M. Tech. (Master of Technology) in Biomedical Engineering & Artificial Intelligence (BEAI)

*This program is currently run under the AICTE approved nomenclature "Biomedical Instrumentation and Signal Processing." The approval for the new name is pending with AICTE.

Faculty of Engineering
M.TECH – Biomedical Engineering & Artificial Intelligence

The Biomedical Engineering & Artificial Intelligence (BEAI) program amalgamates principles from Engineering, Biology, and Medicine to address healthcare challenges, employing quantitative, analytical, software, and hardware approaches for understanding biological processes and innovating disease diagnosis, treatment, and prevention techniques. The future of improved healthcare relies on creating affordable, wearable, portable, energy-efficient, and user-friendly systems for real-time measurement and monitoring, encompassing invasive and non-invasive methods. To achieve this, an interdisciplinary curriculum equips students with advanced skills in signal processing, digital image processing, instrumentation, data science, machine learning, and IoT systems to engineer solutions for clinical-grade issues. Upon graduation, students will be proficient in developing engineering solutions for complex medical problems.
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Center for Wireless Networks and Applications

**M-Tech Biomedical Engineering & Artificial Intelligence**

Revised Curriculum 2023

### PROGRAM OUTCOME

<table>
<thead>
<tr>
<th>PO1</th>
<th>An ability to independently carry out research to solve practical problems</th>
</tr>
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<tbody>
<tr>
<td>PO2</td>
<td>An ability to write and present a substantial technical report / document</td>
</tr>
<tr>
<td>PO3</td>
<td>An ability to demonstrate a degree of mastery over the area as per the specialization of the program</td>
</tr>
<tr>
<td>PO4</td>
<td>An ability to bridge the gap between research and social needs</td>
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### PROGRAM SPECIFIC OUTCOMES

<table>
<thead>
<tr>
<th>PSO1</th>
<th>An insight on the recent trends in biomedical instrumentation and signal processing and the impact of the domain in industry and academia</th>
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</thead>
<tbody>
<tr>
<td>PSO2</td>
<td>Skills to build, apply and evaluate instrumentation, signal processing and data analytic techniques to solve healthcare problems</td>
</tr>
<tr>
<td>PSO3</td>
<td>Capacity to contribute to state-of-the-art research in the field of biomedical instrumentation, signal processing, data analytics, and machine learning</td>
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</table>
The curriculum has been redesigned to reflect the program’s educational outcomes in three significant thrust areas: (a) Biomedical Instrumentation, (b) Biomedical data processing and (c) Biomedical data sciences. Over the course of the first two semesters, foundation /subject core courses are offered to help the students transit from a basic to intermediate level of understanding/expertise in the areas.

- By the end of Semester-2, the elective courses will help the students fine-tune their understanding (of the thrust areas) to a relatively advanced level. This will get them ready to choose their specialization and project interests.
- The 3rd semester elective is meant mainly to help the students link their specialization with the project work and prepare a good feasible work plan for the last semester.
- At the end of the course and project work, a student should be competent in 2/3 of the thrust areas.
# CURRICULUM

## Semester - 1

<table>
<thead>
<tr>
<th>Type</th>
<th>CourseCode</th>
<th>Course Name</th>
<th>L T P</th>
<th>Credits</th>
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<tbody>
<tr>
<td>FC</td>
<td>23MA604</td>
<td>Applied Mathematics and Data Analytics</td>
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<tr>
<td>FC</td>
<td>23BI601</td>
<td>Applied Data Structures and Algorithms</td>
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<tr>
<td>SC</td>
<td>23BI602</td>
<td>Human Physiology</td>
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<td>Embedded System Design</td>
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<td>Biinstrumentation</td>
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<tr>
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<tr>
<td>HU</td>
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<td>Mastery over Mind</td>
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<td>HU</td>
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<td>Glimpses of Indian Culture</td>
<td>2 0 1</td>
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<td>HU</td>
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<td>Career Competency I*</td>
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<td><strong>Total Credits</strong></td>
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*Non-credit Course
1 lecture (L) session = 1 hour
1 practical (P) session = 3 hours

## Semester – 2

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<tr>
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<td>SC</td>
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<td>IoT in Healthcare</td>
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<tr>
<td>SC</td>
<td>23BI612</td>
<td>Applied Machine learning</td>
<td>3 0 1</td>
<td>4</td>
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<tr>
<td>SC</td>
<td>23BI613</td>
<td>Biomedical Signal Processing</td>
<td>3 0 1</td>
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<tr>
<td>SC</td>
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<td>Research Methodology</td>
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<tr>
<td>E</td>
<td>23BI742</td>
<td>Elective 2 Biomedical Image Processing</td>
<td>2 0 1</td>
<td>3</td>
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<tr>
<td>E</td>
<td>23BI681</td>
<td>Live-in-Labs-I - Participatory Design</td>
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<td>HU</td>
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1 lecture (L) session = 1 hour
1 practical (P) session = 3 hours
### Semester – 3

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<tr>
<td>P</td>
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<td>Dissertation- Phase I</td>
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<tr>
<td>P</td>
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<td>Live-in-Labs II- Lab-to-Field: People Centred Innovation</td>
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<td><strong>Total Credits</strong></td>
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1 lecture (L) session = 1 hour  
1 practical (P) session = 3 hours

### Semester – 4

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</table>

1 lecture (L) session = 1 hour  
1 practical (P) session = 3 hours

**Total Course Credits: 70**

### ELECTIVES

**Elective 1**  
**Domain: Instrumentation**

<table>
<thead>
<tr>
<th>Type</th>
<th>CourseCode</th>
<th>Course Name</th>
<th>L T P</th>
<th>Credits</th>
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<tbody>
<tr>
<td>E</td>
<td>23BI731</td>
<td>Wearable Biomedical Systems</td>
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<tr>
<td>E</td>
<td>23BI732</td>
<td>Biosensors</td>
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<td>3</td>
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<tr>
<td>E</td>
<td>23BI733</td>
<td>BioMEMS</td>
<td>3 0 0</td>
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<tr>
<td>E</td>
<td>23BI734</td>
<td>Virtual Instrumentation</td>
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</table>

**Elective 2**  
**Domain: Artificial intelligence/Data processing**

<table>
<thead>
<tr>
<th>Type</th>
<th>CourseCode</th>
<th>Course Name</th>
<th>L T P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>23BI741</td>
<td>Medical Robotics</td>
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<tr>
<td>E</td>
<td>23BI742</td>
<td>Biomedical Image processing</td>
<td>2 0 1</td>
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<tr>
<td>E</td>
<td>23BI743</td>
<td>Bio-Inspired Computing</td>
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<tr>
<td>E</td>
<td>23BI744</td>
<td>Mobile Computing</td>
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</tbody>
</table>

**Elective 3**  
**Domain: Signal Processing/ Artificial intelligence**

<table>
<thead>
<tr>
<th>Type</th>
<th>CourseCode</th>
<th>Course Name</th>
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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>E</td>
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<tr>
<td>E</td>
<td>23BI752</td>
<td>Speech and Audio processing</td>
<td>3 0 0</td>
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<tr>
<td>E</td>
<td>23BI753</td>
<td>Computer Vision</td>
<td>3 0 0</td>
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<tr>
<td>E</td>
<td>23BI754</td>
<td>Artificial Intelligence in Healthcare</td>
<td>3 0 0</td>
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<td>E</td>
<td>23BI755</td>
<td>Brain-computer interfacing</td>
<td>3 0 0</td>
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</table>
Learning Objectives

LO1 Review mathematical concepts of linear algebra, probability distributions and statistical methods.
LO2 To be proficient with analytics tools for healthcare data preparation and analysis.

Course Outcomes

CO1 Ability to understand the steps involved in the data mining process (e.g., pre-processing, classification, regression, clustering, and visualization) and apply them for analysis of healthcare data.
CO2 Ability to describe different methods of predictive analytics and their applications in the healthcare domain.
CO3 Ability to evaluate the data from diverse sources to create meaningful presentations.

Course Contents

Data Analytics with Python: Getting to know data - (a) attributes, statistical description of data, data visualization, similarity - dissimilarity, (b) preprocessing - missing values, noisy data, data reduction, data transformation - normalization, standardization, binning, clustering.


(Part 2 of this is continued in the Applied Machine Learning Course in the next semester)

Textbooks

1. Data Mining Concepts and Techniques by Jiawei Han and Micheline Kamber
3. Business Analytics: Data Analysis and Decision Making by Christian Albright and Wayne Winston
Learning Objectives

LO1 Enable students to design data structures and algorithms to solve complex problems.

LO2 Concrete implementations of various data structures and their use in non-trivial algorithms with proper analysis.

Course Outcomes

CO1 Ability to understand the recursive and non-recursive algorithms and to measure the time and space performance of algorithms by using asymptotic notations.

CO2 Ability to understand the basic Data Structures (Array, Linked list, Stack, Queue) and advanced Data Structure – graph, trees and its traversal and search algorithms.

CO3 Able to develop algorithms for well-known problems using greedy methods and apply dynamic-programming approach for designing graph and matrix-based algorithms.

CO4 Synthesize efficient algorithms in common real-life situations

CO5 Ability to analyse and solve common logic and analytical puzzles and provide optimized solutions for the same.

Course Contents

Basic Data Structures (Array, Linked list, Stack, Queue), Graph (Node, edge, order, size, degree, Adjacency Matrix, Adjacency List graph representation). Why do we study (Algorithms, Design, Analysis),


Advanced Data Structures (Heaps, Binary Search Trees, Hash tables) , Greedy Algorithms (Optimal Caching and Scheduling), Dynamic Programming (Knapsack problem, sequence alignment, shortest path routing), Intractable Problems (P vs. NP), NP-Completeness: Important NP-Complete Problems, Polynomial time reductions, Approximation algorithms

Textbooks

Learning Objectives
LO1 To introduce the basic concepts of human physiology.
LO2 To impart knowledge on the functioning of various organs and systems in the human body.
LO3 To enable the biological concepts to help in biomedical signal analysis.

Course Outcomes
CO1 Ability to understand the physiology, functions of various organs and disorders.
CO2 Ability to apply the physiological concepts in modelling biomedical systems.
CO3 Ability to analyse the functioning of various vital organs and systems.

Course Contents
Circulatory system - physiology of the heart - Conducting system of the heart - Arterial and venous blood pressure. Gastrointestinal system - Gastric secretion - Pancreatic secretion - Renal physiology - Structure of kidney - Respiratory system - Mechanism of breathing - Regulation of respiration - Transport of gases - Hypoxia - Endocrinology - Endocrine glands - Hormones and their functions.

Textbooks
Learning Objectives

LO1 To introduce design concepts of embedded systems.
LO2 To provide insights on embedded C programming for configuring microcontroller and peripherals.
LO3 To enable development of embedded system models.

Course Outcomes

CO1 Ability to identify the features of microcontroller.
CO2 Ability to apply embedded C programming skills for configuring microcontroller peripherals.
CO3 Ability to analyse external peripheral interfacing with a microcontroller.
CO4 Ability to design and develop embedded systems using microcontroller.

Course Contents

Microcontroller fundamentals: ARM ASM programming and basic of C; IO Interfacing: LED and Switch; Design and Development Process: Architecture, Microarchitecture, Design, Implementation, Verification and Validation; Development Tools: Block Diagrams, Flow Charts, Call Graphs, Dataflow Graphs, Finite State Machines; The Parallel Interface: GPIO; The Serial Interface: UART, I2C, SPI; PLL programming; Timer: SysTick; Fixed Point; Software: Stucts, Stacks and Recursion; Device Driver: Interfacing with an Hitachi HD44780 display; IO Synchronization; Interrupts; DAC: Music Synthesis and Music Playback; ADC: Real world interfacing and Data Acquisition.

Significant labs include prototypes of actual embedded systems, e.g., Traffic Light Controller (FSM), LCD Device Driver (Hitachi HD44780), Digital Piano (DAC, Interrupts), Digital Vernier Caliper (ADC, Interrupts, LCD), Distributed Data Acquisition (Interrupts, ADC, LCD, UART). Capstone Design Project, A popular video game, e.g., Space Invaders, Connect-4, Pipe Dream, etc.

Textbooks

Learning Objectives

LO1 To understand the fundamental principles of electronics.
LO2 To design, test and analyse biomedical circuits and signals.

Course Outcomes

CO1 Apply knowledge of engineering and science to understand the principle of biomedical electronic circuits.
CO2 Understand how to measure and fine-tune circuit performance to solve problems in the areas of biomedical signals.

Course Contents


Laboratory module will involve hands-on hardware experiments on
1. Network theorems, voltage, and current division.
2. Diode circuits
3. Passive filters
4. Transistor amplifiers
5. Active filters
6. Signal conditioning circuits
7. Medical signal acquisition circuits

Recommended Tools: NI-Multisim software for simulations, Digilent Analog Discovery kits and Waveforms software for hands-on circuit implementation.

Textbooks

Learning Objectives

LO1 To familiarize with major signal and image acquisition modalities in healthcare.
LO2 To understand instrumentation and signal characteristics associated with each modality.

Course Outcomes

CO1 To get familiarized with
(a) biomedical signal acquisition modalities like ECG, EEG, EMG,
(b) biomedical imaging modalities like x-ray, MRI, CT and
(c) surgical and other analytic equipment.
CO2 Ability to read and interpret data from diverse modalities.

Course Contents

Introduction to biomedical instruments and data – purpose – types – data characteristics – data acquisition and analysis.
Biomedical signals and their measurements – Biopotentials - Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyography (EMG), Photoplethysmography (PPG).
Medical images and their measurements - X-ray, Magnetic Resonance Imaging (MRI), Computed Tomography (CT), PET, and SPECT, Ultrasonography.
Surgical Instruments, ENT, and Ophthalmic Instruments. Medical equipment safety.
The course will include a hospital field visit.

Textbooks

Learning Objectives

LO1 To understand the concepts of Internet of Things.
LO2 To provide exposure to the routing protocols used in medical IoT devices.
LO3 To comprehend on applications of IoT in the field of healthcare.

Course Outcomes

CO1 Ability to understand the basic architecture of an IoT device.
CO2 Ability to apply big data analytics in Medical IoT devices.
CO3 Ability to analyse mobility in location based IoT systems.
CO4 Ability to evaluate the performance of IoT applications in healthcare.

Course contents


Textbooks

Learning Outcomes

LO1 To introduce different machine learning paradigms.
LO2 To provide understanding of machine learning algorithms to be used on a given dataset for regression/classification problems.

Course Outcomes

CO1 Ability to conduct data analysis and data visualization.
CO2 Apply the complete ML pipeline in real-world dataset - Analyse datasets, decide pre-processing steps, visualize data, apply ML models, and infer the meaning based on different performance metrics.

Course contents


Textbooks

1. An Introduction to Statistical Learning by Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani (2022)
Learning Objectives

LO1 To introduce characteristics of biomedical signals.
LO2 To provide understanding of artifact removal in biomedical signals.
LO3 To enhance knowledge in event detection and waveform analysis of biomedical signals.
LO4 To provide insight on pattern classification in biomedical signals.

Course Outcomes

CO1 Ability to understand concepts of signal processing.
CO2 Ability to apply algorithms for signal processing.
CO3 Ability to analyse biomedical signals and systems.
CO4 Ability to evaluate biomedical signal processing systems.

Course contents

Brief introduction to biomedical signals - Challenges in biomedical signal acquisition and analysis - Need for Computer Aided Diagnosis (CAD)
Sampling and reconstruction - Types of noise - Random noise - Structured noise - Physiological interference - Linear time-invariant filters - Time domain filters - Synchronized averaging - Moving average filters - Derivative based filters.
Transform domain analysis of signals and systems - Discrete Fourier Transform (DFT) and its properties - Pole-zero plot - Time-frequency analysis - Short-Time Fourier Transform (STFT) - Wavelet Transform
Filter design - Butterworth filters - Notch and comb filters - Event detection - Analysis of waveshape and waveform complexity - Morphological analysis - Envelope extraction and analysis - Feature extraction - Receiver operating characteristics - Case studies - Removal of artifacts - QRS Detection and classification of ectopic beats in ECG signals - Detection of epileptic seizures in EEG signals - Study of muscular contraction using parametric analysis of EMG signals.

Laboratory module will involve hands-on experiments on
1. Digital signal processing - Basic operations
2. Time domain filtering
3. Discrete Fourier Transform (DFT)
4. Frequency domain filtering
5. Artifact removal in bio-signals
6. Waveform analysis and feature extraction from bio-signals
7. Pattern classification in bio-signals

Recommended Tools: MATLAB, Python

Textbooks

1. Rangayyan, Rangaraj M, Biomedical signal analysis, John Wiley & Sons, 2015

Learning Objectives

LO1 To enable defining and formulating research approaches towards obtaining solutions to practical problems.
LO2 To facilitate development of scientific oral and written communication skills.
LO3 To comprehend the concepts behind adhering to scientific ethics and values.

Course Outcomes

CO1 Ability to understand some basic concepts of research and its methodologies.
CO2 Ability to define and apply appropriate parameters and research problems.
CO3 Ability to develop skills to draft research papers.
CO4 Ability to analyse and comprehend the ethical practices in conducting research and dissemination of results in different forms.

Course contents

Meaning of research - Types of research - Research process - Problem definition - Objectives of research - Research questions - Research design - Approaches to research - Quantitative vs. qualitative approach - Understanding theory - Building and validating theoretical models - Exploratory vs. confirmatory research - Experimental vs theoretical Research - Importance of reasoning in research.

Problem formulation - Conducting literature review - Referencing - Information sources - Information retrieval - Role of libraries in information retrieval - Tools for identifying literatures - Indexing and abstracting services - Citation indexes.

Experimental research - Cause effect relationship - Development of hypothesis -Measurement systems analysis - Error propagation - Validity of experiments - Statistical design of experiments - Field experiments - Data/Variable types & classification - Data collection - Numerical and graphical data analysis - Sampling - Observation - Surveys -Inferential statistics and interpretation of result.

Preparation of dissertation and research papers - Tables and illustrations - Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript - References, citation, and listing system of documents. Ethics of Research - Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work.

Intellectual property: To give an idea about IPR, registration, patents-copyrights, and its enforcement.

Textbooks


| 23BI731 | Wearable Biomedical Systems | 3 0 0 3 |

Learning Objectives

LO1 To introduce the fundamentals of wearable sensor technology.
LO2 To impart knowledge on electronics in wearable system design.
LO3 To enable knowledge development on principles of energy harvesting.
LO4 To provide insight to assistive technologies in wearable system.

Course Outcomes

CO1 Ability to understand the basics of wearable sensor system design.
CO2 Ability to apply the IC technologies for bio sensing.
CO3 Ability to analyse the energy and power consumption requirements in system design.
CO4 Ability to evaluate the multi parameter measurements from wearable sensors.

Course contents

Introduction to Wearable sensors - Attributes of wearables - Meta-wearable - Challenges and opportunities - Future of wearables - Social interpretation of Aesthetics - Case study - Google glass - Wearable haptics - Need for wearable haptic devices - Categories of wearable haptic and tactile display - Wearable Sensors - Chemical and Biochemical sensors - System design - Challenges in chemical biochemical sensing – Applications.
Flexible Electronics and Energy Harvesting Systems - Thin-film transistors - Low-power Integrated Circuit design for biopotential sensing - Analog circuit design techniques -
Lowpower design for ADCs - Digital circuit design techniques - Architectural design for low power biopotential acquisition - Practical considerations - Energy harvesting from human body - Temperature gradient - Foot motion - Wireless energy transmission - Energy harvesting from light and RF energy - Energy and power consumption issues - Future considerations


Textbooks


23BI732 Biosensors 3 0 0 3

Learning Objectives

LO1 To introduce the operation of biosensors.
LO2 To provide understanding on characterization techniques of biosensors.
LO3 To impart knowledge on Lab-on-a-Chip concepts.

Course Outcomes

CO1 Ability to understand the working principles of biosensors.
CO2 Ability to characterize optical and electrochemical sensors.
CO3 Ability to analyse the response of biosensors.

Course contents

Electrochemical biosensors - Construction and working of potentiometric - Amperometric and impedemetric sensors - Development and applications of piezoelectric sensors - Electrochemical sensors for glucose - Vitamins - Cholesterol - Dopamine - Biochips and electrochemical microarrays - Lab-on-a-chip - Biosensing using nanomaterials - Biocompatibility of sensors - PCR Principles.

Textbooks


Learning Objectives

LO1 To introduce the basics of MEMS.
LO2 To provide understanding fabrication of BioMEMS.
LO3 To impart knowledge on biomedical applications of MEMS.

Course Outcomes

CO1 Ability to understand the operation of micro devices, micro systems, and their application.
CO2 Ability to design the micro devices, micro systems using the MEMS fabrication process.
CO3 Ability to analyse the optic MEMS applications in bioengineering.
CO4 Ability to evaluate the performance of MEMS in diagnostic applications.

Course contents


Textbooks

Learning Objectives

LO1 To provide knowledge of virtual instrumentation.
LO2 To enable understanding of virtual signal processing tools.
LO3 To introduce biomedical applications of virtual instrumentation.

Course Outcomes

CO1 Ability to understand programming concepts for virtual instrumentation.
CO2 Ability to analyze bio-signal processing algorithms using virtual instrumentation.
CO3 Ability to develop virtual codes for biomedical applications.

Course contents

Introduction to virtual instrumentation - Loops and structures - Arrays and clusters - Graphs and charts File and string handling - Basics of data acquisition - Common communication buses using DAQ assistant - Real world DAQ and issues - Network and distributed systems.
Data handling techniques - Signal acquisition and sampling theorem - Effect of undersampling - Convolution - Designing an FIR and IIR filters - FFT analysis of periodic and aperiodic signals - Designing low pass filter - High pass filter - Bandpass filter - Band reject filter - Notch filter and Comb filter.
Processing of ECG, EMG and EOG signals - Adaptive signal processing - Data compression techniques - AZTEC - TP - CORTES and KL transform.

Textbooks


Learning Objectives

LO1 To impart basic understanding of robotics.
LO2 To enable understanding the design and control concepts of medical robots.
LO3 To comprehend on the application of robotics in the field of healthcare.

Course Outcomes

CO1 Ability to understand different types of Robotic Systems.
CO2 Ability to apply the concepts of robotics for surgery.
CO3 Ability to analyse the positioning and orientation of medical robots.
CO4 Ability to design the kinematics model for a specified robotic system.

Course contents

Introduction to robots - Robots as mechanical devices - Classification of robotic manipulators - Robotic systems - Accuracy and repeatability - Wrists and end-effectors - Mathematical modelling of robots - Symbolic representation of robots - The configuration space - The state space - The workspace common kinematic arrangements of manipulators - Forward kinematics - Inverse kinematics - Velocity kinematics.

Textbooks


Image processing practical exercises:
1. Basic operations on images
2. Image enhancement using point operations.
3. Image enhancement using spatial domain filters.
4. Histogram processing of images.
5. Image enhancement using frequency domain filters.
7. Medical image segmentation using edge and region-based methods.
8. Extraction of shape and texture features from a medical image.
9. Design of pattern classification system for biomedical images.

Recommended Tools MATLAB, Python

Textbooks

5. Yoo, Terry S. Insight into Images: Principles and Practice for Segmentation, Registration and Image Analysis, CRC Press

| 23BI743 | Bio-Inspired Computing | 3 0 0 3 |

Learning Objectives

LO1 To introduce concepts of Bio-inspired Computing and its applications.
LO2 To provide insight on Artificial Neural Networks.
LO3 To introduce Fuzzy logic and Fuzzy Systems.
LO4 To provide knowledge on optimization algorithms.

Course Outcomes

CO1 Ability to understand the principles of bio-inspired algorithms.
CO2 Ability to apply bio-inspired techniques for pattern recognition and optimization tasks.
CO3 Ability to analyse problems in medical applications using bio-inspired approaches.
CO4 Ability to evaluate performance of optimization algorithms.

Course contents


Textbooks


Learning Objectives

LO1 To introduce different mobile application and development platforms
LO2 To provide an overview of the use of portable devices and wireless communication technologies to enable access to digital resources and services from anywhere.

Course Outcomes

CO1 Ability to comprehend the technical modules of mobile devices, operating systems and applications.
CO2 Introduction to Android platform and the design of user interface for mobile applications
CO3 Introduction to working with database and security systems.
CO4 Overview is Security systems and permissions in mobile computing.

Course contents

History of mobile devices, mobile operating systems and mobile application frameworks, Modern mobile operating systems, and their architecture. Overview of mobile application development languages: C and Java. Introduction to Android platform: virtual machine, development tools, Java packages, emulators, services, Structure, and lifecycle of an application for Android system. User interface design for mobile applications: Graphical User
Interface - preparing containers and components, management of component layout, event handling; Introduction to integration and working with database. Overview of security and permissions, Bluetooth communication, deployment of application.

Textbooks

2. Rajiv Ramnath, Roger Craws, and Paolo Sivilotti, Android SDK 3 for Dummies, Wiley.
7. Joshua Morony, Building Mobile Apps with Ionic & Angular [eBook].

| 23B1751 | Multivariate Signal Processing | 3 0 0 3 |

Learning Objectives

LO1 To provide basic concepts of multivariate signals.
LO2 To impart knowledge on statistical analysis of multivariate time series data.
LO3 To introduce time and spectral domain approaches for analysing multivariate biomedical data.

Course Outcomes

CO1 Ability to understand the basics of multivariate signal processing.
CO2 Ability to apply statistical analysis for multivariate time series data.
CO3 Ability to analyse multi-domain features of Biomedical signals.
CO4 Ability to evaluate performance of multivariate signal processing algorithms.

Course contents

Data compression of EEG and ECG signals - EMG Source signal separation techniques - EEG signal separation and Pattern Classification - Correlation of Biomedical signals - Evaluating causal relations in biomedical systems - Case studies - ICA based analysis on neurological disorders using EEG - Deep learning-based arrhythmia classification using EEG.
Textbooks


| 23BI752      | Speech and Audio Processing | 3 0 0 3 |

Learning Objectives

LO1 To introduce the concepts of signal processing with application to speech processing.
LO2 To provide insights on feature extraction for speech coding, synthesis, and recognition.
LO3 To enable understanding of deep learning applications to speech processing and healthcare.

Course Outcomes

CO1 Ability to understand concepts of Speech signal processing.
CO2 Ability to apply the concepts of signal processing to feature extraction of speech/audio signals.
CO3 Ability to analyse and process speech data for speech coding, synthesis, and recognition.
CO4 Ability to evaluate speech/audio processing techniques in healthcare applications.

Course contents

Introduction to signal processing - FIR and IIR filters - DFT - FFT - Speech analysis overview - Modelling of speech production - Speech perception and models - Feature extraction for speech processing - Auditory system as a filter bank - Linear predictive coding - Spectrum - Cepstrum - Mel-frequency cepstral coefficients. Introduction to music synthesis - Music signal analysis - Source separation - Speech recognition - Synthesis and coding - Introduction to deep neural networks - Applications of deep learning techniques to speech processing - Applications of speech and audio processing in healthcare - Case studies - Dysarthria – Aphasia. Analysis of speech/audio - Experiment with speech analysis and synthesis - Experiment with deep learning techniques for speech recognition - Analyse the speech signals of controls with dysarthria and aphasia.

Textbooks

Learning Objectives

LO1 To introduce the fundamentals of image formation.
LO2 To provide understanding of segmentation techniques in vision-based applications.
LO3 To impart knowledge on advanced concepts in image representation techniques.
LO4 To provide insights on implementation of computer vision algorithms for biomedical applications.

Course Outcomes

CO1 Ability to understand the fundamental concepts in computer vision.
CO2 Ability to apply segmentation techniques and descriptors.
CO3 Ability to analyse medical problems using computer vision techniques.
CO4 Ability to evaluate performance of computer vision algorithms in biomedical applications.

Course contents


Textbooks

Learning Objectives

LO1 To provide basic introduction to artificial intelligence and its role in biomedicine and healthcare.
LO2 To introduce different concepts, methods, and potential intelligent systems in medicine.

Course Outcomes

CO1 Ability to understand decision support systems.
CO2 Ability to apply neural networks and deep neural networks for healthcare problems.
CO3 Ability to apply time-series forecasting for healthcare applications.

Course contents


Textbooks


Learning Objectives

LO1 To introduce the concepts of Brain Computer Interfacing (BCI).
LO2 To impart knowledge about the data acquisition methods used in BCI.
LO3 To enhance the understanding on BCI signal Processing and parameter extraction.
LO4 To enable the knowledge on classification of cognitive task from BCI parameters.

Course Outcomes

CO1 Ability to understand the basic concepts of EEG and BCI.
CO2 Ability to apply signal processing techniques in BCI.
CO3 Ability to analyse human cognition using BCI parameters.
CO4 Ability to evaluate machine learning methods in BCI applications.

Course contents

Brain activation patterns - Spikes - Oscillatory potential - Event-Related Potentials (ERP) - Mu rhythms - Stimulus related potentials - Visual evoked potentials and auditory evoked potentials.

Textbooks


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### Course Objectives

The course will enable the students to

- Mastery Over Mind (MaOM) is an Amrita initiative to implement schemes and organize university-wide programs to enhance health and wellbeing of all faculty, staff, and students (UN SDG -3)
- It gives an introduction to immediate and long-term benefits of MAOM meditation and equips every attendee to manage stressful emotions and anxiety, in turn facilitating inner peace and harmony.
- This course will enhance the understanding of experiential learning based on the University’s mission: “Education for Life along with Education for Living” and is aimed to allow learners to realize and rediscover the infinite potential of one’s true Being and the fulfillment of life’s goals.

### Course Outcomes

**CO1:** To be able to describe what meditation is and to understand its health benefits

**CO2:** To understand the causes of stress and how meditation improves well-being

**CO3:** To understand the science of meditation

**CO4:** To learn and practice MAOM meditation in daily life

**CO5:** To understand the application of meditation to improve communication and relationships

**CO6:** To be able to understand the power of meditation in compassion-driven action

### CO-PO Mapping

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Syllabus:

Unit 1: Describe Meditation and Understand its Benefits (CO1)
A: Importance of meditation. How does meditation help to overcome obstacles in life (Pre-recorded video with Swami Shubhamritananda Puri)
Reading 1: Why Meditate? (Swami Shubamritananda ji)

Unit 2: Causes of Stress and How Meditation Improves Well-being (CO2)
A: Learn how to prepare for meditation. Understand the aids that can help in effectively practicing meditation. Understand the role of sleep, physical activity, and a balanced diet in supporting meditation. (Pre-recorded video with Dr. Ram Manohar)

Unit 3: The Science of Meditation (CO3)
A: A preliminary understanding of the Science of meditation. What can modern science tell us about this tradition-based method? (Pre-recorded video with Dr. Shyam Diwakar)
B: How meditation helps humanity according to what we know from scientific research (Pre-recorded video with Dr. Shyam Diwakar)
Reading 1: Does Meditation Aid Brain and Mental Health (Dr Shyam Diwakar)

Unit 4: Practicing MA OM Meditation in Daily Life (CO4)
Guided Meditation Sessions following scripts provided (Level One to Level Five)
Reading 1: MA OM and White Flower Meditation: A Brief Note (Swami Atmananda Puri)

Unit 5: Improving Communication and Relationships (CO5)
How meditation and mindfulness influence interpersonal communication. The role of meditation in improving relationship quality in the family, at the university and in the workplace. (Pre-recorded video with Dr Shobhana Madhavan)

Unit 6 Meditation and Compassion-driven Action (CO6)
Understand how meditation can help to motivate compassion-driven action. (Pre-recorded video with Dr Shobhana Madhavan)

Text Books/Reference Books:
1. Meditation and Spiritual Life-Swami Yatiswarananda, Ramakrishna Math
3. Dhyana Yoga-Holy Gita Swami Chinmayanda
4. Voice of God, Chandrasekharendra Saraswati, 68th Acharya of Sri Kanchi Kamakoti Peetam,
5. Hindu Dharma-Chandrasekharendra Saraswati, 68th Acharya of Sri Kanchi Kamakoti Peetam,
6. Mind: It’s Mysteries and control-Swami Sivananda Saraswati
8. Books on Amma’s teachings like Awaken children, From Amma’s Heart etc.

### Evaluation Pattern

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*CA – Can be Quizzes, Assignment, Projects, and Reports

<table>
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<tr>
<th>23HU601</th>
<th>Career Competency I</th>
<th>L-T-P-C: 0-0-3-P/F</th>
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**Pre-requisite:** An open mind and the urge for self-development, basic English language skills and knowledge of high school level arithmetic.

**Course Objectives:**
- Help students transit from campus to corporate and enhance their soft skills
- Enable students to understand the importance of goal setting and time management skills
- Support them in developing their problem solving and reasoning skills
- Inspire students to enhance their diction, grammar and verbal reasoning skills

**Course Outcomes:**
CO1: **Soft Skills** - To develop positive mindset, communicate professionally, manage time effectively and set personal goals and achieve them.
CO2: **Soft Skills** - To make formal and informal presentations with self-confidence.
CO3: **Aptitude** - To analyze, understand and employ the most suitable methods to solve questions on arithmetic and algebra.
CO4: **Aptitude** - To analyze, understand and apply suitable techniques to solve questions on logical reasoning and data analysis.
CO5: **Verbal** - To infer the meaning of words and use them in the right context. To have a better understanding of the nuances of English grammar and become capable of applying them effectively.
CO6: **Verbal** - To identify the relationship between words using reasoning skills. To understand and analyze arguments and use inductive/deductive reasoning to arrive at conclusions and communicate ideas/perspectives convincingly.

**CO-PO Mapping**

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<th>CO</th>
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Syllabus

Soft Skills
Introduction to ‘campus to corporate transition’:
Communication and listening skills: communication process, barriers to communication, verbal and non-verbal communications, elements of effective communication, listening skills, empathetic listening, role of perception in communication.
Assertiveness skills: the concept, assertiveness and self-esteem, advantages of being assertive, assertiveness and organizational effectiveness.
Self-perception and self-confidence: locus of control (internal v/s external), person perception, social perception, attribution theories-self presentation and impression management, the concept of self and self-confidence, how to develop self-confidence.
Goal setting: the concept, personal values and personal goals, goal setting theory, six areas of goal setting, process of goal setting: SMART goals, how to set personal goals
Time management: the value of time, setting goals/ planning and prioritizing, check the time killing habits, procrastination, tools for time management, rules for time management, strategies for effective time management
Presentation skills: the process of presentation, adult learning principles, preparation and planning, practice, delivery, effective use of voice and body language, effective use of audio visual aids, dos and don’ts of effective presentation
Public speaking—an art, language fluency, the domain expertise (Business GK, Current affairs), self-confidence, the audience, learning principles, body language, energy level and conviction, student presentations in teams of five with debriefing

Verbal
Vocabulary: Familiarize students with the etymology of words, help them realize the relevance of word analysis and enable them to answer synonym and antonym questions. Create an awareness about the frequently misspelt words, commonly confused words and wrong form of words in English.
Grammar: Train students to understand the nuances of English Grammar and thereby enable them to spot grammatical errors and punctuation errors in sentences.
Reasoning: Stress the importance of understanding the relationship between words through analogy questions and learn logical reasoning through syllogism questions. Emphasize the importance of avoiding the gap (assumption) in arguments/ statements/ communication.
Oral Communication Skills: Aid students in using the gift of the gab to improve their debating skills.
Writing Skills: Introduce formal written communication and keep the students informed about the etiquettes of email writing. Make students practise writing emails especially composing job application emails.

Aptitude
Ratio, Proportion & Variation: Basics, Alligations, Mixtures, and Partnership.
Averages: Basics, and Weighted Average.
Time, Speed and Distance: Basics, Average Speed, Relative Speed, Boats & Streams, Races and Circular tracks.
Statistics: Mean, Median, Mode, Range, Variance, Quartile Deviation and Standard Deviation.
Data Interpretation: Tables, Bar Diagrams, Line Graphs, Pie Charts, Caselets, Mixed Varieties, and other forms of data representation.
Equations: Basics, Linear, Quadratic, Equations of Higher Degree and Problems on ages.
Logarithms, Inequalities and Modulus: Basics

References

Soft Skills
Communication and listening skills:

Assertiveness skills:
- John Hayes “Interpersonal skills at work”, Routledge, 2003

Self-perception and self-confidence:

Time management:
- Stephen Covey, “The habits of highly effective people”, Free press Revised edition, 2004
- Kenneth H. Blanchard and Spencer Johnson, “The One Minute Manager”, William Morrow, 1984

Verbal
- Erica Meltzer, “The Ultimate Guide to SAT Grammar”
- Jeff Kolby, Scott Thornburg & Kathleen Pierce, “Nova’s GRE Prep Course”
- Kaplan’s GRE Comprehensive Programme
- Manhattan Prep, “GRE Verbal Strategies Effective Strategies Practice from 99th Percentile Instructors”
- Wren & Martin, “English Grammar & Composition”
- www.bbc.co.uk/learningenglish
- www.cambridgeenglish.org
- www.englishforeveryone.org
- www.merriam-webster.com

Aptitude
Evaluation Pattern

<table>
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<tr>
<th>Assessment</th>
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Pass / Fail

*CA - Can be presentations, speaking activities and tests.

23HU611 Career Competency II L-T-P-C: 0-0-3-1

Pre-requisite: Willingness to learn, team spirit, basic English language and communication skills and knowledge of high school level arithmetic.

Course Objectives:

- Help students to understand the importance of interpersonal skills and team work
- Prepare the students for effective group discussions and interviews participation.
- Help students to sharpen their problem solving and reasoning skills
- Empower students to communicate effectively by using the correct diction, grammar and verbal reasoning skills

Course Outcomes:

CO1: Soft Skills - To demonstrate good interpersonal skills, solve problems and effectively participate in group discussions.
CO2: Soft Skills - To write technical resume and perform effectively in interviews.
CO3: Aptitude - To identify, investigate and arrive at appropriate strategies to solve questions on arithmetic by managing time effectively.
CO4: Aptitude - To investigate, understand and use appropriate techniques to solve questions on logical reasoning and data analysis by managing time effectively.
CO5: Verbal - To be able to use diction that is more refined and appropriate and to be competent in knowledge of grammar to correct/improve sentences
CO6: Verbal - To be able to examine, interpret and investigate passages and to be able to generate ideas, structure them logically and express them in a style that is comprehensible to the audience/recipient.

CO-PO Mapping

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Syllabus
Soft Skills
Interpersonal skill: ability to manage conflict, flexibility, empathetic listening, assertiveness, stress management, problem solving, understanding one’s own interpersonal needs, role of effective team work in organizations

Group problem solving: the process, the challenges, the skills and knowledge required for the same. Conflict management: the concept, its impact and importance in personal and professional lives, (activity to identify personal style of conflict management, developing insights that helps in future conflict management situations.)

Team building and working effectively in teams: the concept of groups (teams), different stages of group formation, process of team building, group dynamics, characteristics of effective team, role of leadership in team effectiveness. (Exercise to demonstrate the process of emergence of leadership in a group, debrief and reflection), group discussions.

Interview skills: what is the purpose of a job interview, types of job interviews, how to prepare for an interview, dos and don’ts of interview, One on one mock interview sessions with each student

Verbal
Vocabulary: Help students understand the usage of words in different contexts. Stress the importance of using refined language through idioms and phrasal verbs.
Grammar: Enable students to identify poorly constructed sentences or incorrect sentences and improvise or correct them.
Reasoning: Facilitate the student to tap her/his reasoning skills through critical reasoning questions and logical ordering of sentences.
Reading Comprehension: Enlighten students on the different strategies involved in tackling reading comprehension questions.
Public Speaking Skills: Empower students to overcome gloss ophobia and speak effectively and confidently before an audience.
Writing Skills: Practice closet tests that assess basic knowledge and skills in usage and mechanics of writing such as punctuation, basic grammar and usage, sentence structure and rhetorical skills such as writing strategy, organization, and style.

Aptitude
Sequence and Series: Basics, AP, GP, HP, and Special Series.
Geometry: 2D, 3D, Coordinate Geometry, and Heights & Distance.
Logical Reasoning I: Arrangements, Sequencing, Scheduling, Venn Diagram, Network Diagrams, Binary Logic, and Logical Connectives, Clocks, Calendars, Cubes, Non-Verbal reasoning and Symbol based reasoning.
Logical Reasoning II: Blood Relations, Direction Test, Syllogisms, Series, Odd man out, Coding & Decoding, Cryptarithmetic Problems and Input - Output Reasoning.
Data Sufficiency: Introduction, 5 Options Data Sufficiency and 4 Options Data Sufficiency.
Campus recruitment papers: Discussion of previous year question papers of all major recruiters of Amrita Vishwa Vidyapeetham.
Miscellaneous: Interview Puzzles, Calculation Techniques and Time Management Strategies.

References
Soft Skills

Team Building
- Thomas L. Quick, "Successful team building", AMACOM Div American Mgmt Assn, 1992

**Verbal**
• “GMAT Official Guide” by the Graduate Management Admission Council, 2019
• Arun Sharma, “How to Prepare for Verbal Ability And Reading Comprehension For CAT”
• Joern Meissner, “Turbocharge Your GMAT Sentence Correction Study Guide”, 2012
• Kaplan, “Kaplan GMAT 2012 & 13”
• Manhattan Prep, “Sentence Correction 6th Edition GMAT”
• Mike Barrett “SAT Prep Black Book The Most Effective SAT Strategies Ever Published”
• Mike Bryon, “Verbal Reasoning Test Workbook Unbeatable Practice for Verbal Ability, English Usage and Interpretation and Judgement Tests”
• www.bristol.ac.uk/arts/skills/grammar/grammar_tutorial/page_55.htm
• www.campusgate.co.in

**Aptitude**
• www.mbatious.com
• www.campusgate.co.in
• www.careerbless.com

**Evaluation Pattern**

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