

**Uka Tarsadia University**



**B. Tech.  
Semester VII**

**BRAIN MACHINE INTERFACE  
AI6009**

**EFFECTIVE FROM July-2023**

**Syllabus version: 1.00**

Subject Code	Subject Title
AI6009	Brain Machine Interface

Teaching Scheme				Examination Scheme				
Hours		Credits		Theory Marks		Practical Marks		Total Marks
Theory	Practical	Theory	Practical	Internal	External	Internal	External	
3	0	3	0	40	60	-	-	100

#### Objectives of the course:

- Understand the basic concepts of brain computer interface
- Study the various signal acquisition methods
- Learn about the signal processing methods used in BCI
- Understand the various machine learning methods of BCI.
- Learn the various applications of BCI
- Learn the various hardware and software components of BCI

#### Course outcomes:

Upon completion of the course, the student shall be able to

CO1: Comprehend and appreciate the significance and role of BCI in the present contemporary world.

CO2: Understand brain activation methods.

CO3: Select appropriate feature extraction methods.

CO4: Apply machine learning algorithms for BCI.

CO5: Understand the applications of BCI in real-time.

CO6: Understand the BCI hardware and software.

Sr. No.	Topics	Hours
<b>Unit – I</b>		
<b>1</b>	<b>Introduction to BCI:</b> Introduction, Brain structure and function, Brain Computer Interface Types, Synchronous and Asynchronous, Invasive BCI, Partially Invasive BCI - Non Invasive BCI, Structure of BCI System, BCI Monitoring Hardware, EEG, ECoG, MEG, fMRI.	6
<b>Unit – II</b>		
<b>2</b>	<b>Brain Activation:</b> Brain activation patterns - Spikes, Oscillatory potential and ERD, Slow cortical potentials, Movement related potentials-Mu rhythms, motor imagery, Stimulus related potentials - Visual Evoked Potentials – P300 and Auditory Evoked Potentials, Potentials related to cognitive tasks.	8
<b>Unit – III</b>		

<b>3</b>	<b>Feature Extraction Methods:</b> Data Processing – Spike sorting, Frequency domain analysis, Wavelet analysis, Time domain analysis, Spatial filtering -Principal Component Analysis (PCA), Independent Component Analysis (ICA), Artefacts reduction, Feature Extraction - Phase synchronization and coherence	8
<b>Unit – IV</b>		
<b>4</b>	<b>Machine Learning methods for BCI</b> Classification techniques –Binary classification, Ensemble classification, Multiclass Classification, Evaluation of classification performance, Regression - Linear, Polynomial, RBF's, Perceptron's, Multilayer neural networks, Support vector machine, Graph theoretical functional connectivity analysis	8
<b>Unit – V</b>		
<b>5</b>	<b>Applications of BCI:</b> Case Studies - Invasive BCIs: decoding and tracking arm (hand) position, controlling prosthetic devices such as orthotic hands, Cursor and robotic control using multi electrode array implant, Cortical control of muscles via functional electrical stimulation. Noninvasive BCIs:P300 Mind Speller, Visual cognitive BCI, Emotion detection. Ethics of Brain Computer Interfacing.	8
<b>Unit – VI</b>		
<b>6</b>	<b>BCI Hardware and Software:</b> Electroencephalography, EEG Electrode Placement and Signal Characteristics, Electrocardiogram, Intracortical Recording, Amplifiers, Analog-To-Digital Conversion, Artifacts, Hardware Interfaces, Software Components of BCI Implementation, Evaluating BCI Hardware and Software.	7

**Text book:**

3. Rajesh. P. N. Rao - “Brain-Computer Interfacing: An Introduction”, Cambridge University Press, First edition, 2013.

**Reference books:**

7. Jonathan Wolpaw, Elizabeth Winter Wolpaw - “Brain Computer Interfaces: Principles and practice”, Oxford University Press, USA, Edition 1, January 2012
8. Ella Hassianien, Azar. A. T (Editors) - “Brain-Computer Interfaces Current Trends and Applications”, Springer, 2015.
9. Bernhard Graimann, Brendan Allison, GertPfurtscheller - "Brain-Computer Interfaces: Revolutionizing Human-Computer Interaction", Springer, 2010

**Course objectives and Course outcomes mapping:**

- Understand the basic concepts of brain computer interface: CO1
- Study the various signal acquisition methods: CO2
- Learn about the signal processing methods used in BCI: CO3
- Understand the various machine learning methods of BCI: CO4
- Learn the various applications of BCI: CO5
- Learn the various hardware and software components of BCI: CO6

**Course units and Course outcomes mapping:**

Unit No.	Unit Name	Course Outcomes					
		CO1	CO2	CO3	CO4	CO5	CO6
1	Introduction to BCI	✓					
2	Brain Activation		✓				
3	Feature Extraction Methods			✓			
4	Machine Learning methods for BCI				✓		
5	Applications of BCI					✓	
6	BCI Hardware and Software						✓

**Programme outcomes:**

- PO 1: Engineering knowledge: An ability to apply knowledge of mathematics, science, and engineering.
- PO 2: Problem analysis: An ability to identify, formulates, and solves engineering problems.
- PO 3: Design/development of solutions: An ability to design a system, component, or process to meet desired needs within realistic constraints.
- PO 4: Conduct investigations of complex problems: An ability to use the techniques, skills, and modern engineering tools necessary for solving engineering problems.
- PO 5: Modern tool usage: The broad education and understanding of new engineering techniques necessary to solve engineering problems.
- PO 6: The engineer and society: Achieve professional success with an understanding and appreciation of ethical behaviour, social responsibility, and diversity, both as individuals and in team environments.
- PO 7: Environment and sustainability: Articulate a comprehensive world view that integrates diverse approaches to sustainability.
- PO 8: Ethics: Identify and demonstrate knowledge of ethical values in non-classroom activities, such as service learning, internships, and field work.
- PO 9: Individual and team work: An ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give/receive clear instructions.
- PO 11: Project management and finance: An ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and

in multidisciplinary environments.

PO 12: Life-long learning: A recognition of the need for, and an ability to engage in life-long learning.

**Programme outcomes and Course outcomes mapping:**

Programme Outcomes	Course Outcomes					
	C01	C02	C03	C04	C05	C06
P01						
P02		✓	✓		✓	✓
P03						
P04						
P05						
P06						
P07						
P08						
P09	✓	✓	✓	✓	✓	✓
P010						
P011						
P012						