GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: BIOMEDICAL ENGINEERING
SUBJECT NAME: BIOELECTRICITY
SUBJECT CODE: 3713113
M.E. I SEMESTER

Type of course: Core Subject

Prerequisite:

1. Cell physiology and electrical activities of cell
2. Nernst / Equilibrium Potential
3. Basics of diffusion phenomena across the cell membrane

Rationale: By this course, the post graduate biomedical engineering student will be able to understand the electric potentials and currents produced by or occurring within living organisms. Bioelectric potentials are generated by a variety of biological processes and generally range in strength from one to a few hundred millivolts. The course aims to understand the electrical properties exhibited by cell. The course also covers the types of synaptic transmission that takes place in skeletal and smooth muscle cells and also in neurons.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No	Content	Teaching Hrs.	Module Weightage
1	**Action potential of excitable cells:** Resting membrane potential, Nernst equation, Goldman-Hodgkin-Katz equation, Electrochemical driving force, Sodium pump, Hodgkin-Huxley model, significance of parameters in Hodgkin-Huxley equations; Factors determining the initiation, amplitudes, and kinetic properties of action potentials.	10	30%
2	**Voltage clamp and Ion channel modeling:** Voltage-clamp experiments: design, and analysis of results; Modeling the Potassium channel conductance, Modeling the Sodium channel conductance, Current-voltage curves for voltage-gated ion channels: generation and analysis. Calcium channel I-V curves	8	15%
3	**Passive membrane electrical properties:** Cellular resistance, capacitance, time constant and space constant, methods of measurement; Importance in cellular excitation and signaling: Impulse propagation.	8	15%
4	**Electrophysiology of synaptic transmission:** Prejunctional and postjunctional electrical events; time courses of	10	30%

	transmitter-activated membrane currents and potentials in skeletal and smooth muscle; Electrical models of the skeletal and smooth muscle membranes.		
5	**Electrodes as bioelectric transducers** The electrode-electrolyte interface; Specifications and selection criteria for electrodes; Surface, needle, implanted electrodes; Polarizable and non-polarizable electrodes; Practical considerations	6	10%

Reference Books:

1. R.D. Barr & R.L. Plonsey : Bioelectricity: A Quantitative Approach, Academic Press, N.Y., 1988.
2. E.R. Kandel & J. Shwartz (ed.) : Principles of Neural Science, 3rd ed., 1991.
3. B. Katz : Nerve, Muscle, and Synapse, Mc-Graw Hill, New York, 1966.
4. J.G. Nicholls, A.R. Martin & B. Wallace : From Neuron to Brain, 3rd ed., Sinauer, Sunderland, 1992.
5. J.J.B. Jack, D. Noble & R.W. Tsien : Electric Current Flow in Excitable Cells, Oxford University Press, 1983.

Course Outcome:

After learning the course the students should be able to:

1. Understand the mechanisms governing the generation of bioelectrical signals
2. To analyse the properties of action potentials in muscle cells and neurons
3. Simulate the ionic current (mainly Potassium current and Sodium current) and conductance
4. To investigate the time courses of synaptic potentials and currents

List of Experiments:

1. To simulate the action potential in neurons using NEURON platform
2. To analyse the factors contribute to the generation of action potential
3. To simulate the Sodium channels current along with conductance
4. To investigate the factors responsible for the Sodium current and conductance
5. To simulate the Potassium channels current along with conductance
6. To investigate the factors responsible for the Potassium current and conductance
7. To develop a model for synaptic potential in neurons

Note: Experiments will be performed mostly on NEURON platform, a free open source software for modeling individual and networks of neurons.

List of Open Source Software/learning website:

https://www.neuron.yale.edu/neuron/
http://vlab.amrita.edu/index.php
https://in.mathworks.com/matlabcentral/fileexchange/47353-action-potential-simulator
https://www.britannica.com/science/bioelectricity