GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Biomedical Engineering

Subject Code : ME03031021

Subject Name : Introduction to Neuromuscular Engineering

w. e. f. Academic Year:	2024-25
Semester:	III
Category of the Course:	MOPEC

Prerequisite:	Human Anatomy and Physiology, Bio potentials and Bioelectricity, Biomechanics
Rationale:	To introduce fundamental and latest engineering and neuroscience tools for analysis and simulation of muscle contraction. These are interdisciplinary areas which include biology, physiology, medicine and engineering. This will enable students to use an engineering analysis and simulation approach to understand tendon-driven neuromuscular system.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	To understand the physiology of skeletal muscle and its contraction	R, U
02	Identification of neural circuits and signalling pathways in controlling the muscle	R, U
03	Apply various numerical techniques for neuromuscular physiology and developments of models	U, A
04	Development of neuronal circuits for upper motor and lower motor control of the brainstem and spinal cord	N, E
05	Applications of various medical devices used in brain and muscles dysfunctions	N, E

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	0	3	70	30	0	0	100

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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Structure of Skeletal Muscles, Neuromuscular Synapse, Muscles contraction and its mechanism, Fast and slow motor units and functional role, Presynaptic and postsynaptic inhibition, Monosynaptic reflexes, Oligosynaptic reflexes, Polysynaptic reflexes, Voluntary control of single muscle, EMG pattern during Isotonic movement & Isometric contraction, Nerve terminal regeneration in neuromuscular junction	8	19%
2.	Overview of the cellular components of the nervous system, neural circuits, organization of human nervous system, and neural signaling, Somatosensory system, Sensory contributions to movement control, Contributors of muscular fatigue, Muscular mechanism of fatigue, Spinal mechanism of fatigue, Adaptive changes during fatigue, Abnormal fatigue, Numerical approaches limb and musculotendon kinematics, Neural control of eccentric vs. concentric contractions, Modeling of the neuromusculoskeletal system	11	24%
3.	Single value decomposition, Monte Carlos method, Hypothesis testing with Monte Carlos method, Analysis of Synaptic transmission using monte Carlos method, Monte Carlos simulation of vesicular release, Monte Carlos simulation of buffered diffusion into and out of model synapse, Kinematic and electromyography analysis of limb movement	12	29%
4.	Lower motor neuron circuits, Upper motor neuron control of the brainstem and spinal cord, Sensorimotor brain maps. Brain plasticity and neurorehabilitation.	7	14%
5.	Review of recent advances in neuromuscular engineering: brain-machine interfaces, deep brain and transcranial stimulation, brain imaging, muscle and brain implants	7	14%
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20%	**30%**	**15%**	**15%**	**10%**	**10%**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested **Learning Resources:**

(a) Books:

1. Latash, Mark L. Neurophysiological basis of movement. Human Kinetics, 2008.
2. Thomas Jessell, Steven Siegelbaum, and A. J. Hudspeth. Principles of neural science. Eds. Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell. Vol. 4. New York: McGraw-hill, 2000.
3. Dale Purves [et al.], Neuroscience, 5th Edition, Sinauer Associates, Inc., 2012, ISBN: 978-0-87893- 695-3
4. Eric Kandel, James Schwartz, Principles of Neural Sciences, 5th Edition, McGraw-Hill Education/Medical, 2012, ISBN-13: 978-0071390118.
5. John Hall, Guyton and Hall Textbook of Medical Physiology, 13th Edition, Elsevier, 2015, ISBN: 978-1455770052.
6. De Schutter, Erik. Computational neuroscience: realistic modeling for experimentalists. CRC Press, 2000.
7. Tedesco, Erik (2011) Study of the nerve terminal regeneration in neuromuscular junction intoxicated with different presynaptic neurotoxins. [Ph.D. thesis]

(b) Open source software and website:

1. https://www.coursera.org/learn/synapses

List of Laboratory/Learning Resources Required:

Neuroprosthetic arm, Real time EMG acquisition system, Computer system with latest version of software for the modeling of neuromuscular physiology, Kinematic Gait Trainer

Suggested Project List: NA

Suggested Activities for Students:

a. Neural Simulation Using Computational Tools

- Activity: Use software like NEURON or Brian2 to simulate synaptic transmission and action potentials in neurons.
- Objective: Explore the dynamics of neural signaling and synaptic plasticity in a controlled environment.

b. Monte Carlo Simulations for Synaptic Transmission

- Activity: Use a programming language like Python or MATLAB to model vesicular release and diffusion in synaptic clefts using Monte Carlo methods.
- Objective: Understand how randomness in synaptic processes can influence overall neuronal behavior and signal transmission.

c. Biomechanics Simulations

- Activity: Use simulation software (e.g., OpenSim) to model human limb movements and analyze kinematics and muscle forces during different activities (e.g., walking, running, lifting).
- Objective: Apply principles of biomechanics to study the effects of different movements on muscle and tendon dynamics.

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