



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering

Subject Code: 3723117

Semester – II

Subject Name: Introduction to Neuromuscular Engineering

Type of course: Elective

Prerequisite: Human Anatomy and Physiology, Biopotentials 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.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
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	08
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	10
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



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4	Lower motor neuron circuits, Upper motor neuron control of the brainstem and spinal cord, Sensorimotor brain maps. Brain plasticity and neurorehabilitation.	06
5	Review of recent advances in neuromuscular engineering: brain-machine interfaces, deep brain and transcranial stimulation, brain imaging, muscle and brain implants	06

Suggested Specification table with Marks (Theory):

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

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference 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]



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Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the physiology of skeletal muscle and its contraction	25
CO-2	Identification of neural circuits and signalling pathways in controlling the muscle	20
CO-3	Apply various numerical techniques for neuromuscular physiology and developments of models	25
CO-4	Development of neuronal circuits for upper motor and lower motor control of the brainstem and spinal cord	15
CO-5	Applications of various medical devices used in brain and muscles dysfunctions	15

List of Experiments:

- To study the operations and functionality of neuroprosthetic arm
- To analyze the EMG characteristics for various behavioral and physical stimulation
- To simulate buffered diffusion into and out of model synapse
- To analyze synaptic transmission using monte Carlos method
- To analyze kinematic of limb movement
- To study the deep brain and transcranial stimulation techniques
- To understand the brain imaging, muscle and brain implants

Major Equipments:

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

List of Open Source Software/learning website:

<https://www.coursera.org/learn/synapses>