M. Tech. (Master of Technology)

in

Biomedical Instrumentation & Signal Processing

Faculty of Engineering

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M.TECH – Biomedical Instrumentation and Signal Processing

The Biomedical Instrumentation and Signal Processing (BISP) 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 Instrumentation and Signal Processing

(Proposed to be RENAMED as M-Tech **Biomedical Engineering & AI**)

Revised Curriculum 2023

PROGRAM OUTCOME

PO1	An ability to independently carry out research to solve practical problems
PO2	An ability to write and present a substantial technical report / document
PO3	An ability to demonstrate a degree of mastery over the area as per the specialization of the program
PO4	An ability to bridge the gap between research and social needs

PROGRAM SPECIFIC OUTCOMES

PSO1	An insight on the recent trends in biomedical instrumentation and signal processing and the impact of the domain in industry and academia
PSO2	Skills to build, apply and evaluate instrumentation, signal processing and data analytic techniques to solve healthcare problems
PSO3	Capacity to contribute to state-of-the-art research in the field of biomedical instrumentation, signal processing, data analytics, and machine learning

FOCUS AREAS AND TEACHING PLAN

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<tr><th>Area of Focus</th><th colspan="2">S1</th><th colspan="2">S2</th><th colspan="2">S3</th><th>S4</th></tr>
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+ lab</td><td>Embedded systems
+ lab</td><td>Elective 1</td><td></td><td></td><td rowspan="4">Project phase I</td><td rowspan="4">Project phase II</td></tr>
<tr><td>Biomedical Instruments and Data Interpretation</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">DATA PROCESSING</td><td>Image</td><td></td><td></td><td>Elective 2
Image processing
+lab</td><td></td><td></td></tr>
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<tr><td>DATA SCIENCE</td><td>Applied Mathematics and Data Analytics</td><td>Programming (Python)</td><td>Applied M/C learning</td><td>IoT in Health</td><td>Elective 3</td><td></td><td></td></tr>
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BASIC	FC
INTERMEDIATE	SC
ADVANCED	E
COMPETENT	Project

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

Type	CourseCode	Course Name	L T P	Credit
FC	23MA604	Applied Mathematics and Data Analytics	3 0 1	4
FC	23BI601	Applied Data Structures and Algorithms	1 0 1	2
SC	23BI602	Human Physiology	2 0 0	2
SC	23BI603	Embedded System Design	3 0 1	4
SC	23BI604	Bioinstrumentation	2 0 1	3
SC	23BI605	Biomedical Instruments and Data Interpretation	3 0 0	3
HU	22AVP103	Mastery over Mind	1 0 2	2
HU	22ADM501	Glimpses of Indian Culture	2 0 1	P/F
HU	23HU601	Career Competency I*	0 0 3	P/F
		Total Credits		**20**

*Non-credit Course
1 lecture (L) session = 1 hour
1 practical (P) session = 3 hours

Semester – 2

Type	CourseCode	Course Name	L T P	Credit
SC	23BI611	IoT in Healthcare	2 0 1	3
SC	23BI612	Applied Machine learning	3 0 1	4
SC	23BI613	Biomedical Signal Processing	3 0 1	4
SC	23RM704	Research Methodology	2 0 0	2
E		Elective 1	3 0 0	3
E	23BI742	Elective 2 Biomedical Image Processing	2 0 1	3
P	23BI681	Live-in-Labs-I - Participatory Design	0 0 0	0
HU	23HU611	Career Competency II	0 0 3	1
HU		**Total Credits**		**20**

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

Semester – 3

Type	CourseCode	Course Name	L T P	Credit
E		Elective 3	3 0 0	3
P	23BI798	Dissertation- Phase I		10
P	23BI781	Live-in-Labs II- Lab-to-Field: People Centred Innovation	0 0 1	1
		Total Credits		**14**

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

Semester – 4

Type	CourseCode	Course Name	L T P	Credit
P	23BI799	Dissertation- Phase II		16
		Total Credits		**16**

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

Total Course Credits: 70

ELECTIVES

Elective 1
Domain: Instrumentation

Type	CourseCode	Course Name	L T P	Credit
E	23BI731	Wearable Biomedical Systems	3 0 0	3
E	23BI732	Biosensors	3 0 0	3
E	23BI733	BioMEMS	3 0 0	3
E	23BI734	Virtual Instrumentation	3 0 0	3

Elective 2
Domain: Artificial intelligence/Data processing

Type	CourseCode	Course Name	L T P	Credit
E	23BI741	Medical Robotics	3 0 0	3
E	23BI742	Biomedical Image processing	2 0 1	3
E	23BI743	Bio-Inspired Computing	3 0 0	3
E	23BI744	Mobile Computing	2 0 1	3

Elective 3
Domain: Signal Processing/ Artificial intelligence

Type	CourseCode	Course Name	L T P	Credit
E	23BI751	Multivariate Signal Processing	3 0 0	3
E	23BI752	Speech and Audio processing	3 0 0	3
E	23BI753	Computer Vision	3 0 0	3
E	23BI754	Artificial Intelligence in Healthcare	3 0 0	3
	23BI755	Brain-computer interfacing	3 0 0	3

SYLLABUS

23MA604	Applied Mathematics and Data Analytics	3-0-1-4

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.

Applied Math with Python: Mathematical Foundations - Linear Algebra- Vectors, Matrices, Eigenvalues, Eigenvectors, singular value decomposition, dimensionality reduction, Principal component analysis, linear transformations.

Probability and Statistics: Random Variables, Probability Distributions, Distribution functions and properties, Discrete and Continuous, Statistical Inference – Estimation and Hypothesis Testing.

Machine Learning (Part 1): Machine learning basics, linear regression & logistic regression (classification).
(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
2. An Introduction to Probability and Statistics by Rohatgi and Saleh.
3. Business Analytics: Data Analysis and Decision Making by Christian Albright and Wayne Winston

23BI601	Applied Data Structures and Algorithms	1-0-1-2

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),

Recursion - Recursion problems, Sorting and searching (Selection Sort, Bubble sort, Insertion Sort), Divide and Conquer- Merge Sort and Quick Sort, Methods for Analysing Algorithms, Asymptotic Analysis:- Worst case, average case, best case analysis, Recurrence Relations. Graph Algorithms.

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

1. Cormen T H, Leiserson CE, Rivest R L and Stein C," Introduction to Algorithms", Prentice Hall of India Private Limited. Third Edition 2009.
2. Michael T Goodrich and Roberto Tamassia," Algorithm Design and Applications", Wiley, 2014.
3. Rajeev Motwani and Prabhakar Raghavan," Randomized Algorithms", Cambridge University Press, 1995.

23BI602	Human Physiology	2-0-0-2

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

Cell Physiology - Introduction to cell organelles - Bioelectric potentials – Homeostasis – Transport mechanisms. Neuro muscular system - Bone types. Nervous system - Sensory nervous system - Motor nervous system - Brain structure and its functions. Blood and lymph - Functions of blood - Blood groups.
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

1. Physiology, 5th Edition, Linda S. Costanzo, Saunders-Elsevier 2009.
2. Marieb E and Hoehn K, Human Anatomy & Physiology, Tenth Edition, Benjamin Cummings, 2014.
3. Guyton A C and Hall J E, Textbook of Medical Physiology, Thirteenth Edition, Elsevier Saunders, 2015.

23BI603	Embedded System Design	3-0-1-4

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: Structs, 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

1. Jonathan WValvano, “Embedded Systems: Introduction to ARM® Cortex™-M Microcontrollers”,
Fourth Edition,CreateSpace Independent Publishing Platform, 2013.
2. Joseph Yiu, "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Third Edition, Newnes, 2013.
3. Martin, "The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach", First Edition,Newnes, 2009.
4. Arnold S. Berger, “Embedded System Design”, First Edition, CRC Press, 2001.

23BI604	Bioinstrumentation	2 0 1 3

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

Basics of circuits and systems – Network theorems and laws – Diodes – transistors – amplifier circuits – filter circuits – Op-amps – Active filters – signal conditioning and processing circuits - peak detectors, rectifiers, comparators, timers, multivibrator. Analog circuits for processing medical data.

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

1. Microelectronic Circuits by Sedra Smith, 5^{th} edition, 2004
2. Electric Circuits, Nilsson, J.W. and Riedel, S.A., 9^{th} edition, 2011

23BI605	Biomedical Instruments and Data Interpretation	3-0-0-3

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

1. Ananthi, S. A, "Textbook of medical instruments", New Age International, 2005.
2. Webster, J. G. (ed.), "Medical instrumentation: application and design", Fourth edition, John Wiley & Sons, Hoboken
3. J.J.Carr&J.M.Brown, "Introduction to Biomedical Equipment Technology" Pearson Education, Asia.

23BI611	IoT in Healthcare	2-0-1-3

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

Introduction to IoT - Physical design of IoT - Logical design of IoT - IoT enabling technologies - IoT levels and deployment templates - Cloud computing - Deployment models - Service models - Service management - Cloud security - Communication protocols - CoAP – MQTT. IoT in Healthcare - Challenges in current healthcare systems - IoT healthcare services - Big data in IoT - Architecture of apache flume and spark - Wireless Body Area Networks (WBAN) Routing Protocols - Medium access control - Issues of WBAN.
Case Studies - Wearable sensor network for remote health monitoring - IoT based location aware smart healthcare framework - Analysis of recovery of mobility through inertial navigation techniques and virtual reality - Control and remote monitoring of muscle activity and simulation in the rehabilitation process.

Textbooks

1. Valentina Emilia Balas and Souvik Pal, Healthcare Paradigms in the Internet of Things Ecosystem, Academic Press, 2021.
2. Arsheep Bahga and Vijay Madisetti, Internet of Things: A Hands-on Approach, Universities Press, 2015.
3. Rajkumar Buyya and Amir Vahid Dastjerdi, Internet of Things Principles and Paradigms, Elsevier Inc, 2016.

23BI612	Applied Machine Learning	3-0-1-4

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

Introduction to machine learning and machine learning applications. Data featurization, vectorization, linear algebra, and matrix representations. Supervised learning - linear regression, polynomial regression, logistic regression, Support Vector Machine and ANN. Regularization, tuning, overfitting, underfitting. Unsupervised learning: Clustering, dimensionality reduction. Deep Neural networks: multilayer perceptron, transfer learning, edge models. ML model evaluation metrics, MLOps - introduction to converting ML models from test bench to production (saving, loading, using trained models).

Textbooks

1. An Introduction to Statistical Learning by Gareth James, Daniela Witten, Trevor Hastie, and
Robert Tibshirani (2022)
2. Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts,
tools, and techniques to build intelligent systems. O' Reilly Media, 2019.

23BI613	Biomedical Signal Processing	3 0 1 4

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
2. Subasi, Abdulhamit. Biomedical signal analysis and its usage in healthcare in Biomedical Engineering and its Applications in Healthcare, pp. 423-452. Springer, 2019.
3. Devasahayam, S.R., Signals and systems in biomedical engineering: signal processing and physiological systems modeling. Springer Science & Business Media, 2014.
4. Haykin, Simon, and Barry Van Veen, Signals and systems, John Wiley & Sons, 2007
5. John G.Proakis and DimitusG.Manolakis, “Digital Signal Processing, Principles, Algorithms and Applications", Third Edition, Prentice Hall of India, 2002.

6. Subasi, A., Practical guide for biomedical signals analysis using machine learning techniques: A MATLAB based approach. Academic Press, 2019.
7. Blinowska, Katarzyn J., and Jaroslaw Zygierewicz. Practical biomedical signal analysis using MATLAB. CRC Press, 2011.

23RM704	Research Methodology	2 0 0 2

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.

Medical Ethics: Moral, Legal, Social, Religious and Cultural Contexts, Information and Consent, Truthfulness, Voluntariness, Patient Data Confidentiality, End-of-Life Ethics, Case Studies, Regulatory
Compliance.

Textbooks

1. Bordens, K. S. and Abbott, B. B., Research Design and Methods - A Process Approach, 8th Edition, McGraw-Hill, 2011.
2. C. R. Kothari, Research Methodology - Methods and Techniques, 2nd Edition, New Age International Publishers.
3. Davis, M., Davis K., and Dunagan M., Scientific Papers and Presentations, 3rd Edition, Elsevier Inc.
4. Michael P. Marder, Research Methods for Science, Cambridge University Press, 2011.
5. T. Ramappa, Intellectual Property Rights Under WTO, S. Chand, 2008.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, Intellectual Property in New Technological Age. Aspen Law & Business; 6th Edition July 2012.
7. Tony Greenfield and Sue Greener., Research Methods for Postgraduates, 3rd Edition, John Wiley & Sons Ltd., 2016.
8. Gopalakrishnan B, Khaute M, Bhat B S, Bhat S, Sastry S R, Kaur K, Menon M, Kamath A, Saha M, Sadhya M, Reflections on Medical Law and Ethics in India, First Edition, Eastern Law House, 2016.

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
Monitoring Physical and Physiological Parameters - Wearable sensors for physiological signal measurement - Physical measurement - cardiovascular diseases – Neurological diseases - Gastrointestinal diseases - Wearable and non-invasive assistive technologies - Assistive devices for individuals with severe paralysis - Wearable tongue drive system - Dual-mode tongue drive system.

Textbooks

1. Edward Sazonov, Michael R Neuman, Wearable Sensors: Fundamentals, Implementation and Applications, Academic Press, USA, 2014.
2. Tom Bruno, Wearable Technology: Smart Watches to Google Glass for Libraries, Rowman & Littlefield Publishers, Lanham, Maryland, 2015.
3. Raymond Tong, Wearable Technology in Medicine and Health Care, Academic Press, USA, 2018.
4. Haider Raad, The Wearable Technology Handbook, United Scholars Publication, USA, 2017.

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

1. Zhang X, Ju H and Wang J, Electrochemical Sensors, Biosensors and Their Biomedical Applications, Academic Press, 2008.

2. Grundler P, Chemical Sensors -An Introduction for Scientists and Engineers, Springer Verlag, 2007.
3. Rasooly A and Herold K E (Eds), Biosensors and Biodetection: Methods and Protocols, Volume 503: Optical-Based Detectors, Springer-Verlag, 2009.

23BI733	BioMEMS	3-0-0-3

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

History of BioMEMS - overview of the different types of MEMS and microsystems, Smart systems and 3D architectures. Current state of the art and trends at the academic and industrial levels. Micropatterning of substrates and cells - Microfluidics - Molecular biology on a Chip - Cell-based chips for biotechnology - BioMEMS for cell biology - Tissue microengineering MEMS for biomedical sensing and diagnostic applications - MEMS for in vivo sensing - MEMS and Electrical Impedance Spectroscopy (EIS) for non-invasive measurement of cells - MEMS ultrasonic transducers for biomedical applications - BioMEMS for drug delivery applications - BioMEMS for drug delivery applications - Applications of MEMS technologies for minimally invasive medical procedures - Smart microgrippers for bioMEMS applications. Optical bio-sensing applications - Colorimetric detection - Fluorescence detection - Luminescence detection - Bioluminescence detection - Chemiluminescence detection - Bio chemiluminescence detection - Electrochemiluminescence detection.

Textbooks

1. Albert Folch, Introduction to BioMEMS, CRC Press, 2013.
2. Shekhar Bhansali and Abhay Vasudev, MEMS for Biomedical Applications, Woodhead Publishing Limited, 2012.
3. Samira Hosseini, Michelle Alejandra Espinosa-Hernandez, Ricardo Garcia-Ramirez, Ana Sofia Cerda-Kipper, Sofia Reveles-Huizar, Luis Acosta-Soto, BioMEMS - Biosensing Applications, Springer, 2021.

23BI734	Virtual Instrumentation	3 0 0 3

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 analyse 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 of 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

1. Sanjay Gupta and Joseph John, Virtual Instrumentation Using Labview, Tata McGraw Hill Education Private Limited, 2010.
2. Behzad Ehsani, Data Acquisition using LabVIEW, Packt Publishing, 2016.
3. Kunal Mitra, Stephanie Miller, Short Pulse Laser Systems for Biomedical Applications, Springer Briefs in Applied Sciences and Technology, 2017.
4. Leon Goldman, The Biomedical Laser Technology and Clinical Applications, Springer Verlag, 1981.

23BI741	Medical Robotics	3 0 0 3

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.
Medical robots - Robots for navigation - Movement replication - Robots for imaging - Rehabilitation and prosthetics - Describing spatial positioned orientation - Standardizing kinematic analysis - Computing joint angles - Quaternions - Robot kinematics -Three-joint robot - Six-joint robot.
Application of medical robots - The learning curve of robot - Assisted laparoscopic surgery - Haptic feedback in robotic heart surgery - Robotic applications in neurosurgery - Miniature robotic guidance for spine surgery.

Textbooks

1. Achim Schweikard and Floris Ernst, Medical Robotics, Springer, 2015.
2. VanjaBozovic, Medical Robotics, Springer, 2008.
3. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Robot Modeling and Control, John Wiley & Sons, 2005.

23BI742	Biomedical Image Processing	2 0 1 3

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, (2) biomedical imaging modalities like x-ray, MRI, CT and (3) surgical and other analytic equipment.
CO3 Ability to read and interpret data from diverse modalities.

Course Contents

Imaging Modalities: Brief survey of major modalities for medical imaging: Ultrasound, X-ray, CT, MRI, PET, and SPECT.
Objectives of biomedical image analysis - Computer aided diagnosis, Removal of artifacts - Image Enhancement - Gray level transforms - Histogram transformation.

Spatial domain filters - Frequency domain filters - Morphological image processing - Binary morphological operations and properties - Morphological algorithms - Medical Image Segmentation, Thresholding - Region growing - Region splitting and merging - Edge detection. Analysis of shape and texture - Representation of shapes and contours - Shape factors - Models for generation of texture - Statistical analysis of texture - Fractal analysis - Fourier domain analysis of texture - Applications - Contrast enhancement of mammograms - Detection of calcifications by region growing - Shape and texture analysis of tumours.
Reconstruction Techniques, Classification and Clustering, Examples of Image Classification for Diagnostic/Assistive Technologies, Case studies.

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.
6. Denoising of medical images.
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.
10. Performance metrics in bioimages.

Recommended Tools MATLAB, Python

Textbooks

1. Suetens, P. Fundamentals of Medical Imaging, Cambridge University Press
2. Dougherty, G, Digital Image Processing for Medical Applications, Cambridge University Press
3. Prince, J. & Links, J. Medical Imaging Signals and Systems, Prentice Hall
4. Bankman, Isaac., Handbook of Medical Imaging: Processing and Analysis, Academic Press
4. Yoo, Terry S. Insight into Images: Principles and Practice for Segmentation, Registration and Image Analysis, CRC Press
5. Sethian, J.A., Level-set Methods, Cambridge University Press, 2000

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

Neural networks - Artificial neurons - Activation functions - Learning rules - Supervised and Unsupervised Learning - Single layer and multilayer perceptron - Kohenen's self-organizing networks - Hopfield networks. Fuzzy systems - Fuzzy sets and relations - Membership functions - Rule base reduction methods - Decision making with fuzzy information - Fuzzy classification and pattern recognition - Neuro-fuzzy systems. Introduction to genetic algorithms - Parent selection - Crossover - Mutation - Genetic Programming - Particle Swarm Optimization - Ant colony optimization - Artificial immune systems - Case Studies - Fuzzy region growing for segmentation of calcifications in mammograms - Classification of normal and ectopic beats using neural networks - Image registration using hybrid bio-inspired approaches.

Textbooks

1. Fausett, Laurene V. Fundamentals of neural networks: architectures, algorithms and applications, Pearson Education India, 2006.
2. Ross, Timothy J. Fuzzy logic with engineering applications. Vol. 2. New York: Wiley, 2004.
3. Goldberg, David E. Genetic algorithms, Pearson Education India, 2006.

23BI744	Mobile Computing	2 0 1 3

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

1. Bill Phillips, Chris Stewart, Brian Hardy, and Kristin Marsicano, Android Programming: The Big Nerd Ranch Guide, 2017.
2. Rajiv Ramnath, Roger Craws, and Paolo Sivilotti, Android SDK 3 for Dummies, Wiley.
3. Asoke K. Talukder, Roopa R. Yavagal, Mobile Computing: Technology, Applications, and Service Creation, 2007.
4. Burnette E., Hello, Android: Introducing Google's Mobile Development Platform, 2010.
5. Steele J, The Android Developer's Cookbook: Building Applications with the Android SDK, 2010.
6. Chris Griffith, Mobile App Development with Ionic: Cross-Platform Apps with Ionic, Angular & Cordova, 2017.
7. Joshua Morony, Building Mobile Apps with Ionic & Angular [eBook].

23BI751	**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

Concept of random variables - Stochastic processes - Relations among random variables - correlation, multiple correlation, and partial correlation - Univariate and multivariate Gaussian distributions - Univariate Time Series - Time domain approach - Frequency domain approach. Time series models - AR Models, ARMA Models - Multivariate Time Series - Time domain approach and spectral domain approach - Assessing relations among time series in the spectral domain - Data based estimation versus model based estimation - Principal Component Analysis (PCA) - Signal decorrelation - Independent Component Analysis (ICA).
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

1. William W. S. Wei, Multivariate Time Series Analysis and Applications, Wiley, 2019.
2. Katarzyn Blinowska, Jaroslaw Zygierewicz, Practical Biomedical Signal Analysis Using MATLAB -Multiple channels (multivariate) signal, CRC press, 2011.
3. Johnson, Applied Multivariate Statistical Analysis, PHI publisher, 2012.
4. Jocelyn Chanussot, Jocelyn Chanussot, Kacem Chehdi, Multivariate Image processing, Wile Publication, 2009.

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 health care.

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

1. B. Gold, N. Morgan, D. Ellis, Speech, and Audio Signal Processing: Processing and Perception of Speech and Music, Wiley, 2011.
2. Xuedong Huang, Alex Acero, Hsiao-Wuen Hon, Spoken Language Processing: A guide to theory, algorithm and system development, Prentice Hall Inc., 2001.
3. U Kamath, J Liu, J Whitaker, Deep Learning for NLP and speech recognition, Springer, 2019.

4. Nancy Helm-Estabrooks, Martin L. Albert, & Marjorie Nicholas, Manual of Aphasia and Aphasia Therapy, Third Edition, Pro-Ed, 2013.

23BI753	Computer Vision	3 0 0 3

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

Camera Models and Calibration - Camera Projection Models - Orthographic - Affine - Perspective - Projective models - Projective geometry - Transformation of 2-D and 3-D - Internal Parameters - Lens distortion models - Calibration methods - Linear, direct, indirect and multiplane methods - Epipolar geometry - Stereo and Multi-view reconstruction. Image representation - Edge detection - Motion estimation - Regularization theory - Optical computation - Stereo vision - Structure from motion. Shape representation and Segmentation - Deformable curves and surfaces - Snakes and active contours - Level set representations - Feature detectors and descriptors - Object Recognition - Hough transforms - Case study - Vision model for mammogram image analysis.

Textbooks

1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer; 2011.
2. D. Forsyth and J. Ponce, Computer Vision - A modern approach, Prentice Hall.
3. Sonka M, Hlavac V, Boyle R, Image processing, analysis, and machine vision, Cengage Learning; 2014.
4. Gonzalez R C and Woods R E, Digital Image Processing, Third Edition, Prentice Hall, 2010.

23BI754	Artificial Intelligence in Healthcare	3 0 0 3

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

Introduction of concepts, methods, and potential of intelligent systems in medicine: History and status quo, and decision support system. Application on any specific area of interest, Risk stratification, Data acquisition and pre-processing, Feature identification and extraction, Model selection and implementation, Model validation and evaluation with performance metrics, visualization and interpretability. Introduction to neural networks and applications in healthcare. Deep neural networks, Convolutional neural networks, ARIMA for time series forecasting, SHAP analysis for feature analysis and selection

Textbooks

1. Begg, Rezaul, Daniel TH Lai, and Marimuthu Palaniswami, computational intelligence in biomedical engineering. CRC Press, 2007.
2. Hudson, Donna L., and Maurice E. Cohen. Neural networks and artificial intelligence for biomedical engineering, Institute of Electrical and Electronics Engineers, 2000.
3. Agah, Arvin, Introduction to medical applications of artificial intelligence, Medical Applications of Artificial Intelligence, CRC Press, 2013. 18-25.

23BI755	Brain Computer Interfacing	3 0 0 3

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

– Potentials related to cognitive tasks - Brain computer interface types - Invasive -Non-invasive - Brain signal for BCI signal - EEG - MEG - fNIRS – fMRI. BCI signal processing - Spatial - Temporal - Spatio-temporal filters - Spike sorting - Time and frequency domain analysis - Wavelet analysis - Principal Component Analysis (PCA) -Independent Component Analysis (ICA) - Artifacts reduction - Feature Extraction - Phase synchronization and coherence - ERP Analysis in BCI. Interfacing Brain and Machine - BCI system monitoring hardware - Machine Learning for feature classification - BCI application - Neuro prosthetic devices - Cursor and robotic control using multi electrode array implant - Visual cognitive BCI - Emotion detection.

Textbooks

1. Ella Hassianien, A &Azar.A.T, Brain-Computer Interfaces Current Trends and Applications, Springer, 2015.
2. Rajesh.P, N.Rao, Brain-Computer Interfacing: An Introduction, Cambridge University Press, First edition, 2013.
3. Jonathan Wolpaw, Elizabeth Winter Wolpaw, Brain Computer Interfaces Principles and practice, Oxford University Press, USA, Edition 1, January 2012.
4. Bernhard Graimann, Brendan Allison, GertPfurtscheller, Brain-Computer Interfaces: Revolutionizing Human-Computer Interaction, Springer, 2010

22AVP103	**Mastery Over Mind**	**L-T-P-C: 1-0-2-2**

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 MA OM 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 fulfilment 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

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1								1	2	2		2			
CO2			2		2				2	2		2			
CO3					2			2	2	2		2			
CO4			3		3		2	3	2	3		3			

CO5			2		2			2	2	3		3			
CO6			2					2	2	3		3			

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)*

B: Causes of Stress. The problem of not being relaxed. Effects of stress on health. How meditation helps to relieve stress. Basics of stress management at home and the workplace. *(Pre-recorded video with Prof Udhaykumar)*

Reading 1: Mayo Clinic Staff (2022, April 29). *Meditation: A Simple, Fast Way to Reduce Stress.* Mayo Clinic. https://www.mayoclinic.org/tests-procedures/meditation/in-depth/meditation/art-20045858 (PDF provided)

Reading 2: 'Efficient Action.' Chapter 28 in *Amritam Gamaya* (2022). Mata Amritanandamayi Mission Trust.

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)

Reading 2: 'Science and Spirituality.' Chapter 85 in Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.

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)

Reading 2: 'Live in the Present Moment.' Chapter 71 in Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.

Unit 5: Improving Communication and Relationships (CO5)

How meditation and mindfulness influence interpersonal communication. The role ofmeditation in improving relationship quality in the family, at the university and in theworkplace. (Pre-recorded video with Dr Shobhana Madhavan)

Reading 1: Seppala E (2022, June 30th) 5 Unexpected Ways Meditation Improves Relationships a Lot. Psychology Today. https://www.psychologytoday.com/intl/blog/feeling-it/202206/5-unexpected-ways-meditation-improves-relationships-lot

Reading 2: 'Attitude.' Chapter 53 in Amritam Gamaya (2022). Mata AmritanandamayiMission Trust.

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)

Reading 1: Schindler, S., & Friese, M. (2022). The relation of mindfulness and prosocialbehavior: What do we (not) know?. Current Opinion in Psychology, 44, 151-156.

Reading 2: 'Sympathy and Compassion.' Chapter 100 in Amritam Gamaya (2022). MataAmritanandamyi Mission Trust.

Text Books/Reference Books:

1. Meditation and Spiritual Life-Swami Yatiswarananda, Ramakrishna Math
2. The Complete Works of Swami Vivekananda Vol Vii by Advaita Ashram Mayavati Almora Himalayas
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
7. Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.
8. Books on Amma's teachings like Awaken children, From Amma's Heart etc.

9. The Science of Meditation: How to Change Your Brain, Mind and Body by Daniel Goleman and Richard. J. Davidson.
10.Allen, Cynthia (2020) The Potential Health Benefits of Meditation
11. Seppala E (2022, June 30th Unexpected Ways Meditation Improves Relationships a Lot.Psychology Today
12. Sharma, Hari (2022) Meditation: Process and Effects
13. Mayo Clinic Staff (2022, April 29). Meditation: A Simple, Fast Way to Reduce Stress.
14. Schindler, S., & Friese, M. (2022). The relation of mindfulness and prosocial behavior: Current Opinion in Psychology

Evaluation Pattern

Assessment	Internal	End Semester
Midterm	20	
Continuous assessment	40	
End Semester/Project		40

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

23HU601	**Career Competency I**	**L-T-P-C: 0-0-3-P/F**

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.
C05: 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.
C06: 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

PO / CO	**PO1**	**PO2**	**PO3**
CO1	2	1	-
CO2	2	1	-
CO3	2	1	-
CO4	2	1	-
CO5	1	2	-

CO6	2	2	-

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

Numbers: Types, Power Cycles, Divisibility, Prime, Factors & Multiples, HCF & LCM, Surds, Indices, Square roots, Cube Roots and Simplification.

Percentage: Basics, Profit, Loss & Discount, and Simple & Compound Interest.

Ratio, Proportion & Variation: Basics, Alligations, Mixtures, and Partnership.

Averages: Basics, and Weighted Average.

Time and Work: Basics, Pipes & Cistern, and Work Equivalence.

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:

- Andrew J DuRbin , "Applied Psychology: Individual and organizational effectiveness", Pearson-Merril Prentice Hall, 2004
- Michael G Aamodt, "An Applied Approach, 6th edition", Wadsworth Cengage Learning, 2010

Assertiveness skills:

- Robert Bolton, Dorothy Grover Bolton, "People Style at Work..and Beyond: Making Bad Relationships Good and Good", Ridge Associates Inc., 2009
- John Hayes "Interpersonal skills at work", Routledge, 2003
- Nord, W. R., Brief, A. P., Atieh, J. M., & Doherty, E. M., "Meanings of occupational work: A collection of essays (pp. 21- 64)", Lexington, MA: Lexington Books, 1990

Self-perception and self-confidence:

- Mark J Martinko, "Attribution theory: an organizational perspective", St. Lucie, 1995
- Miles Hewstone, "Attribution Theory: Social and Functional Extensions", Blackwell, 1983

Time management:

- Stephen Covey, "The habits of highly effective people", Free press Revised edition, 2004
- Kenneth H Blanchard , "The 25 Best Time Management Tools & Techniques: How to Get More Done Without Driving Yourself Crazy" , Peak Performance Press, 1st edition 2005
- Kenneth H. Blanchard and Spencer Johnson, "The One Minute Manager" , William Morrow, 1984

Verbal

- Erica Meltzer, "The Ultimate Guide to SAT Grammar"
- Green, Sharon, and Ira K. Wolf, "Barron's New GRE", Barron's Educational Series, 2011
- Jeff Kolby, Scott Thornburg & Kathleen Pierce, "Nova's GRE Prep Course"
- Kaplan, "Kaplan New GRE Premier", 2011-2012
- Kaplan's GRE Comprehensive Programme
- Lewis Norman, "Word Power Made Easy", Goyal Publishers, Reprint edition, 1 June 2011
- Manhattan Prep, "GRE Verbal Strategies Effective Strategies Practice from 99th Percentile Instructors"
- Pearson- "A Complete Manual for CAT", 2013
- R.S. Aggarwal, "A Modern Approach to Verbal Reasoning"
- S. Upendran, "Know Your English", Universities Press (India) Limited, 2015
- Sharon Weiner Green, Ira K. Wolf, "Barron's New GRE, 19th edition (Barron's GRE)", 2019
- Wren & Martin, "English Grammar & Composition"
- www.bbc.co.uk/learningenglish
- www.cambridgeenglish.org
- www.englishforeveryone.org
- www.merriam-webster.com

Aptitude

- Arun Sharma, "How to Prepare for Quantitative Aptitude for the CAT Common Admission Test", Tata Mc Graw Hills, 5th Edition , 2012
- Arun Sharma, "How to Prepare for Logical Reasoning for the CAT Common Admission Test", Tata Mc Graw Hills, 2nd Edition, 2014
- Arun Sharma, "How to Prepare for Data Interpretation for the CAT Common Admission Test", Tata Mc Graw Hills, 3nd Edition, 2015
- R.S. Aggarwal, "Quantitative Aptitude For Competitive Examinations", S. Chand Publishing, 2015
- R.S. Aggarwal, "A Modern Approach To Verbal & Non-Verbal Reasoning", S. Chand Publishing, Revised -2015
- Sarvesh Verma, "Quantitative Aptitude-Quantum CAT" , Arihant Publications, 2016

- www.mbatious.com
- www.campusgate.co.in
- www.careerbless.com

Evaluation Pattern

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50
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.
C05: 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
C06: 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

PO / CO	PO1	PO2	PO3
CO1	2	1	-
CO2	2	1	-
CO3	2	1	-
CO4	2	1	-
CO5	1	2	-
CO6	2	2	-

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.

Permutations & Combinations: Basics, Fundamental Counting Principle, Circular Arrangements, and Derangements.

Probability: Basics, Addition & Multiplication Theorems, Conditional Probability and Bayes' Theorem.

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

- **Brian Cole Miller, "Quick Team-Building Activities for Busy Managers: 50 Exercises That Get Results in Just 15 Minutes", AMACOM; 1 edition, 2003.**
- **Patrick Lencioni, "The Five Dysfunctions of a Team: A Leadership Fable", Jossey-Bass, 1st Edition, 2002**

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"
- Kaplan, "New GMAT Premier", Kaplan Publishing, U.K., 2013
- Manhattan Prep, "Critical Reasoning 6th Edition GMAT"
- 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

- Arun Sharma, "How to Prepare for Quantitative Aptitude for the CAT Common Admission Test", Tata Mc Graw Hills, 5th Edition, 2012
- Arun Sharma, "How to Prepare for Logical Reasoning for the CAT Common Admission Test", Tata Mc Graw Hills, 2nd Edition , 2014
- Arun Sharma, "How to Prepare for Data Interpretation for the CAT Common Admission Test", Tata Mc Graw Hills, 3nd Edition , 2015
- R.S. Aggarwal, "Quantitative Aptitude For Competitive Examinations", S. Chand Publishing , 2015
- R.S. Aggarwal, "A Modern Approach To Verbal & Non-Verbal Reasoning", S. Chand Publishing , Revised -2015
- Sarvesh Verma, "Quantitative Aptitude-Quantum CAT" , Arihant Publications , 2016
- www.mbatious.com
- www.campusgate.co.in
- www.careerbless.com

Evaluation Pattern

Assessment	**Internal**	**External**
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

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