subject is instructed to imagine moving his arm in different directions.
- 2 – When testing the system, find which neuron is active.
- 3 – Determine movement direction as a function in the preferred direction of active neurons.

Question 5

What are the disadvantages of using traditional EEG recording systems?

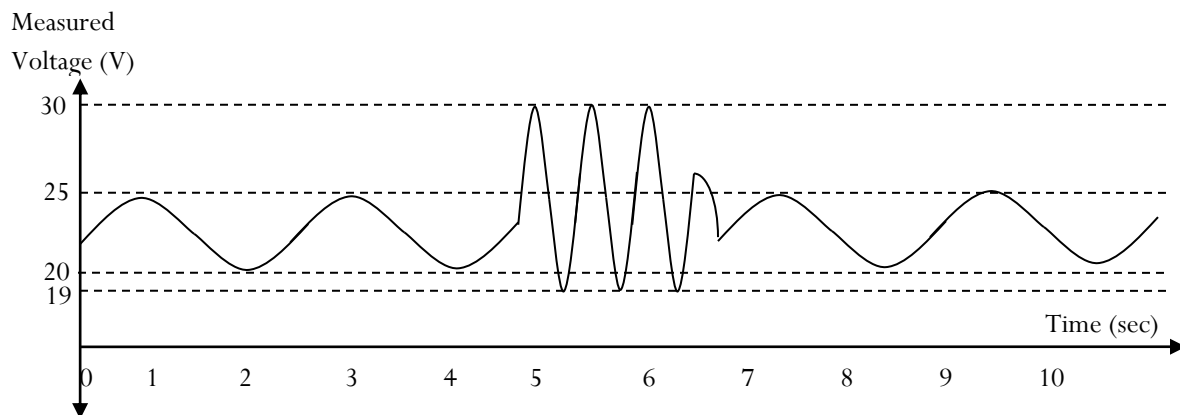
Answer:

- 1 – The use of conductive gel which is inconvenient as it takes time in preparation and sticks to the hair.
- 2 – Too many cables and wires are connected to the head cap which makes it difficult to setup and hard to move with.

Sample Midterm Questions

Question 6

Consider the following voltage trace measured from a plethysmography that shows a patient's breathing pattern using an elastic band wrapped around the chest.



i – **What** is the respiratory rate in breaths per minute of this patient at different time intervals?

ii – If the elastic band used is a 10-cm long elastic resistive transducer with a resting resistance of $0.4\text{ k}\Omega$ and given that a constant current of 3 mA is being used in the circuit, **find** the chest diameter for each of the different levels shown in the measured voltage above.

Answer:

- i – 0 \rightarrow 5 sec: 2 cycles/5 sec = 0.4 breaths/sec = 24 breaths/min
 5 \rightarrow 6.5: 3 cycles/1.5 sec = 2 breaths/sec = 120 breaths/min
 6.5 \rightarrow end: 24 breaths/min

ii – $R = \rho l/A$

$$0.4\text{ k}\Omega = 400\Omega = (\rho/A) \times 10/100$$

$$\rho/A = 4000$$

At 30V: $V = IR = (3/1000) \times R = 30\text{V}$

$$R = 10000\Omega$$

Since $\rho/A = 4000$

Therefore, $l = 2.5\text{m}$

Since $2.5 = 2\pi r \rightarrow \text{Diameter} = 0.79\text{m}$

At 25V: $V = IR = (3/1000) \times R = 25\text{V}$

Sample Midterm Questions

$$R = 8333\Omega$$

$$\text{Since } \rho/A = 4000$$

$$\text{Therefore, } l = 2.08\text{m}$$

$$\text{Since } 2.08 = 2\pi r \rightarrow \text{Diameter} = 0.66\text{m}$$

$$\text{At } 20\text{V: } V = IR = (3/1000) \times R = 20\text{V}$$

$$R = 6666.6\Omega$$

$$\text{Since } \rho/A = 4000$$

$$\text{Therefore, } l = 1.66\text{m}$$

$$\text{Since } 1.66 = 2\pi r \rightarrow \text{Diameter} = 0.53\text{m}$$

$$\text{At } 19\text{V: } V = IR = (3/1000) \times R = 19\text{V}$$

$$R = 6333.33\Omega$$

$$\text{Since } \rho/A = 4000$$

$$\text{Therefore, } l = 1.583\text{m}$$

$$\text{Since } 1.583 = 2\pi r \rightarrow \text{Diameter} = 0.503\text{m}$$

Question 7

Suggest the design of a system that can find the heart rate but without reading ECG signals.

Answer:

One solution is to fix a microphone near the heart on the chest and record the sounds that occur as a result of heart beating. The time difference between heart beats can then be determined and the heart rate can be found.