

# EE6621: COMPUTATIONAL PHYSIOLOGY AND NEURAL SYSTEMS

---

## Effective Term

Semester A 2025/26

## Part I Course Overview

### Course Title

Computational Physiology and Neural Systems

### Subject Code

EE - Electrical Engineering

### Course Number

6621

### Academic Unit

Electrical Engineering (EE)

### College/School

College of Engineering (EG)

### Course Duration

One Semester

### Credit Units

3

### Level

P5, P6 - Postgraduate Degree

### Medium of Instruction

English

### Medium of Assessment

English

### Prerequisites

Nil

### Precursors

Nil

### Equivalent Courses

Nil

### Exclusive Courses

BME6122 Physiological Modeling, BME8133 Physiological Modeling

## Part II Course Details

### Abstract

This course explores the application of engineering principles to modeling in physiology and neuroscience, leveraging computing as a tool to better understand human body and the brain. It covers signal processing, control systems, and circuit theory for modeling complex biological processes, progressing from foundational physiology concepts to specialized topics in neural systems. Areas include advanced mathematical and computational methods, electrical analogs in physiological systems, feedback control in physiology, neuronal circuit modeling, bioelectric signal analysis, sensory system modeling, large-scale brain modeling, and neuromuscular system integration. Emphasis is placed on translating physiological concepts into quantitative frameworks, implementing models using computational tools familiar to engineers, and critically analyzing model predictions. Students will engage with current research literature and apply knowledge to construct, analyze, and interpret models of physiological and neural systems. This course prepares students for research and innovation in engineering applications such as wearables, human-computer interaction, biomedical instrumentation, and AI-driven healthcare technologies.

### Course Intended Learning Outcomes (CILOs)

CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Develop and implement models of physiological and neural systems using engineering principles	x	x	x
2	Apply signal processing techniques to analyze bioelectric signals, and basic machine learning algorithms for pattern recognition and classification of physiological data.		x	x
3	Analyze feedback mechanisms in physiological systems using control theory principles		x	x
4	Critically evaluate current research in computational neuroscience and physiology, applying this knowledge to interpret and refine models of complex biological systems	x	x	x

#### A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

#### A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

#### A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

### Learning and Teaching Activities (LTAs)

LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Interactive presentations that incorporate theoretical concepts with real-world examples	1, 2, 3, 4

2	Case Study Analyses	Guided examinations of real physiological datasets or research papers, where students critically analyze data, evaluate existing models, and develop their own computational solutions using signal processing and machine learning techniques.	1, 2, 3, 4	
3	Project	Develop and present a computational model of a physiological or neural system, applying course concepts to solve a real-world problem.	1, 2, 3, 4	

**Assessment Tasks / Activities (ATs)**

	ATs	CILO No.	Weighting (%)	Remarks ("- " for nil entry)	Allow Use of GenAI?
1	Assignments	1, 2, 3, 4	30	-	Yes
2	Project	1, 2, 3, 4	30	-	Yes
3	Test	1	10	-	No

**Continuous Assessment (%)**

70

**Examination (%)**

30

**Examination Duration (Hours)**

2

**Minimum Continuous Assessment Passing Requirement (%)**

30

**Minimum Examination Passing Requirement (%)**

30

**Additional Information for ATs**

Remark:

To pass the course, students are required to achieve at least 30% in course work and 30% in the examination.

**Assessment Rubrics (AR)****Assessment Task**

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 &amp; thereafter)

**Criterion**

Achievements in CILOs

**Excellent**

(A+, A, A-) High

**Good**

(B+, B, B-) Significant

**Fair**

(C+, C, C-) Moderate

**Marginal**

(D) Basic

**Failure**

(F) Not even reaching marginal levels

---

**Assessment Task**

Coursework (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**Criterion**

Achievements in CILOs

**Excellent**

(A+, A, A-) High

**Good**

(B+, B, B-) Significant

**Fair**

(C+, C, C-) Moderate

**Marginal**

(D) Basic

**Failure**

(F) Not even reaching marginal levels

---

**Assessment Task**

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

**Criterion**

Achievements in CILOs

**Excellent**

(A+, A, A-) High

**Good**

(B+, B) Significant

**Marginal**

(B-, C+, C) Basic

**Failure**

(F) Not even reaching marginal levels

---

## Assessment Task

Coursework (for students admitted from Semester A 2022/23 to Summer Term 2024)

### Criterion

Achievements in CILOs

### Excellent

(A+, A, A-) High

### Good

(B+, B) Significant

### Marginal

(B-, C+, C) Basic

### Failure

(F) Not even reaching marginal levels

---

## Additional Information for AR

Constructive Alignment with Programme Outcomes

### PILO

1,2,3

### How the course contribute to the specific PILO(s)

Students explore advanced computational modeling of physiological/neural systems, evaluating current research and applying engineering principles to complex biological systems.

4,5

Projects and case studies involve solving real-world problems, developing models for physiological/neural systems, preparing for innovation in biomedical applications.

6

Project presentations develop professional communication abilities.

## Part III Other Information

### Keyword Syllabus

#### Foundations of Physiological Modeling

Advanced mathematical techniques; computational methods; introduction to physiological control systems.

#### Electrical Analogs in Physiological Systems

Electrical analog of cardiovascular model; linear model of respiratory mechanics; linear model of muscle mechanics.

#### Physiological Control Systems

Cardiovascular control mechanisms; respiratory control systems; system integration and stability in cardiorespiratory networks; modeling closed-loop systems.

#### Neuronal Dynamics and Signaling

Hodgkin-Huxley model; cable theory, compartmental modelling; synaptic transmission models; neuronal networks, population dynamics.

#### Visual System Modeling

Retinal and cortical processing; color vision; object recognition; eye movement, visual attention.

#### Auditory System Modeling

Peripheral processing; central auditory processing; sound localization, spatial hearing models.

#### Brain Networks and Neural Interfaces

Large-scale neural network; brain connectivity; fMRI and EEG/MEG signals; brain-computer interfaces.

**Reading List****Compulsory Readings**

Title	
1	Michael C. K. Khoo, Physiological Control Systems: Analysis, Simulation and Control .2nd ed., Wiley-IEEE Press, 2018.
2	Paul Miller, An Introductory Course in Computational Neuroscience, MIT Press, 2018.

**Additional Readings**

Title	
1	Archilles J. Pappano & Withrow Gil Wier, Cardiovascular Physiology, 11th ed., Elsevier, 2018.
2	John B. West & Andrew M. Luks, West's Respiratory Physiology, 11th ed., LWW, 2020.
3	Eric R. Kandel et al., Principles of Neural Science, McGraw Hill, 2021.
4	Peter Dayan & Laurence F. Abbott, Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, 2005.
5	Mark. F. Bear, Barry W. Connors, and Michael A. Paradiso, Neuroscience: Exploring the Brain, 4th ed., Jones & Bartlett Learning, 2020.
6	Robert Rosenbaum, Modeling Neural Circuits Made Simple with Python, MIT Press, 2024
7	Pascal Wallisch et al., MATLAB for Neuroscientists: An Introduction to Scientific Computing in MATLAB, 2nd ed., Academic Press, 2013.
8	Katsuhiko Ogata, Modern Control Engineering,5th ed., Pearson, 2009.