GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch: Bio Medical Engineering

Course / Subject Code : ME01031051

Course /Subject Name : Biological Control System and Modelling

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	1. Human anatomy and physiology, 2. Control system & analysis, Higher Engineering Mathematics 3. MATLAB Simulink
Rationale:	By this course, the post graduate biomedical engineering student will be able to understand the physiological concepts and mathematical tools that they will need to understand and analyze these physiological control systems. This course will also provide an introduction to the structures and mechanisms responsible for the proper functioning of these systems. This course will combine physiology, linear control theory, and MATLAB simulink with the objective of explaining how these complex systems operate in a healthy human body.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Understand the physiological concepts and mathematical tools
02	Analyse the physiological control systems
03	Investigate the key strategies that the body uses to regulate its function
04	Identify the different biological diseases
05	Design the effective treatments using mathematical modeling

**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	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Modelling of physiological system** Introduction to physiological system, classification of model – grey box & black box, parametric & non parametric, lumped & distributed models, linear & non-linear, Purpose of physiological modelling and signal analysis, Engineering system and physiological system, System variables & properties.	7	**15%**
2.	**Time-Domain and Frequency Domain Analysis of Linear Control Systems** descriptors of impulse and step responses, open-loop versus closed-loop dynamics, Simulink application: dynamics of neuromuscular, reflex motion, steady-state responses to sinusoidal inputs, graphical representations of frequency response, frequency response of a model of circulatory, control, frequency response of glucose-insulin regulation, Control of biological systems using biological parts.	8	**15%**
3.	**Identification of Physiological Control Systems** Nonparametric and parametric identification methods, problems in parameter estimation: identifiability and Input design, identification of closed-loop systems: "opening the loop, identification under closed-loop conditions.	7	**15%**
4.	**Optimization in Physiological Control** Optimization in systems with negative feedback, single-parameter optimization: control of Respiratory frequency, constrained optimization: airflow pattern Regulation, control of aortic flow Pulse, adaptive control of physiological variables.	8	**20%**
5.	**Complex Dynamics in Physiological Control Systems** Spontaneous variability, nonlinear control systems with delayed feedback, coupled nonlinear oscillators: model of circadian rhythms, time-varying physiological closed-loop systems: Sleep apnea model, propagation of system noise in feedback loops.	8	**20%**
6	**Systems Biology of Diseases and the Design of Effective Treatments** Introduction, pathologies & control engineering perspectives, engineering control systems & disease treatment.	7	**15%**
	Total		**100**

Reference Books:

1. Michel C Khoo, Physiological Control Systems -Analysis, simulation and estimation, Prentice Hall of India, 2001.
2. Modeling and Simulation in Medicine and the Life Sciences (2nd Edition), by F.C. Hoppensteadt and C.S.Peskin, Springer (2002) ISBN: 0-387-95072-9.
3. Christof Koch, "Biophysics of Computation", Oxford University Press, 28-Oct-2004
4. R.C. Dorf and R.H. Bishop, Modern Control Systems, 12 th Edition, Prentice Hall
5. L. Sherwood and C. Ward, Human Physiology: from cells to systems, Third Canadian Edition, Nelson
6. Biological Control Systems: Systems Biology of Diseases and the Design of Effective Treatments, Abstract, By Babatunde A. Ogunnaike, 2016

List of Experiments:

1. To simulate the glucose-insulin regulation
2. Modeling of control of respiratory frequency and constrained optimization of airflow patternRegulation
3. Modeling of Baroreceptor Reflex: The Blood Pressure Control Systems
4. Simulink implementation of Cardiovascular variability model with single feedback loop
5. Modeling of Cardiovascular variability model with two interacting feedback loops
6. Simulink implementation of the circadian model
7. To simulate the model of state-chemoreflex interactions in obstructive sleep apnea.

Major Equipment:

High configured Computer system with licensed version MATLAB software (MATLAB 9.3 version)

List of Open Source Software/learning website:

1. https://systemsbiology.org/about/what-is systems-biology/http://systems-biology.org/software/model-editor/ http://www.physiome.org/Models/tutorial.html https://www.nature.com/subjects/systems-biology
2. https://in.mathworks.com/academia/courseware/quantitative-human-systems-physiology.htmlhttps://simtk.org/projects/biogears

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