Department of Electronics and Communication Engineering
&
Amrita Centre for Biomedical Engineering

M.Tech Biomedical Engineering - Curriculum 2025

About Amrita

Amrita Vishwa Vidyapeetham is a multi-disciplinary, research-intensive, private university, educating a vibrant student population of over **24,000** by **1700+** strong faculty. Accredited with the highest possible 'A++' grade by NAAC, Amrita offers more than 250 UG, PG, and Ph.D. programs in Engineering, Management, and Medical Sciences including Ayurveda, Life Sciences, Physical Sciences, Agriculture Sciences, Arts & Humanities, and Social & Behavioral Sciences.

With seven campuses at Amaravati, Amritapuri, Bengaluru, Chennai, Coimbatore, Kochi, and Mysuru and a new upcoming campus at NCR Delhi (Faridabad) and spread over 1200+ acres with 10 million square feet of built-up space, Amrita is one of India's top-ranked private universities. Amrita has emerged as the seventh ranked university in the National Institutional Ranking Framework (NIRF) Rankings 2024.

About the Department

The Department of Electronics and Communication Engineering, one of the oldest in the University, offers technology-oriented courses to create manpower in crucial areas, in line industrial expectations. The vision of the department is to mould tomorrow's technocrats, imbibing the essence of human values, innovation and creativity in science and technology, towards building a peaceful self-sustaining nation. The department also aims at setting standards in teaching and learning for providing a bright career path for the students and to establish itself as a centre of excellence in research.

About the Amrita Centre for Biomedical Engineering (AMBE)

The state-of-the-art facility was established in 2007 as a Centre of Excellence under the "Mission Reach" program of TIFAC CORE to advance knowledge and expertise in biomedical science and engineering and to develop low-cost biomedical devices and products with an emphasis on point-of-care applications. Several devices such as a low-cost insulin pump, X-ray digitizer, skull implants, etc. have already been developed and many more are in the pipeline.

About the Postgraduate Program in Biomedical Engineering

The Department of Electronics and Communication Engineering (ECE) and Amrita Biomedical Engineering (AMBE) jointly offer the M.Tech. program in Biomedical Engineering. Biomedical engineering is a strong multidisciplinary field which aims at using the principles of engineering in biology and medicine. It encompasses a broad spectrum of topics, a few of which are Biomedical Instrumentation, Biosensors, Biomedical Signal Processing, Biomaterials, Artificial Intelligence for Healthcare, and Drug Design. The integration of medicine and engineering has revolutionized the health industry to produce outcomes which could not even have been imagined a few years back. Advanced technological developments in health care have been made possible due to the synergistic contribution of engineers, mathematicians, physicians, computer scientists, and other professionals. Biomedical engineering plays a vital role in interfacing technology with the medical domain, to support physicians in decision-making. The integration of computers with medical care has resulted in significantly more information to be used for the diagnosis and to

predict the progress of diseases in a well-defined manner. Students pursuing the programme would be able to develop and implement algorithms for objective interpretation and analysis of biological data. The primary goal is to successfully practice biomedical engineering to serve healthcare institutions, academia, and industry at regional, national and international levels and to achieve personal and professional success with commitment to ethical and social responsibility, both as individuals and in team environments.

The program will leverage the resources available at the Amrita Biomedical Engineering (AMBE) Centre as well as in the Biosensor Research and Intelligent Systems labs. The program will be interdisciplinary involving faculty from the Departments of ECE, Chemical Engineering, and the School of Physical Sciences.

The salient features of the programme include:

- Strong Interdisciplinary nature
- Internships and Placement Opportunities
- Around 200+ Publications in International Journals / Conferences
- 10 research projects worth about 110 lakhs from various funding agencies
- 5+ Patents granted.
- International collaborations and dual degree
- PhD opportunities in Amrita, top institutions in India (like IISc and IITs) and abroad, such as RMIT, University of Sydney, Deakin, NTU, etc.
- Career opportunities at reputed organizations including, but not limited to, Cerner Healthcare, Skanray, Philips Healthcare, Medtronic Engineering, Bosch Healthcare, Auro Lab, Tata Elxsi etc.… and reputed Hospitals nationwide.

Vision:

To be a global leader in biomedical engineering education, excelling in scientific research, and innovation in developing healthcare solutions.

Mission:

- To excel in Biomedical Engineering, by integrating principles from engineering, biology, and medicine through innovative teaching and learning techniques.
- To engage in cutting-edge research that addresses current and emerging issues in healthcare.
- To help create new technologies, devices and diagnostic procedures by building a strong partnership with industry partners, research institutions, and healthcare providers.

Program Educational Objectives (PEO)

PEO1: Graduates will acquire comprehensive knowledge and develop strong expertise in the field, enabling them to apply their understanding of basic sciences and engineering principles in the interdisciplinary area of biomedical engineering.

PEO2: Graduates will have the capability to think critically, evaluate, and address complex challenges in the area of advanced healthcare technology.

PEO3: Graduates will cultivate strong ethical practices, demonstrate professional competency and leadership skills, and offer engineering solutions that benefit society, all while engaging in lifelong learning to promote holistic personal development.

Program Outcomes (PO)

PO1	An ability to independently carry out research /investigation and development work 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 in the area of biomedical engineering.
PSO1	An ability to design, simulate, and analyze bioengineering systems using modern tools and technologies to address specific biomedical needs and challenges,
PSO2	An ability to engage in independent and lifelong learning to keep up with advancements in bioengineering technologies and evolving healthcare industry requirements.

Programme Core

Semester -I

Type	Code	Course Name	Teaching Schemes			Credits
			L	T	P	
FC	25BM601	Analytical Techniques for Biomedical Engineering	3	0	0	3
FC	25BM602	Biomedical Signal Processing	3	0	0	3
FC	25BM603	Principles of Biomedical Electronics	3	0	0	3
SC	25BM604	Biomaterials	3	0	0	3
SC	25BM605	Human Physiology	2	0	0	2
SC	25BM606	Principles of Machine Learning	2	0	3	3
SC	25BM681	Analytical Techniques for Biomedical Engineering Lab	0	0	3	1
SC	25BM682	Biomedical Electronics Lab	0	0	3	1
HU	22ADM501	Glimpses of Indian Culture	0	0	3	P/F
HU	23HU601	Career Competency - I	0	0	3	P/F
HU	25AVP501	Mastery Over Mind (MAOM)	1	0	2	2
		Total	**17**	**0**	**14**	**21**

Semester -II

Type	Code	Course Name	Teaching Schemes			Credits
			L	T	P	
SC	25BM611	Biomedical Image Processing	3	0	0	3
SC	25BM612	Biosensors and Point-of-Care Testing Devices	3	0	0	3
E		Elective-1	3	0	0	3
E		Elective-2	3	0	0	3
E		Elective-3	3	0	0	3
E	25BM613	Medical Ethics and Standards	1	0	0	1
SC	25BM683	Biosensors and Point-of-Care Testing Devices Lab	0	0	3	1
SC	25BM684	Biomedical Engineering Lab	0	0	3	1
SC	25RM600	Research Methodology	2	0	0	2
HU	23HU611	Career Competency -II	0	0	3	1
SC	25BM698	Industry Internship*	0	0	2	1
		Total	**18**	**0**	**11**	**22**

* *Internship will be completed between the second and third semester in a / an hospital / establishment approved by the department.*

Semester -III

Type	Code	Course Name	Teaching Schemes			Credits
			L	T	P	
P	25BM798	Dissertation Phase I	0	0	30	10
		Total	**0**	**0**	**30**	**10**

Semester -IV

Type	Code	Course Name	Teaching Schemes			Credits
			L	T	P	
P	25BM799	Dissertation Phase II	0	0	45	15

Total Credits: 68

Evaluation Pattern:

1. All courses offered to M.Tech - Biomedical Engineering will follow a common evaluation pattern mandated by the School of Engineering.
2. All courses offered to M.Tech - Biomedical Engineering, by other Schools, will follow the evaluation pattern mandated by the individual Schools offering the course.

Programme Elective domains

S.No	Course code	Course Name	Credit	Type
1	25BM731	Translational Biomedical Engineering	3	Track 1 Translational Biosciences
2	25BM732	Wearable Health Technologies	3	
3	25BM733	Bio-Microfluidics and Microfabrication	3	
4	25BM734	Regenerative and Molecular Medicine	3	
5	25BM735	Pharmacogenomics and Deep Drug Design	3	
6	25BM736	Nanomaterials for Biomedical Applications	3	
7	25BM737	Biomechanics	3	
8	25BM741	Medical Decision Support Systems	3	Track 2 AI for Healthcare
9	25BM742	Multimodal Image Analysis	3	
10	25BM743	Bio-Inspired Computing	3	
11	25BM744	Multi-Sensor Data Fusion	3	
12	25BM745	Computational Neuroscience	3	
13	25BM746	Speech and Audio Signal Processing	3	
14	25BM747	Brain Computer Interfacing	3	
15	25BM748	Multivariate Signal Processing	3	
16	25BM751	Embedded Computing for Biomedical Applications	3	Track 3 Healthcare systems
17	25BM752	Medical Robotics and Automation in Healthcare	3	
18	25BM753	Advanced Electronics for Healthcare	3	
19	25BM754	IoT in Healthcare	3	
20	25BM755	Biomedical Equipment and Safety	3	
21	25BM756	BioMEMS	3	
22	25BM757	Biomedical Laser Instrumentation	3	
23	25BM758	Virtual Instrumentation for Biomedical Engineering	3	

25BM601 Analytical Techniques for Biomedical Engineering 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To familiarize the basic concepts in electroanalytical, spectroscopic and microscopic techniques and apply them for the biomedical device development

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the basic concepts in electroanalytical techniques and apply them for biomedical science and engineering
CO2: To understand the basics of spectroscopy and apply them for biomedical science and engineering
CO3: To analyze microscopic data and use them for the characterization of nanomaterials and biological samples
CO4: To apply spectroscopic, electro-analytical and microscopic techniques for the complete characterization of materials

Skills Acquired: Sound knowledge in electro-analytical, spectroscopic and microscopic techniques

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	2	3	2	3
CO 2	2	2	3	2	3
CO 3	2	2	3	2	3
CO 4	2	2	3	2	3

Course Contents:

Unit 1: Electroanalytical Techniques

The electrode-electrolyte interface - double layer - origin of potential - cell potential - Nernst equation - Ion selective electrodes - Faradaic and non-faradaic process - exchange current - electrode kinetics - Butler - Volmer equation - current - overpotential diagrams - Tafel plots. Study of electrode reactions - Controlled potential techniques (sampled current voltammetry, chronoamperometry, chronocoulometry) - potentiodynamic techniques (linear sweep and cyclic voltammetry techniques). Electrochemical impedance spectroscopy - equivalent circuits - AC impedance - Bode and Nyquist plots - Biomedical applications of electroanalytical techniques

Unit 2: Spectroscopic Techniques

UV-Vis Spectroscopy - Type of electronic transitions - Allowed and forbidden transitions. Chromophore and auxochromes - Factors governing absorption maximum and intensity - Interpretation of absorption spectra - Photoluminescence Spectroscopy - Fluorescence and phosphorescence - principles - Stokes shift - quantum yield and applications - Hook's law - vibrational frequency - Modes of vibrations and selection rules - Fingerprint and functional group

region - Factors influencing vibrational frequency - Interpretation of the IR spectra Raman Scattering - Polarization - SERS - selection rules - Spectroscopic applications in medicine and biology

Unit 3: Microscopic Techniques

Principles of SEM - AFM - STM - STEM - TEM - Confocal microscopy - Fluorescence microscopy - Sample preparation - instrumentation - working and biomedical applications

Textbooks / References:

[1] W. Kemp, 1988. Organic Spectroscopy, 3rd Edition, McMillan International Higher Education. [Online]. Available: https://tinyurl.com/Kemp-1988
[2] D. L. Pavia, G. M. Lampman, G. A. Kriz, and J. R. Vyvyan, 2009. Introduction to Spectroscopy, 5th Edition, Brooks-Cole. [Online]. Available: https://tinyurl.com/Pavia-2009
[3] Joseph Wang, Analytical Electrochemistry Fourth Edition, John Wiley & Sons, 2006
[4] Christopher M. A. Brett and Ana Maria Oliveira Brett, Electrochemistry: Principles, Methods, and Applications, Oxford University Press, 1994
[5] Silverstein, R.M. and Bassler, G.C., 2015. Spectrometric identification of organic compounds, 8th edition. Wiley

25BM602 BIOMEDICAL SIGNAL PROCESSING 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To introduce the concepts of signals
- To introduce the concepts of systems
- To provide an insight on filtering techniques
- To impart knowledge on application of signals and systems for biomedical tasks

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the time domain and frequency domain representation of signals
CO2: To understand the time domain and frequency domain representation of systems
CO3: To analyze the systems using various filtering techniques
CO4: To apply signal and system analysis to biomedical problems

Skills Acquired: Characterization of signals and systems for biomedical applications

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	2	2	3	2
CO 2	2	2	2	3	2
CO 3	2	2	2	3	2
CO 4	2	2	3	3	2

Course Contents:
Unit 1:

Signal Introduction - Elementary signals - Classification of signals - Operations on signals - Sampling - Aliasing - Systems - Classification of systems - LTI Systems - Interconnection of systems - Time domain representation - Frequency domain representation: DTFT - DFT- Signals and Systems - Z transform basics - Analysis of discrete time systems using Z transforms

Unit 2:

Types of noise - Random noise - Structured noise - Physiological interference - Time domain filters - Synchronized averaging - Moving average filters - Derivative based filters - Frequency domain filters - Digital filters - IIR and FIR filter design - Notch filters - Weiner filtering

Unit 3:

Introduction to Biomedical signals - ECG - EEG - Speech - Origin of biomedical signals - Signal-Relation of electrocardiogram (ECG) components to cardiac events - Types of noise in biomedical signals - Artifact Removal - Case studies - Removal of artifacts High-frequency noise in the ECG - Motion artifact in the ECG - Power-line interference in ECG signals - Maternal interference in fetal ECG - Event detection - Case studies ECG - QRS Detection - EEG rhythms - Detection of epileptic seizures - Study of muscular contraction using parametric analysis of EMG signals

Textbooks / References:

[1] Rangayyan, Rangaraj M, Biomedical signal analysis, John Wiley & Sons, 2015
[2] Haykin, Simon, and Barry Van Veen, Signals and systems, John Wiley & Sons, 2007
[3] Devasahayam, S.R., Signals and systems in biomedical engineering: signal processing and physiological systems modeling. Springer Science & Business Media, 2012
[4] Subasi, Abdulhamit. Biomedical signal analysis and its usage in healthcare in Biomedical Engineering and its Applications in Healthcare, pp. 423-452. Springer, 2019

25BM603 PRINCIPLES OF BIOMEDICAL ELECTRONICS 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To analyze electronic circuits
- To use electronic components and circuits
- To familiarize the student with the essentials of bioelectricity / biopotentials
- To realize the challenges of Bio-signal acquisition

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the origin and characteristics of typical biopotentials
CO2: To understand various techniques for circuit analysis
CO3: To understand the operation of simple electronic components and circuits

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO1	2	-	2	3	2

CO2	2	-	2	3	2
CO3	3	-	3	3	2

Course Contents:

Unit 1:
Biopotentials - Cell Potential - Action Potential - Typical Bio-Signals - ECG - EEG - EMG and PPG - Characteristics - Requirements - Interfacing - Challenges

Unit 2:
Fundamentals of Circuit Analysis - Voltages - Currents - Source - Independent and Dependent - Resistors - Capacitors and Inductors - Kirchoff's Voltage and Current Laws - Mesh Current and Node Voltage Analysis - Superposition Theorem - Miller's Theorem - Maximum Power Transfer - Thevenin's and Norton's equivalents - Impedance matching - Loading Effect

Unit 3:
Basics of Electronics - Diode Characteristics - Diode Circuits - Rectifiers - Half-wave - Full - wave and Bridge - Special Diodes - Regulators - BJTs - Biasing - Characteristics - Configurations - Amplifiers - Operational Amplifiers - Characteristics - Amplifiers - Frequency Response

Textbooks / References:
[1] Boylestad R L and Nashelsky L, Electronic Devices and Circuit Theory, 11th ed. Upper Saddle River, N.J.: Pearson/Prentice Hall, 2014. [Online]. Available: https://tinyurl.com/Boylestad-2014
[2] Sedra A and Smith K C, Microelectronic Circuits - Theory and Applications, 7th ed. (South Asia Edn). New Delhi, India: Oxford University Press, 2017
[3] Alexander C K and Sadiku M N O, Fundamentals of Electric Circuits, 7th ed. India: McGraw-Hill, 2022. [Online]. Available: https://tinyurl.com/Alexander-2022
[4] Najarian K and Splinter R, Biomedical Signal and Image Processing, 2nd ed. Boca Raton: CRC/Taylor & Francis, 2006. [Online]. Available: https://tinyurl.com/Najarian-2006

25BM604 BIOMATERIALS 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- Introduce basic structure and properties of different classes of materials
- Introduce the basics of molecular and cellular host responses and biocompatibility testing
- Apply the understanding of materials and biocompatibility in designing materials and devices for some biomedical applications

Course Outcomes:

At the end of the course, the student should be able

CO1: To apply the understanding of materials and biocompatibility in designing materials and devices for some biomedical applications
CO2: To design materials for biomedical applications including cardiovascular, ophthalmologic, orthopedic, dental and other applications
CO3: To interpret the results from common materials characterization instruments

Skills Acquired:

- Students will develop basic level skills in designing materials and devices for biomedical implantation or applications
- They will also gain familiarity with structure-property characterization of biomaterials

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	3	2	3	2	2
CO 2	2	2	3	3	2
CO 3	3	2	3	2	2

Course Contents:

Unit 1:

Introduction to Biomaterials - Overview of the Biomedical Product Development Process and Regulation - Basics of Material Structure - Overviews of Metals - Polymers - Ceramics and Natural Materials used in Biomedical Engineering - Surface Modification Methods - Properties and Characterization of Materials

Unit 2:

Structure - Function and Adhesion of Proteins - Cell-Surface Interactions - Blood-Materials Interactions - Molecular and Cellular Host Responses - Biocompatibility - Degradation of Biomaterials - Testing of Biomaterials

Unit 3:

Biomedical Applications of Materials in the Areas - Cardiovascular - Orthopedic - Ophthalmologic - Dental Implants - Sutures - Burn Dressings - Adhesives & Sealants - Bioelectrodes - Biomedical Sensors & Biosensors - Tissue Engineering and Scaffolds

Textbooks / References:

[1] Ratner B D, Hoffman A S, Schoen F J, and Lemons J E, Biomaterials Science: An Introduction to Materials in Medicine, Fourth Edition, Academic Press, 2020

[2] Hill D, Design Engineering of Biomaterials for Medical Devices, John Wiley, 1998

25BM605 HUMAN PHYSIOLOGY 2-0-0-2

(Pre-requisite: Nil)

Course Objectives:

- To introduce the basic description of cells, tissues, organs and biological systems
- To impart knowledge on the functioning of various organs and systems
- To enable the biological concepts to biomedical signal analysis

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the anatomy, physiology, functions of various organs and disorders
CO2: To apply the physiological concepts in modelling biomedical systems
CO3: To analyze the functioning of various vital organs and systems

Skills Acquired: The understanding of human physiology, biomedical signals and abnormalities

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	-	2	2	2	-
CO 2	-	3	3	2	-
CO 3	-	2	3	2	-

Course Contents:

Unit 1:
Cell Physiology - Introduction to cell organelles - Bioelectric potentials - Neuro muscular system - Bone types - Special senses - Nervous system - Sensory nervous system - Motor nervous system - Brain structure and its functions – Physiology of eye - Diseases of eye - Diabetic retinopathy - Blood and lymph - Functions of blood - Blood groups - Hemostasis

Unit 2:
Circulatory system - Functional anatomy of the heart - Conducting system of the heart - Cardiac cycle - Arterial and venous blood pressure - Gastrointestinal system - Gastrointestinal hormones - Digestion and absorption of Carbohydrates, Proteins and Lipids

Unit 3:
Renal physiology - Structure of kidney - Glomerular filtrate - Skin - Respiratory system - Mechanism of breathing - Regulation of respiration - Transport of gases - Hypoxia - Endocrinology - Endocrine glands and its disorders - Hormones and their functions

Textbooks / References:

[1] Anne Waugh and Allison Grant, Anatomy and Physiology in Health and Wellness, fourteenth edition, Elsevier, 2022
[2] Garry's, Atlas of human anatomy, Scientific International, 2018
[3] Marieb, Elaine N, Essentials of human anatomy and physiology, Pearson Education, 2006
[4] Marieb, Elaine N, Wilhelm, Patricia Brady, Mallatt, Jon B, Human Anatomy, Pearson India, 2019

25BM606 Principles of Machine Learning 2-0-3-3
(Pre-requisite: Nil)

Course Objectives:

- To introduce the concepts and provide a mathematical foundation for developing machine learning models
- To impart knowledge on algorithm design and its applications
- To impart knowledge on different types of machine learning algorithms

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the mathematical foundations of machine learning
CO2: To understand different types of classification and regression systems
CO3: To understand different deep learning techniques
CO4: To understand the type of machine learning algorithms suitable to solve a specific problem

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	2	2	-	-
CO 2	2	2	2	3	2
CO 3	2	2	3	3	2
CO 4	2	2	2	3	3

Course Contents:

Unit 1:
Introduction to linear algebra and optimization - finding the maxima and minima - Jacobian and Hessian matrix - gradient descent algorithms and its refinements - standard datasets - classification and regression - k-nearest neighbor classifier - Bayes classifiers - classifier performance measures

Unit 2:
Introduction to support vector machine (SVM) - linear and nonlinear SVMs - kernel trick - SVM for regression and classification - Introduction to deep neural networks - activation functions - loss functions - error back propagation

Unit 3:
CNN - RNN - GRU - LSTM - vanishing and exploding gradients - GAN - transformers - Decision tree classification - Normalizing flows - Introduction to diffusion models - Selected Applications

List of experiments:

1. Introduction to Python
2. Familiarize with neurokit2, read ECG and extract features
3. Generation of standard dataset, blobs, half moon, and iris, and visualize them
4. Development of different types of SVM classifiers on standard datasets
5. Use different performance measures and compare the classifiers
6. Development of a CNN classifier using MIT BIH data
7. Develop an RNN/LSTM classifier on MIT BIH data or any biomedical dataset from Physionet
8. Develop a regression system and use it as a classifier
9. Decision tree classifier or normalizing flows
10. Attention modelling

Textbooks / References

[1] Ian Goodfellow, Yoshua Bengio, et. al., Deep Learning, MIT Press, 2016. [Online]. Available: https://tinyurl.com/Ian-2016

[2] K P Soman, et al, Machine Learning with SVM and other Kernel Methods, PHI, New Delhi 2009
[3] T Chakraborthy, Introduction to large language models, Generative AI for Text, Wiley India, 2025
[4] D. Foster, Generative Deep Learning, O'Reilly, 2023

25BM681 Analytical Techniques for Biomedical Engineering Lab 0-0-3-1

Course Objectives:

- To understand the principles and operation of various electroanalytical, spectroscopic, and microscopic tools
- Familiarize and do hands-on experiments using controlled potential, potential sweep, and impedance-based techniques
- Familiarize and do hands-on experiments using UV-Vis, IR, Raman, and fluorescence spectroscopic techniques
- Familiarize and do hands-on experiments using SEM, AFM, Raman, and fluorescence microscopic techniques

Course Outcomes:

At the end of the course, the student should be able

CO1: To implement experiments based on controlled potential, potential sweep, and impedance-based techniques
CO2: To do experiments using IR, UV-Vis, fluorescence, and Raman Spectroscopic techniques
CO3: To conduct microscopic analysis of samples using SEM, TEM, AFM, Raman, and fluorescent microscopic techniques
CO4: To apply spectroscopy, electrochemistry, and microscopy for the design of a new analytical experiment

Skills Acquired: Hands-on experience and operational skills on the modern equipment for electroanalytical, spectroscopic, and microscopic techniques

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	3	2	3	2
CO 2	2	3	2	3	2
CO 3	2	3	2	3	2
CO 4	2	3	2	3	2

Experiments:

[1] UV-Vis spectrophotometric estimation of - (i) blood haemoglobin by alkaline hematin D and (ii) creatinine by Jaffe reaction
[2] Surface functionalization of reduced graphene oxide and its spectroscopic characterization
[3] Controlled potential/potentiodynamic electrodeposition of thin films and their characterization using impedance spectroscopy, and atomic force microscopy

[4] Synthesis and functionalization of gold nanoparticles and their spectroscopic and microscopic characterisation
[5] Biofunctionalization of carbon quantum dots and spectroscopic characterisation
[6] Chronoamperometric detection of glucose
[7] Cell tagging and fluorescent imaging using quantum dots

25BM682 Biomedical Electronics Laboratory 0-0-3-1

Course Objectives:

- To set up simple electronic circuits
- To develop basic BioSignal acquisition circuits

Course Outcomes:
At the end of the course, the student should be able

CO1: To set up and troubleshoot circuits
CO2: To implement basic electronic subsystems
CO3: To prototype simple BioSignal acquisition systems

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	3	-	2	3	2
CO 2	3	-	2	3	2
CO 3	3	-	3	3	2

Experiments:

[1] Simple Network Measurements
[2] Demonstrating the concepts of Superposition and Loading
[3] Diode Circuits - Half-wave and Bridge Rectifiers
[4] Zener Voltage Regulators
[5] BJT / MOSFET - Characteristics, Biasing and Amplifiers
[6] Operational Amplifiers - Characteristics; Inverting and Non-Inverting amplifiers
[7] Difference and Instrumentation Amplifiers
[8] Active Filters - Low Pass, High Pass and Band pass
[9] PPG Acquisition
[10] ECG Acquisition

Textbooks / References:

[1] Alexander C K and Sadiku M N O, Fundamentals of Electric Circuits, 7th ed. India: McGraw- Hill, 2022
[2] Sedra A and Smith K C, Microelectronic Circuits - Theory and Applications, 7th ed. (South Asia Edn). New Delhi, India: Oxford University Press, 2017

23HU601 Career Competency- I 0-0-3

Prerequisite:

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:

PO/CO	PO1	PO2	PO3
CO 1	2	1	-
CO 2	2	1	-
CO 3	2	1	-
CO 4	2	1	-
CO 5	1	2	-
CO 6	2	2	-

Course contents:

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 audiovisual 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 etiquette of email writing - Make students practice 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 - Allegations - Mixtures - Partnership
Averages - Basics - Weighted Average
Time and Work - Basics - Pipes & Cistern - 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 - Standard Deviation
Data Interpretation - Tables - Bar Diagrams - Line Graphs - Pie Charts – Caselets - Mixed Varieties - other forms of data representation
Equations - Basics - Linear - Quadratic - Equations of Higher Degree - Problems on ages
Logarithms, Inequalities and Modulus - Basics

Textbooks / References:

Soft Skills:

Communication and listening skills:

[1] Andrew J Durbin, Applied Psychology: Individual and organizational effectiveness, Pearson- Merril Prentice Hall, 2004

[2] Michael G Aamodt, An Applied Approach, 6th edition, Wadsworth Cengage Learning, 2010
[3] Assertiveness skills: Robert Bolton, Dorothy Grover Bolton, People Style at Word. And Beyond: Making Bad Relationships Good and Good, Ridge Associates Inc., 2009
[4] John Hayes Interpersonal skills at work, Routledge, 2003
[5] 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
[6] Self-perception and self-confidence: Mark J Martinko, Attribution theory: an organizational perspective, St. Lucie, 1995
[7] Miles Hewstone, Attribution Theory: Social and Functional Extensions, Blackwell,1983
[8] Time management: Stephen Covey, The habits of highly effective people, Free press Revised edition, 2004. [online]. Available: https://tinyurl.com/Stephen-Covey-2004e
[9] 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
[10] Kenneth H. Blanchard and Spencer Johnson, The One Minute Manager, William Morrow, 1984

Verbal:

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

Aptitude:

[27] Arun Sharma, How to Prepare for Quantitative Aptitude for the CAT Common Admission Test, Tata Mc Graw Hills, 5th Edition, 2012
[28] Arun Sharma, How to Prepare for Logical Reasoning for the CAT Common Admission Test, Tata Mc Graw Hills, 2nd Edition, 2014
[29] Arun Sharma, How to Prepare for Data Interpretation for the CAT Common Admission Test, Tata Mc Graw Hills, 3rd Edition, 2015
[30] R.S. Aggarwal, Quantitative Aptitude for Competitive Examinations, S. Chand Publishing, 2015. [Online]. Available: https://tinyurl.com/R-S-Aggarwal-2015
[31] R.S. Aggarwal, A Modern Approach to Verbal & Non-Verbal Reasoning, S. Chand Publishing, Revised-2015. [Online]. Available: https://tinyurl.com/Aggarwal-2015

[32] Sarvesh Verma, Quantitative Aptitude-Quantum CAT, Arihant Publications, 2016
[33] www.mbatious.com
[34] www.campusgate.co.in
[35] www.careerbless.com

25AVP501 Mastery Over Mind (MAOM) 1-0-2-2

Course Overview:

Master Over the Mind (MAOM) is an Amrita initiative to implement schemes and organise university-wide programs to enhance health and wellbeing of all faculty, staff, and students (UN SDG -3). This program, as part of our efforts for sustainable stress reduction, gives an introduction to immediate and long-term benefits and equips every attendee to manage stressful emotions and anxiety, facilitating inner peace and harmony.

With a meditation technique offered by Amrita Chancellor and world-renowned humanitarian and spiritual leader, Sri Mata Amritanandamayi Devi (Amma), this course has been planned to be offered to all students of all campuses of AMRITA, starting off with all first years, wherein one hour per week is completely dedicated for guided practical meditation session and one hour on the theory aspects of MAOM. The theory section comprises lecture hours within a structured syllabus and will include invited guest lecture series from eminent personalities from diverse fields of excellence. This course will enhance the understanding of experiential learning based on 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:

At the end of the course, the student should be able

CO1: To relate to the causes of stress in one's life.
CO2: To experiment with a range of relaxation techniques
CO3: To model a meditative approach to work, study, and life.
CO4: To develop appropriate practice of MA-OM technique that is effective in one's life
CO5: To inculcate a higher level of awareness and focus.
CO6: To evaluate the impact of a meditation technique

CO – PO Affinity Map:

PO/CO PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
CO 1	3	3	3	2		-	2	3	-	3	-	3	-	-	-
CO 2	3	3	3	2	2		2	3	3	3	-	3	-	-	-
CO 3	3	3	2	2	2	2	2	3	3	3	-	3	-	-	-
CO 4	3	3	3	2	-	2	3	3	3	3	-	3	-	-	-
CO 5	3	2	2	2	-	2	-	3	2	2	-	2	-	-	-
CO 6	3	2	2	2	3	2	_	3	2	2	-	2	-	-	-

Course Contents:

Unit 1:

Causes of Stress - The problem of not being relaxed - Need for meditation - Basics of stress management at home and workplace - Traditions and Culture - Principles of meditation - promote a sense of control and autonomy in the Universal Human Value System - Different stages of Meditation - Various Meditation Models - Various practices of Meditation techniques in different schools of philosophy - Indian Knowledge System

Unit 2:

Improving work and study performance - Meditation in daily life - Cultivating compassion and good mental health with an attitude of openness and acceptance - Research and Science of Meditation - Significance of practicing meditation and perspectives from diverse fields like science, medicine, technology - philosophy - culture - arts - management - sports - economics, healthcare, environment - The role of meditation for stress and anxiety reduction in one's life with insights based on recent cutting-edge technology - The effect of practicing meditation for the wholesome wellbeing of an individual

Unit 3:

Communications - principles of conscious communication - Relationships and empathy - Meditative approach in managing and maintaining better relationships in life during the interactions in the world - Role of MAOM in developing compassion - Empathy and responsibility - Instilling interest and Orientation to humanitarian projects as a key to harness intelligence and compassion in youth - Methodologies to evaluate effective awareness and relaxation gained from meditation - Evaluating the global transformation through meditation by instilling human values which leads to service learning and compassion driven research

Textbooks / References:

[1] Mata Amritanandamayi Devi, Cultivating Strength and vitality, published by Mata Amritanandamayi Math, Dec 2019

[2] Swami Amritaswarupananda Puri, The Color of Rainbow published by MAM, Amritapuri.

[3] Craig Groeschel, Winning the War in Your Mind: Change Your Thinking, Change Your Life Zondervan Publishers, February 2019

[4] R Nagarathna et al, New Perspectives in Stress Management Swami Vivekananda Yoga Prakashana publications, Jan 1986

[5] Swami Amritaswarupananda Puri Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation, August 2019
[6] Swami Amritaswarupananda Puri from Amma's Heart - Amma's answer to questions raised during world tours March 2018
[7] Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.
[8] Mata Amritanandamayi Devi Compassion: The only way to Peace:Paris Speech, MA Center, April 2016
[9] Mata Amritanandamayi Devi Understanding and collaboration between Religions, MA Center, April 2016
[10] Mata Amritanandamayi Devi Awakening of Universal Motherhood: Geneva Speech M A center, April 2016

25BM611 Biomedical Image Processing 3-0-0-3

(Pre-requisite: Biomedical Signal Processing)

Course Objectives:

- To introduce modalities for medical image acquisition
- To familiarize algorithms for medical image processing
- To provide knowledge on feature analysis in biomedical images
- To give insight on applications of biomedical image processing

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand various medical imaging techniques
CO2: To apply different techniques for the enhancement of images
CO3: To apply different image segmentation algorithms
CO4: To analyze various features from biomedical images

Skills Acquired: Implementing algorithms for processing and analyzing medical images

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	-	3	2	2
CO 2	2	-	3	3	3
CO 3	2	-	3	3	3
CO 4	3	-	3	3	3

Course Contents:

Unit 1:

Overview of computer aided diagnosis - Medical image acquisition - X-ray imaging - Tomography - Nuclear medicine imaging - SPECT imaging - Positron imaging tomography - Ultrasonography - Magnetic resonance imaging - Image Enhancement - Gray level transforms - Histogram transformation - Spatial filters for smoothing and sharpening

Unit 2:

Frequency domain filtering - Morphological image processing - Binary morphological operations and properties - Morphological algorithms - Boundary Extraction - Region filling - Extraction of

connected components - Image segmentation - Thresholding - Region growing - Region splitting and merging - Edge detection

Unit 3:
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 - Fuzzy region growing to detect breast tumors - Shape analysis of tumors - Analysis of breast masses using texture measures

Textbooks / References:

[1] Rangayyan R M, Biomedical Image Analysis, Fifth Edition, CRC Press, 2005 [Online]. Available: https://tinyurl.com/Rangayan-2015
[2] Gonzalez R C, Woods R E, Digital Image Processing, Fourth Edition, Pearson, 2018
[3] Alejandro F. Frangi, Jerry L. Prince, and Milan Sonka, Medical Image Analysis, Elsevier, 2023.
[4] Meyer-Baese A, Pattern Recognition and Signal Analysis in Medical Imaging, Academic Press, Second Edition, 2014 [Online]. Available: https://tinyurl.com/Haykin-2002
[5] Andrew Webb, Introduction to Biomedical Imaging, Second Edition, Wiley-IEEE Press, 2022

25BM612 Biosensors and Point-of-Care testing devices 3-0-0-3
(Pre-requisite: Nil)

Course Objectives:

- To introduce the concept of biosensors and point-of-care testing devices
- To provide an insight into the working principle of optical and electrochemical sensors
- To learn the fabrication and testing of various biosensors
- To learn the fabrication and testing of paper analytical devices and microfluidic devices for point of care applications

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the working principles of various types of biosensors
CO2: To understand the fabrication and testing of biosensors and apply them to new analytes
CO3: To understand the use of nanomaterials for biosensing to enhance sensor performance and apply them for real time applications
CO4: To understand the fabrication and testing of microfluidics-based point of care testing devices

Skills Acquired: Fabrication and testing biosensors and POCT devices

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	2	3	3	2
CO 2	2	2	3	3	2
CO 3	2	2	3	3	2
CO 4	3	2	3	3	2

Course Contents:

Unit 1:

Introduction to biosensor - classification - characteristics - Enzymatic and nonenzymatic sensors - DNA and protein-based sensors - Immunosensors - Biosensing using nanomaterials - Application of surface plasmon resonance - Chemiluminescence and electroluminescence - FRET in biosensing - Application of metal - Semiconducting quantum dots - Carbon nanotubes - Graphene and carbon dots in biosensing

Unit 2:

Electrochemical and optical biosensors - Fabrication - Characterisation and testing of potentiometric - Voltametric - Amperometric and impedimetric biosensors - Fabrication and testing of colorimetric and fluorometric sensors - Piezoelectric sensors

Unit 3:

Biochips and wearable devices - Paper based analytical devices - Vertical and lateral flow assays - Lab-on-a-chip devices - Wearable sensors - Epidermal electronics system - Lab-on-skin devices

Textbooks / References:

[1] Wang, J. (2023). Analytical Electrochemistry. Wiley. Zhang, X., Ju, H., & Wang, J. (2008). Electrochemical Sensors, Biosensors and Their Biomedical Applications. Elsevier [Online]. Available : https://tinyurl.com/Wang-2008

[2] Grundler, P. (2007). Chemical Sensors – An Introduction for Scientists and Engineers. Springer-Verlag, Berlin Heidelberg. [Online] . Available : https://tinyurl.com/grudler-2007

[3] Ju, H., Zhang, X., & Wang, J. (2011). NanoBiosensing: Principles, Development and Application. Springer. [Online] .Available : https://tinyurl.com/Zang-2011

[4] Merkoci, A. (2009). Biosensing Using Nanomaterials. Wiley

25BM613 **Medical Ethics and Standards** **1-0-0-1**

(Pre-requisite: Nil)

Course Objectives:

- To understand the need for and the various aspects of ethics in medical research
- To realize the need for proper control and security of patient / volunteer data
- To be able to knowledgeably participate and contribute to the development of protocols and standards for the acquisition, processing, storage, analysis, and dissemination of patient / volunteer data

Course Outcomes:

At the end of the course, the student should be able

CO 1: To understand the different aspects of medical ethics

CO 2: To realize the importance of data confidentiality

CO 3: To understand the importance of standards in biomedical research

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	-	2	3	2
CO 2	2	-	2	3	2
CO 3	3	-	3	3	2

Course Contents:

Ethics - Medical Ethics - Moral - Legal - Social - Religious and Cultural Contexts - Information and Consent - Truthfulness - Voluntariness - Patient Data Confidentiality - End-of-Life Ethics - Genetics and Biotechnology - Children and Pregnant Women - Clinical Trials - Case Studies

Standards - Need - Development - Responsible Bodies - Examples - Medical Device Safety - Waveform formats - Nomenclature

Textbooks / References:

[1] M. Dunn and R. A. Hope, Medical Ethics: A Very Short Introduction, 2nd ed., Oxford University Press, 2018 [Online]. Available: https://tinyurl.com/dunn-2018
[2] R. Gupta, Medical Ethics, 4th ed., New Delhi: Jaypee Brothers Medical Publishers, 2019
[3] O. Timms, Biomedical Ethics, 2nd ed., New Delhi: Elsevier, 2019
[4] Shamoo A and Resnik D B, Responsible conduct of research, 2nd ed., Oxford: Oxford University, 2009 [Online]. Available: https://tinyurl.com/shamoo-2009
[5] T. L. Beauchamp and J. F. Childress, Principles of Biomedical Ethics, 8th ed., Oxford: Oxford University Press, 2020. [Online] Available: https://tinyurl.com/beauchamp-2019
[6] Code of Federal Regulations (CFR) – Title 21, 1-99, Chapter H, Apr. 2024, Federal Register National Archives and Records Administration, IEC 60601-1-11:2015 Medical Electrical Equipment Part 1-11, 2nd ed., 2015
[7] IS 13450 – Parts 1 & 2; IS 18128 – Parts 2 & 3; ISO 11073

25BM683 Biosensors and Point-of-Care testing devices Lab 0-0-3-1

Course Objectives:

- To understand the process of development and testing of electrochemical and optical sensors
- Fabrication and testing of paper-based point of care testing devices
- Design, simulation and fabrication of microfluidic components

Course Outcomes:

At the end of the course, the student should be able

CO1: To develop and test electrochemical biosensors and immunosensors
CO2: To develop colorimetric and fluorometric biosensors
CO3: To fabricate and test paper based analytical devices
CO4: To fabricate and test microfluidic components for fluid mixing

Skills Acquired: Fabrication and testing biosensors and POCT devices

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	3	3	3	2	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3

Experiments:

[1] Fabrication and testing of electrochemical sensor
[2] Fabrication and testing of electrochemical immunosensor
[3] Fabrication and testing of colorimetric biosensor
[4] Fabrication and testing of Fluorescence based biosensor
[5] Fabrication and testing of paper-based biosensors
[6] Fabrication of microfluidic components and testing
[7] Fabrication of quantum dots based bacterial sensors

25BM684 Biomedical Engineering Lab 0-0-3-1

Course Objectives:

- To provide hands-on experience in filtering biomedical signals
- To enhance practical knowledge in biomedical signal analysis
- To enable hands-on experience in the processing of biomedical images
- To develop the skill set for higher learning in image processing

Course Outcomes:

At the end of the course, the student should be able

CO1: To apply algorithms for signal and image processing
CO2: To analyze biomedical signals and systems
CO3: To analyze the extracted features from different biomedical images
CO4: To analyze the biomedical images

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	2	2	3	3
CO 2	3	3	2	3	2
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3

Skills Acquired: Programming ability towards implementation of algorithms for processing and analyzing biomedical signals and images

Experiments:

Exp.No	Experiment details
1	Introduction to Python

2	Types of standard signals, operations, and convolution
3	Design of derivative filter to remove baseline wondering in ECG
4	Design of time and frequency domain filters
5	Design of notch filter to remove powerline artifact in ECG
6	Implementation of Pan-Tompkins algorithm for QRS detection in ECG signal
7	Basic operations on images
8	Image enhancement using spatial domain and frequency domain filters
9	Denoising of medical images
10	Medical image segmentation using edge and region-based methods
11	Extraction of shape and texture features from a medical image
12	Design of pattern classification system for biomedical images

Recommended Tools: Python

Textbooks / References:

[1] Rangayyan, Rangaraj M., Biomedical Signal Analysis, John Wiley & Sons, 2024. [Online] Available: https://tinyurl.com/Rangayan-2015

[2] Sinha, G. R., and Patel, B. C., Medical Image Processing: Concepts and Applications, Prentice Hall, 2014. [Online] Available: https://tinyurl.com/sinha-2014

[3] Chityala, Ravishankar, and Pudipeddi, Sridevi, Image Processing and Acquisition Using Python, CRC Press, 2020. [Online] Available: https://tinyurl.com/chityala-2020

[4] Gonzalez, Rafael C., Woods, Richard Eugene, and Eddins, Steven L., Digital Image Processing Using MATLAB, Pearson Education India, 2020. [Online] Available: https://tinyurl.com/gonzalez-2004

[5] Blinowska, Katarzyn J., and Jaroslaw Zygierewicz, Practical Biomedical Signal Analysis Using MATLAB®, CRC Press, 2011

[6] Subasi, A., Practical Guide for Biomedical Signals Analysis Using Machine Learning Techniques: A MATLAB-Based Approach, Academic Press, 2019. [Online]. Available: https://tinyurl.com/subasi-2019

25RM600 **Research Methodology** **2-0-0-2**

(Pre-requisite: Nil)

Course Objectives:

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

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand some basic concepts of research and its methodologies

CO2: To define and apply appropriate parameters and research problems

CO3: To develop skills to draft a research paper

CO4: To analyze and comprehend the ethical practices in conducting research and dissemination of results in different forms

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	3	3	2	3
CO 2	2	3	3	2	3
CO 3	2	3	3	2	3
CO 4	2	3	3	2	3

Skills Acquired: Design, analyze and conduct research and comprehend the results

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 - Understanding Modeling & Simulation - 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 Results 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 Intellectual property rights (IPR) - patents -copyrights- Trademarks-Industrial design geographical indication - Ethics of Research- Scientific Misconduct - Forms of Scientific Misconduct - Plagiarism - Unscientific practices in thesis work - Ethics in science

Textbooks / References:

[1] Bordens, K. S. and Abbott, B. B., Research Design and Methods – A Process Approach, 8th Edition, McGraw-Hill, 2011. [Online] Available: https://tinyurl.com/bordens-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, 3rdEdition, Elsevier Inc. [Online]. Available: https://tinyurl.com/davis-2012

[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 the New Technological Age, Aspen Law & Business, 6th Edition July 2012. Tony Greenfield and Sue Greener, Research Methods for Postgraduates, 3rd Edition, John Wiley & Sons Ltd., 2016. [Online]. Available: https://tinyurl.com/merges-2012

23HU611 Career Competency II 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 teamwork
- 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: To demonstrate good interpersonal skills, solve problems and effectively participate in group discussions
CO2: To write technical resume and perform effectively in interviews
CO3: To identify, investigate and arrive at appropriate strategies to solve questions on arithmetic by managing time effectively
CO4: To investigate, understand and use appropriate techniques to solve questions on logical reasoning and data analysis by managing time effectively
CO5: 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: 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:

CO/PO	PO 1	PO 2	PO 3
CO 1	2	2	1
CO 2	2	2	1
CO 3	2	2	1
CO 4	2	2	1
CO 5	1	1	2
CO 6	2	2	2

Course contents:

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 teamwork 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 help 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 glossophobia 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 - Heights & Distance
Permutations & Combinations – Basics - Fundamental Counting Principle- Circular Arrangements - and Derangements
Probability - Basics - Addition & Multiplication Theorems - Conditional Probability and Bayes' Theorem
Logical Reasoning - 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's question papers of all major recruiters of Amrita Vishwa Vidyapeetham

Miscellaneous: Interview Puzzles, Calculation Techniques and Time Management Strategies

Textbooks / References:

Soft Skills:
Team Building:

[1] Thomas L. Quick, Successful team building, AMACOM Div American Mgmt Assn, 1992

[2] Brian Cole Miller, Quick Team-Building Activities for Busy Managers: 50 Exercises That Get Results in Just 15 Minutes, AMACOM; 1 edition, 2003.

[3] Patrick Lencioni, The Five Dysfunctions of a Team: A Leadership Fable, Jossey-Bass, 1st Edition, 2002

Verbal:

[4] GMAT Official Guide by the Graduate Management Admission Council, 2019
[5] Arun Sharma, How to Prepare for Verbal Ability and Reading Comprehension For CAT
[6] Joern Meissner, Turbocharge Your GMAT Sentence Correction Study Guide, 2012
[7] Kaplan, Kaplan GMAT 2012 & 13
[8] Kaplan, New GMAT Premier, Kaplan Publishing, U.K., 2013
[9] Manhattan Prep, Critical Reasoning 6th Edition GMAT
[10] Manhattan Prep, Sentence Correction 6th Edition GMAT
[11] Mike Barrett SAT Prep Black Book the Most Effective SAT Strategies Ever Published
[12] Mike Bryon, Verbal Reasoning Test Workbook Unbeatable Practice for Verbal Ability, English Usage and Interpretation and Judgement Tests
[13] www.bristol.ac.uk/arts/skills/grammar/grammar_tutorial/page_55.htm
[14] www.campusgate.co.in

Aptitude:

[15] Arun Sharma, How to Prepare for Quantitative Aptitude for the CAT Common Admission Test, Tata Mc Graw Hills, 5th Edition, 2012
[16] Arun Sharma, How to Prepare for Logical Reasoning for the CAT Common Admission Test, Tata Mc Graw Hills, 2nd Edition, 2014
[17] Arun Sharma, How to Prepare for Data Interpretation for the CAT Common Admission Test, Tata Mc Graw Hills, 3rd Edition, 2015
[18] R.S. Aggarwal, Quantitative Aptitude for Competitive Examinations, S. Chand Publishing, 2015
[19] R.S. Aggarwal, A Modern Approach to Verbal & Non-Verbal Reasoning, S. Chand Publishing, Revised -2015
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25BM698 INDUSTRY INTERNSHIP 0-0-2-1

Course Objectives:

- To provide students with hands-on clinical exposure in a hospital environment
- To apply biomedical engineering principles to real-world healthcare challenges
- To gain practical experience in the operation and management of medical devices and patient monitoring systems

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand clinical practices and hospital workflows
CO2: To operate and troubleshoot biomedical instruments and patient monitoring systems
CO3: To analyze and interpret clinical data using biomedical engineering approaches

CO-PO Mapping:

Course Contents:

- Students may attend an internship in a hospital or biomedical related research laboratories between the second and third semester in a hospital approved by the department
- Test, measurement, processing, and interpretation of data from hospital resources
- Compilation of overall involvement in the internship as a report and review

25BM798 DISSERTATION PHASE I 0-0-30-10

Course Objectives:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	3	3	2	3
CO 2	2	3	3	2	3
CO 3	2	3	3	2	3

- To enhance students' ability to conduct independent research, including literature review, data collection, and analysis
- To foster critical analysis of existing literature and methodologies in the chosen field of study
- To gain proficiency in selecting appropriate research methods and techniques for addressing research questions

Course Outcomes:

At the end of the course, the student should be able

CO1: To define a research problem
CO2: To apply engineering concepts to the research problem
CO3: To design and conduct independent research in the domain of interest
CO4: To evaluate and analyze the outcomes of the research

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	3	3	2	3
CO 2	2	3	3	2	3
CO 3	2	3	3	2	3
CO 4	2	3	3	2	3

Course Contents:

- Problems and concepts may be defined based on extensive literature survey by standard research articles. Significance of proposed problem and the state-of the art to be explored
- Industry relevant tools may be used for demonstrating the results with physical meaning and create necessary research components
- Publications in reputed journals /conferences may be considered for authenticating the results
- Prepare and submit a detailed technical report
- Provide a presentation and defend the dissertation work carried out

25BM799 DISSERTATION PHASE II 0-0-45-15

Course Objectives:

- To enhance students' ability to conduct independent research, including literature review, data collection, and analysis
- To foster critical analysis of existing literature and methodologies in the chosen field of study
- To gain proficiency in selecting appropriate research methods and techniques for addressing research questions

Course Outcomes:

At the end of the course, the student should be able

CO1: To define a research problem
CO2: To apply engineering concepts to the research problem
CO3: To design and conduct independent research in the domain of interest
CO4: To evaluate and analyze the outcomes of the research

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	3	3	2	3
CO 2	2	3	3	2	3
CO 3	2	3	3	2	3
CO 4	2	3	3	2	3

Course Contents:

- Problems and concepts may be defined based on extensive literature surveys by standard research articles. Significance of proposed problem and the state-of the art to be explored
- Industry relevant tools may be used for demonstrating the results with physical meaning and creating necessary research components
- Publications in reputed journals /conferences may be considered for authenticating the results
- Prepare and submit a detailed technical report
- Provide a presentation and defend the dissertation work carried out

25BM731 TRANSLATIONAL BIOMEDICAL ENGINEERING 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To understand different processes in medical device development
- To introduce different modern approaches in biomedical devices
- To provide deep insight into the materials for sensing and energy storage suitable in biomedical devices
- To introduce different manufacturing technologies for biomedical devices

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand different processes involved in medical life cycle management

CO2: To understand different emerging biomedical devices, their development and manufacturing

CO3: To apply the knowledge of materials science to develop sensing and energy storage

CO4: To understand different methodologies for scaleup manufacturing of biomedical devices

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	2	3	2	2
CO 2	2	2	3	2	2
CO 3	2	2	3	2	2
CO 4	2	2	3	2	2

Skills Acquired: Application of materials science and manufacturing technologies for biomedical device development

Course Contents:

Unit 1:

Medical Device Development Process - Customer Requirements - Proof of Concept - Design Control - Design Verification and Validation - Clinical trials - Process - SAC - IEC approvals - Safety Testing - Design Transfer - Product Launch - Risk Management - Regulatory strategy - Intellectual Property management - Project Management - Start-up company experiences - Support ecosystem - Time to market - Medical Device Standards - Regulatory approval processes - FDA / CE - Medical Devices Rules 2016

Unit 2:

Introduction to emerging technologies in biomedical devices - bench to bedside translation - point of care diagnostic devices - cancer diagnosis - early detection - continuous monitoring devices - development - present status and challenges - Functional materials in biomedical devices - paper microfluidic devices. Bacteria and cell imaging - colorimetric - fluorescent and radiochemical assay - Different types of energy storage devices in biomedical devices

Unit 3:

Fabrication of biomedical devices - conventional manufacturing - rapid manufacturing - forming - additive - subtractive - casting and cooling technologies - 3D printing - bio 3D printing - screen printing - wax printing - lithography - electrochemical methods - electroforming - laser scribing - CNC machining - sheet lamination - powder bed fusion - Design and fabrication of microneedles - cannula - Specification of energy storage devices in biomedical devices - fabrication of flexible batteries and supercapacitors

Textbooks / References:

[1] T. R. Kucklick (Ed.), The Medical Device R&D Handbook, 2nd ed., Boca Raton, Fla.: CRC Press, 2013. [Online]. Available: https://tinyurl.com/Kucklick-2013

[2] E. Whitmore, Development of FDA-regulated medical products: A translational approach, 2nd ed. Milwaukee, Wis: ASQ Quality Press, 2012. [Online]. Available: https://tinyurl.com/Elaine-Whitmore-2012
[3] S. S. Mehta, Commercializing Successful Biomedical Technologies, 2nd Edition, Cambridge: Cambridge University Press, 2022. [Online]. Available: https://tinyurl.com/Mehta-2022
[4] IEC Standards 60601-X, ISO 13485, ISO 14971, ISO 14133, Relevant FDA / CE Regulatory protocols
[5] Luttge, R., 2016. Nano- and microfabrication for industrial and biomedical applications. William Andrew. [Online]. Available: https://tinyurl.com/Regina-Luttge-2016
[6] B. Burge et al., A Manual Introducing Intellectual Property to Scientists – Patents, World Scientific Pub Co Inc, 2010
[7] Özel, T., Bártolo, P.J., Ceretti, E., Gay, J.D.C., Rodriguez, C.A. and Da Silva, J.V.L. eds., 2016. Biomedical devices: design, prototyping, and manufacturing. John Wiley & Sons. [Online]. Available: https://tinyurl.com/Ozel-Bartolo-2016
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25BM732 WEARABLE HEALTH TECHNOLOGIES 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To provide students with comprehensive knowledge and hands-on skills in the design, fabrication, and testing of wearable devices, including the integration of sensors, electronics, and materials for healthcare, fitness, and other applications

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the fundamental concepts of wearable devices, including their purpose, scope, and impact on personal health monitoring and daily life

CO2: To understand and apply the fabrication techniques needed to create flexible, stretchable, and lightweight sensors and their associated electronics that can conform to the body's movement for continuous monitoring

CO3: To apply fundamentals of wearable technologies to develop affordable continuous monitoring wearable sensors and sensors for non-invasive biochemical analysis, such as continuous glucose monitoring, sweat analysis, and biomarker detection

CO4: To analyze the power requirements of wearable devices and explore different energy sources such as batteries, energy harvesting, and low-power circuit design for optimal device operation

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	3	2	3	3	2
CO 2	3	2	3	3	2
CO 3	3	2	3	3	2
CO 4	3	2	3	3	2

Skills Acquired: Design and development of wearable biomedical sensors and devices

Course Contents:

Unit 1:

Introduction to wearable devices - Challenges and opportunities - Future of wearables - Fabrication of wearable devices - materials and methods - system design - introduction to flexible and printed sensors and electronics - data acquisition in wearable devices

Unit 2:

Wearable devices for electrophysiological monitoring - Accelerometers - gyroscopes - PPG - ECG - EMG - pressure and temperature sensors. Wearable devices for biochemical analysis - sweat sensors - ISF sensors - saliva-based sensors - tear-fluid sensors. Wearable devices for continuous monitoring - implantable sensors. Integrated wearable devices - lab-on-a-skin - epidermal electronics - simultaneous sensing and drug delivery - artificial pancreas. Applications - chronic disease - personalized health management - fitness monitoring

Unit 3:

Power management and energy harvesting in wearable devices - flexible electronics - Energy harvesting from biofluids - sweat - interstitial fluid - saliva - Energy harvesting from the human body - temperature gradient - foot motion - wireless energy transmission - Energy harvesting from light and RF energy - energy and power consumption issues - future considerations

Textbooks / References:

[1] Introduction to Flexible Electronics, Aftab M Hussain, CRC Press, 2022. [Online]. Available: https://tinyurl.com/Aftab-Hussain-2022

[2] Wearable Biosensing in Medicine and Healthcare, Mitsubayashi, K Springer, 2024. [Online]. Available: https://tinyurl.com/Mitsubayashi-K-2024

[3] Wearable and autonomous biomedical devices and systems for smart environment, Lay-Ekuakille, A. and Mukhopadhyay, Springer, 2010. [Online]. Available: https://tinyurl.com/Ekuakille-2010

25BM733 BIO-MICROFLUIDICS AND MICROFABRICATION 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To develop a strong understanding of the fundamental principles of microfluidic systems, and their significance in biomedical engineering
- To provide an insight into the various tools/techniques used for microfabrication and apply them to the fabrication of microfluidic components

- To provide a thorough knowledge to design and integrate microfluidic components to develop functional, efficient, and scalable systems for applications like point-of-care diagnostics and high-throughput biological assays
- To apply the concepts of fluid mechanics at the microscale and microfabrication to develop biomedical devices such as lab-on-a-chip, and organ-on-a-chip

Course Outcomes:

At the end of the course, the student should be able

CO1: To demonstrate an understanding of the principles of fluid mechanics at the microscale and apply it to explain the flow of biomolecules, cells, and samples in a device

CO2: To demonstrate the ability to choose a microfabrication technique for biomedical device development depending on the end application

CO3: To design microfluidic devices for biological applications by integrating various microfluidic components to achieve desired fluidic operation on a chip

CO4: To understand how to apply microfluidic systems in areas like point-of-care diagnostics, lab-on-a-chip devices, and organ-on-a-chip technologies

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	3	2	3	3	2
CO 2	3	2	3	3	2
CO 3	3	2	3	3	2
CO 4	3	2	3	3	2

Skills Acquired: Design of microfluidic components, microfabrication techniques, and their practical applications

Course Contents:

Unit 1:

Biomicrofluidics - Basics of fluid mechanics - flow solutions - Navier-Stokes equation - Flow physics at micrometre scale - Fabrication techniques - photolithography - additive techniques - subtractive techniques - pattern transfer techniques - silicon based micromachining - polymer based micromachining - assembly and packaging of microfluidic devices - biocompatibility.

Unit 2:

Fluid flow in microfluidic devices - electrohydrodynamics and electrokinetics - electroosmotic flow - electrophoresis - capillary electrophoresis - capillarity and surface tension - droplet microfluidics - external flow and internal flow control components - microvalves - micropumps - microflow sensors - microneedles - micromixers - microdispensers - microfilters - microseparators - microreactors

Unit 3:

Lab-on-a-chip device - fabrication and testing - applications - organ-on-a-chip fabrication - potential applications - integrated microfluidic devices for healthcare applications - multiplexed analysis - high throughput devices - molecular analysis

Textbooks / References:

[1] Albert Folch, Introduction to BioMEMS, CRC Press, 2013. [Online]. Available: https://tinyurl.com/Albert-Folch-2013
[2] Nam-Trung Nguyen and Steven T. Wereley, Fundamentals and Applications of Microfluidics, Third Edition, Artech House, 2019. [Online]. Available: https://tinyurl.com/Nam-Trung-Nguyen-2019
[3] Jeffrey D Zahn, Methods in Bioengineering: Biomicrofabrication and Biomicrofluidics, Artech House, 2010. [Online]. Available: https://tinyurl.com/Jeffrey-D-2010
[4] Tuhin S Santra, Microfluidics and Bio-MEMS: Devices and Applications, CRC Press, November 2020. Online. Available: https://tinyurl.com/Tuhin-S-Santra-2020
[5] Patrick Tabeling, Introduction to Microfluidics, Oxford University Press, 2005. [Online]. Available: https://tinyurl.com/Patrick-Tabeling-2023
[6] Stephen J. G. Gift, Christopher R. P. Upton, and D. J. M. Miller, Microfabrication for :rofluidics, Artech House

25BM734 REGENERATIVE AND MOLECULAR MEDICINE 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To introduce the fundamental principles of regenerative and molecular medicine
- To understand the molecular mechanisms underlying tissue repair, regeneration, and targeted therapy
- To explore current advancements and technologies used in the development of regenerative and molecular therapeutics

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the features responsible for molecular and regenerative medicine
CO2: To apply the molecular basis for diseases and medicines
CO3: To analyze the features to characterize common regenerative and molecular medicines
CO4: To design and develop new regenerative and molecular medicines

CO-PO mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	-	-	-	-
CO 2	-	-	2	-	2
CO 3	2	2	3	-	2
CO 4	-	-	2	3	2

Skills acquired:

Data analysis-Analyze genetic linkage and epistasis, Critical Thinking, Research in future technologies

Course Contents:

Unit 1:

Regenerative therapy - introduction - applications of regenerative medicine in the nervous system - eye - heart - lung - liver - kidney - pancreas - large scale manufacturing of cells - tissues and

organs - artificial organs - gene therapy applications - engineered tissues and regenerative medicine - molecular therapy for regeneration - personalized therapies in regenerative medicine

Unit 2:

Molecular basis of diseases - human genetics relevant to molecular medicine - single and multi-gene diseases - gene environment interactions in disease manifestation - molecular medicine therapeutics - gene therapy and recombinant molecules in medicine and therapeutic development - signal transduction and its role in human diseases - cellular and tissue microenvironment in diseases - drug resistance with conventional chemotherapies

Unit 3:

Advances in translational research - clinical trials - nano-biotechnology and its applications in molecular medicine - developing novel biomarkers and therapies using high throughput technologies

Textbooks / References:

[1] Marks, A. R., & Neill, U. S. (2010). Textbook of Molecular Medicine: Science in Medicine. Jones & Bartlett Learning. [Online]. Available: https://tinyurl.com/Andrew-Marks-2010
[2] Kusano, M., & Shioda, S. (Eds.). New Frontiers in Regenerative Medicine. Springer. [Online]. Available: https://tinyurl.com/Kusano-2014
[3] Atala, A., Lanza, R., et al. (Eds.). (2018). Principles of Regenerative Medicine. Academic Press. [Online]. Available: https://tinyurl.com/Anthony-Atala-2018
[4] Kresina, T. F. (2001). An Introduction to Molecular Medicine and Gene Therapy. Wiley-Liss. [Online]. Available: https://tinyurl.com/Thomas-Kresina-2001

25BM735 PHARMACOGENOMICS AND DEEP DRUG DESIGN 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To introduce pharmacogenomics and design of personalized drugs
- To provide insights on individual variation and deep drug design strategy
- To enable design of drug action model and study the susceptibility of drugs
- To apply the design concepts to problems of clinical and research interests

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the features responsible for individual variations
CO2: To apply the pharmacogenomic features to study the variation in drug action and susceptibility towards diseases
CO3: To analyze the features to identify the most suitable drugs for each patient
CO4: To design and develop customized drugs for common diseases

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	-	-	-	-
CO 2	-	-	3	-	2

CO 3	-	2	3	-	2
CO 4	-	-	3	3	2

Skills acquired:

- Proficiency in data analysis is crucial for interpreting genomic data and understanding how it relates to medication response
- A solid understanding of computational techniques
- The ability to think critically and problem-solve is vital in pharmacogenomics
- Experience in research or clinical settings is highly valued in pharmacogenomics careers

Course Contents:

Unit 1:

Introduction - Pharmacogenomics and precision drugs - Screening of target mutation - analysis of variants associated with the mutations - Gene expression analysis and study of the expression profile - Model design for the gene and protein

Unit 2:

Design of precision drugs - target discovery - incorporation of SNVs - protein modeling using deep homology modeling - identification of binding sites - docking - MD simulation of protein - ligand complex - correlation between structural features and kinetic stability - thermodynamic stability - free energy analysis MMPBSA/MMGBSA - combination therapy

Unit 3:

Applications - pharmacogenomics in cardiovascular diseases - pharmacogenomics of antitumor chemotherapeutic agents - pharmacogenomics of antitumor targeted agent and immunotherapy - pharmacogenomics of immunosuppressants - pharmacogenomics of psychiatric drugs - pharmacogenomics in therapeutic drug monitoring – pharmacomicrobiomics

Textbooks / References:

[1] Introduction to Genetic Analysis (2020-12th Edition), Anthony Griffiths; John Doebley; Catherine Peichel; David A. Wassarman -ISBN:9781319114787-Macmillon. [Online]. Available: https://tinyurl.com/Anthony-Griffiths-2020

[2] Artificial Intelligence in Drug Design | SpringerLink - Alexander Heifetz - Humana Press. [Online]. Available: https://tinyurl.com/Heifetz-2022

[3] Pharmacogenomics in Drug Discovery and Development:(Methods in Molecular Biology) - Qing Yan (Editor)- Humana press. [Online]. Available: https://tinyurl.com/Qing-Yan-2022

[4] Pharmacogenomics: a primer for clinicians (2021), Lam Jerika T, Gutierrez Mary A and Samit Shah- McGraw Hill Medical, ISBN: 1-260-45711-7

25BM736 NANOMATERIALS FOR BIOMEDICAL APPLICATIONS 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To introduce the concept of nanomaterials and their biomedical applications

- To provide an insight into the various characterisation tools working and apply them for the characterisation of nanomaterials
- To learn the various methods of synthesis of nanomaterials and biofunctionalization
- To understand the suitability of nanomaterials for specific biomedical applications

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the size-dependent properties of nanomaterials and their biomedical applications
CO2: To apply different characterization techniques to assess the surface properties of nanomaterials
CO3: To understand the different physical and chemical methods for the synthesis of high surface area nanomaterials.
CO4: To understand the need of surface functionalization of nanomaterials for biomedical applications and the various methods for achieve the same

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	3	2	2	2
CO 2	2	3	2	3	2
CO 3	2	3	2	3	2
CO 4	2	3	2	3	2

Skills Acquired: Synthesis, characterisation and biofunctionalization of nanomaterials

Course Contents:

Unit 1:

Size dependence of properties - surface to volume ratio - quantum confinement - electrical - optical - mechanical - chemical - magnetic properties of nanomaterials - microscopic techniques to study nanostructures - SEM - AFM - TEM - STM - spectroscopic techniques to characterize nanostructures - Raman - XPS - Auger - EDAX

Unit 2:

Synthetic approaches - colloidal - self-assembly - electrochemical methods - solgel - Langmuir-Blodgett (LB) - chemical vapor deposition - plasma arcing - ball milling - lithography - synthesis - properties and biomedical applications of fullerenes - carbon nanotubes and graphenes - semiconducting quantum dots - wells - wires

Unit 3:

Biofunctionalisation of nanomaterials - noncovalent assembly - covalent assembly - biofunctional nanomaterials - semiconductor nanoparticles - magnetic nanoparticles - applications of biofunctional nanomaterials

Textbooks / References:

[1] Nabok, A. (2005). Organic and Inorganic Nanostructures. Artech House, Inc. [Online]. Available: https://tinyurl.com/Alexei-Nabok-2005

[2] Mozafari, M. R. (Ed.). (2007) Nanomaterials and Nanosystems for Biomedical Applications. Springer. [Online]. Available: https://tinyurl.com/Reza-Mozafari-2007
[3] Ju, H., Zhang, X., & Wang, J. (2011). NanoBiosensing: Principles, Development and Application. Springer. [Online]. Available: https://tinyurl.com/Huangxian-Ju-2011
[4] Wang, Z. L. (Ed.). (2000) Characterisation of Nanophase Materials. Wiley-VCH

25BM737 **BIOMECHANICS** **3-0-0-3**
(Pre-requisite: Nil)

Course Objectives:

- To understand the basic concepts of viscoelasticity, mechanical properties and behavior of skeletal tissues
- To learn the mechanics of human body motion and apply them to gait analysis and sports biomechanics
- To learn the mechanics of skeletal joints and use them to find the unknown forces at the joints for various static and dynamic human activities

Course Outcomes:
At the end of the course, the student should be able

CO1: To understand the viscoelastic behavior of tissues and the structure, function and mechanical properties of skeletal elements
CO2: To analyze the human body motions and apply it to gait analysis and various sports activities
CO3: To analyze the muscle and joint reaction forces at a skeletal joint for various static and dynamic human activities

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	-	3	3	3
CO 2	2	-	3	3	3
CO 3	2	-	3	3	3

Skills Acquired: Good understanding of properties and mechanical behavior of skeletal elements, Ability to perform static and dynamic analysis of human body at rest or in motion.

Course Contents:
Unit 1:
Introduction to biomechanics - basic terminology and concepts - forces - moments and torque - stresses and strain - stress tensor and Hooke's law - orthotropic - transversally isotropic - isotropic material models - viscoelasticity and viscoelastic models - structure - properties - mechanics of skeletal elements - bones - cartilage - muscles - tendon - ligaments

Unit 2:

Anatomical positions - planes and axes - segments of human body - segmental parameters - centre of mass and centre of gravity - biomechanical analysis of human motion - linear and angular kinematics - linear and angular kinetics - application to sports - gait analysis - gait in health and disease

Unit 3:

Biomechanics of joints - classification of joints - upper extremity joints - lower extremity joints - biomechanics of spine - biomechanics of lifting - fracture fixation devices - artificial joints - prosthetics and orthotics

Textbooks / References:

[1] Bernardo Innocenti and Fabio Galbusera, Human Orthopedic Biomechanics: Fundamentals, Devices and Applications, Academic Press, 2022. [Online]. Available: https://tinyurl.com/Bernardo-Innocenti-2022

[2] Susan J. Hall, Basic Biomechanics, 9th Edition, McGraw-Hill, 2022. [Online]. Available: https://tinyurl.com/Susan-Hall-2022

[3] Nihat Özkaya, Dawn Leger, David Goldsheyder, and Margareta Nordin, Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, 4th Edition, Springer, 2017. [Online]. Available: https://tinyurl.com/Nihat-Ozkaya-2017

[4] Margareta Nordin and Victor H. Frankel, Basic Biomechanics of Musculoskeletal System, 4th Edition, Lippincott, Williams and Wilkins, 2012. [Online]. Available: https://tinyurl.com/Margareta-Nordin-2012

[5] Joseph Hamill, Kathleen M. Knutzen, and Timothy R. Derrick, Biomechanical Basis of Human Movement, 5th edition, Lippincott Williams & Wilkins, 2021

25BM741 MEDICAL DECISION SUPPORT SYSTEMS 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To introduce the mathematical concepts of medical decision support systems
- To provide an insight on deep learning architectures
- To impart knowledge on application of deep learning for biomedical problems

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the mathematical concepts of data processing

CO2: To pre-processing of data and features, to be used in deep learning architectures **CO3**: To learn the theory of deep learning techniques

CO4: To analyze biomedical problems and apply deep learning techniques

CO5: To implement deep learning models for medical diagnosis

Skills Acquired: Implementation of deep learning models for medical decision support

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	-	-	2	2	2
CO 2	-	2	2	3	2

CO 3	2	2	2	3	2
CO 4	2	3	2	3	3
CO 5	2	-	2	3	2

Course Contents:
Unit 1:

Introduction to linear algebra - solving linear equations - eigen values and eigen vectors - mean - median - mode - standard deviation and covariance matrix - feature extraction and dimensionality reduction techniques - introduction to probability theory - introduction to optimization - gradient descent techniques - stochastic gradient descent - advanced optimization methods - introduction to high dimensional data visualization - review of performance evaluation of classification systems

Unit 2:

Modeling biomedical data as a source filter model - biomedical data synthesis using source filter model technique - other feature extraction techniques - deep learning architectures - Convolutional Neural Networks (CNN) - Recurrent Neural Networks (RNN) - Autoencoders - Deep Neural Network (DNN) - Deep Belief Network (DBN) - Long Short-Term Memory (LSTM) - attention modeling - transformers

Unit 3:

Word2vec modeling - gene expression prediction - Protein structure classification - word2vec for protein structure classification - Deep learning techniques for optimizing medical data Use cases of the application of deep learning techniques to biomedical data analysis and disease diagnosis - Early diagnosis of heart diseases - ECG Heartbeat classifier - Heart sound analysis using PCG - EEG characterization - Diagnosing Parkinson's/Alzheimer's disease

Textbooks / References:

[1] Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2009
[2] Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep Learning, MIT Press, 2016
[3] Basant Agarwal, Valentina Emilia Balas, Lakshmi CJ Jain, Ramesh chandrapoonia, Manisha, Deep Learning for biomedical and health informatics, Academic press, Elsevier 2020
[4] Kose, Utku, Omer Deperlioglu, JafarAlzubi, and Bogdan Patrut. Deep learning for medical decision support systems. Springer, 2020
[5] Cao, Chensi, Feng Liu, Hai Tan, Deshou Song, Wenjie Shu, Weizhong Li, Yiming Zhou, Xiaochen Bo, and Zhi Xie., Deep learning and its applications in biomedicine, Genomics, proteomics & bioinformatics 16, no. 1, 17-32, 2018

25BM742 MULTI MODAL IMAGE ANALYSIS 3-0-0-3

(Prerequisite: Nil)

Course Objectives:

- To introduce the concepts of various modalities
- To provide an insight on image registration techniques
- To impart knowledge on image fusion

Course Outcomes:

At the end of the course, the student should be able to

CO1: Understand the concepts of image analysis
CO2: Apply image registration techniques
CO3: Apply image fusion techniques
CO4: Implement deep learning models for diagnosis

Skills Acquired: Implementation of deep learning models

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	-	2	2	2
CO 2	3	-	2	3	2
CO 3	3	-	2	3	2
CO 4	3	3	2	3	3

Course Contents:

Unit 1:

Fundamentals of imaging modalities - ultrasound - X-ray - CT - MRI - PET - SPECT - global descriptors - local descriptors - deep learning-based descriptors - CNN - autoencoder - case study - X-ray tissue characterization and classification

Unit 2:

Medical image registration - linear transformation - non-linear transformation - feature-based and voxel-based registration - case study - MRI - PET image registration for diagnosis

Unit 3:

Image fusion techniques - pixel based - feature based - ICA based - Bayesian - EMD - CNN based - performance evaluation of fusion techniques - case study - MRI - CT fusion for diagnosis

Textbooks / References:

[1] Gonzalez R C and Woods R E, Digital Image Processing, Fourth Edition, Prentice Hall, 2010 [Online]. Available: https://tinyurl.com/Gonzalez-2010
[2] Robb, Richard A. Biomedical imaging, visualization, and analysis. John Wiley & Sons, Inc., 1999
[3] Stathaki, Tania. Image fusion: algorithms and applications. Elsevier, 2011 [Online]. Available: https://tinyurl.com/Stathaki-2011
[4] A. Ardheshir Goshtasby, 2-D and 3-D Image Registration for Medical, Remote Sensing, and Industrial Applications, John Wiley and Sons, 2005
[5] Rangayyan R M, Biomedical Image Analysis, Fifth Edition, CRC Press, 2005 [Online]. Available: https://tinyurl.com/Rangayyan-2005

25BM743 BIO-INSPIRED COMPUTING 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To introduce concepts of Bio-inspired Computing its applications

- To provide insight on Artificial Neural Networks
- To introduce Fuzzy logic and Fuzzy Systems
- To provide knowledge on optimization algorithms

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand principles of bio-inspired algorithms
CO2: To apply bio-inspired techniques for pattern recognition and optimization tasks
CO3: To analyze problems in medical applications using bio-inspired approaches
CO4: To evaluate performance of optimization algorithms

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	-	-	2	2	2
CO 2	2	-	2	3	3
CO 3	2	2	3	3	3
CO 4	2	2	3	3	3

Skills Acquired: Programming ability towards implementation of bio-inspired algorithms for analyzing and solving problems in biomedical domain

Course Contents:

Unit 1:

Neural networks - Artificial neurons - Activation functions - Learning rules - Supervised and Unsupervised Learning - Single layer and multilayer perceptrons - Kohenen's selforganizing networks - Hopfiled networks

Unit 2:

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

Unit 3:

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 / References:

[1] Fan, Xumei, William Sayers, Shujun Zhang, Zhiwu Han, Luquan Ren, and Hassan Chizari. Review and classification of bio-inspired algorithms and their applications. Journal of Bionic Engineering 17, 611-631, 2020. [Online] Available: https://tinyurl.com/Xumei-2020

[2] Goldberg, David E. Genetic algorithms, Pearson Education India, 2006

[3] Fausett, Laurene V. Fundamentals of neural networks: architectures, algorithms and applications, Pearson Education India, 2006. [Online] Available: https://tinyurl.com/Fausett-2006
[4] Ross, Timothy J. Fuzzy logic with engineering applications. Vol. 4. New York: Wiley, 2016
[5] Bernardino, Heder S., and Helio JC Barbosa. Artificial immune systems for optimization In Nature-Inspired Algorithms for Optimisation, pp. 389-411. Springer, Berlin, Heidelberg, 2009

25BM744 MULTISENSOR DATA FUSION 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To introduce the mathematical foundations of data fusion methods
- To provide knowledge on intelligent fusion algorithms based on soft computing techniques
- To enable understanding of data fusion models for biomedical applications

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the basics of data fusion algorithms.
CO2: To apply appropriate data fusion techniques in biomedical applications
CO3: To analyze biomedical problems using intelligent fusion algorithms
CO4: To create fusion models for biomedical applications

Skills Acquired: The design and programming ability in data fusion models for biomedical applications

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	-	-	3	-	-
CO 2	-	-	3	2	2
CO 3	2	2	3	3	3
CO 4	3	3	3	3	2

Course Contents:

Unit 1:

Introduction to data fusion process - Data fusion models - Configurations and architectures. Probabilistic Data Fusion - Maximum Likelihood - Bayesian and Maximum entropy methods - Recursive Bayesian methods for estimation and data fusion - Kalman filter theory - Kalman filter as a natural data-level fuser

Unit 2:

Data fusion by nonlinear Kalman filtering - Information filtering - H-infinity filtering - Multiple hypothesis filtering - Data fusion with missing measurements - Possibility theory and dempster -

Shafer Method - Fuzzy Logic based Decision Fusion - Type 1 and type 2 fuzzy logic - Adaptive Neuro-Fuzzy Inference System (ANFIS) and generation of weights - Monte Carlo methods

Unit 3:

Decision Theory based Fusion - Bayesian decision theory - Decision making with multiple information sources - Decision making based on voting - Performance evaluation of Data Fusion systems - ANN based decision fusion - JDL process: Review of algorithms used for object refinement- Situation refinement- Threat refinement and process refinement – Case studies: different data fusion architectures - Detection and diagnosis of diseases using the principles of multi-sensor fusion

Textbooks / References:

[1] James V. Candy, Signal Processing: The Model Based Approach, McGraw -Hill Book Company, 1987
[2] David L. Hall, Mathematical Techniques in Multisensor Data Fusion, Artech House, Boston, 2009
[3] R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998
[4] Jitendra R Raol, Data Fusion Mathematics: Theory and Practice, CRC Press, 2016

25BM745 COMPUTATIONAL NEUROSCIENCE 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To provide understanding of the fundamental concepts behind neuronal signaling and brain function
- To enhance knowledge on neural encoding/decoding and their roles in cognitive functions and disorders
- To enable mathematical and simulation-based modeling of neurons and neural networks.
- To develop analytical and technical skills to evaluate brain function and dysfunction through case studies and computational frameworks

Course Outcomes:

At the end of the course, the student should be able

CO1: Ability to understand the principles of cognitive and systems neuroscience relevant to brain functions and disorders
CO2: Ability to apply information theory and neural coding concepts in modeling cognitive processes
CO3: Ability to analyze neural activity using computational and simulation models
CO4: Ability to critically evaluate learning algorithms and models (e.g., neural networks) in the context of understanding brain behavior and neurological diseases

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2

CO 1	-	-	3	-	-
CO 2	-	-	3	2	-
CO 3	3	2	3	3	2
CO 4	3	3	3	3	2

Skills Acquired: Enables students to construct and apply mathematical models to analyze neuronal dynamics quantitatively

Course Contents:

Unit 1:

Review - Convolution - Linear systems - Vectors - Matrices - Basis vectors - Probability theory - Probability distribution - Bayes theorem - Dynamical systems - Electrical nature of neurons - Synapses - Brain areas - Brain functions - Neuron spikes - Entropy - Spike train information - Brain noise

Unit 2:

Coding principles - Neural encoding - Feature selection - Variability - Neural decoding and signal detection theory - Population coding - Bayesian estimation - Reconstructing stimulus - Neuron models - Mechanistic and interpretive models

Unit 3:

Spike train modelling - simulation of neuron models - Hodgkin-Huxley model - neural correlations - synchrony - synapses modelling - firing rate models - feed forward networks - recurrent networks - synaptic plasticity - statistical learning - unsupervised learning - sparse coding - predictive coding - neurons as classifiers - reinforcement learning - case studies - simulation-based exploration of Parkinson’s disease or epilepsy using simplified neural circuit models - modeling of cognitive impairments - Alzheimer's disease - schizophrenia - cross-reference to computational approaches in cerebrovascular disorders - computational modeling of human brain function using machine learning frameworks

Textbooks / References:

[1] Miller P, An introductory course in Computational Neuroscience, First Edition, MIT Press, 2018

[2] Dayan, P. and Abbott, L.F, Theoretical neuroscience: computational and mathematical modeling of neural systems, First Edition, MIT Press, 2001. [Online] Available: https://tinyurl.com/Dayan-2001

[3] Bielza, C. and Larrañaga, P, Data-Driven Computational Neuroscience: Machine Learning and Statistical Models. First Edition, Cambridge University Press, 2020

[4] Arbib, M.A. and Bonaiuto, J.J, From neuron to cognition via computational neuroscience. First Edition, MIT Press, 2016

25BM746 SPEECH AND AUDIO PROCESSING 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To introduce the concepts of signal processing with application to speech processing

- To provide insights on feature extraction for speech coding, synthesis and recognition
- To enable understanding of deep learning applications to speech processing and health care

Course Outcomes:
At the end of the course, the student should be able

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

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	-	-	2	3	3
CO 2	-	-	-	3	2
CO 3	2	2	3	3	3
CO 4	2	2	3	2	3

Skills Acquired: Ability towards implementation of algorithms for analysis of speech and audio signals

Course Contents:
Unit 1:
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

Unit 2:
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

Unit 3:
Analysis of speech/audio - Experiment with speech analysis and synthesis - Experiment with deep learning techniques for speech recognition - Analyze the speech signals of controls with dysarthria and aphasia.

Textbooks / References:
[1] B. Gold, N. Morgan, D. Ellis, Speech and Audio Signal Processing: Processing and Perception of Speech and Music, Wiley, 2011
[2] U Kamath, J Liu, J Whitaker, Deep Learning for NLP and speech recognition, Springer, 2019
[3] Xuedong Huang, Alex Acero, Hsiao-Wuen Hon, Spoken Language Processing: A guide to theory, algorithm and system development, Prentice Hall Inc., 2001. [Online] Available: https://tinyurl.com/Xuedong-Huang-2001
[4] Nancy Helm-Estabrooks, Martin L. Albert, & Marjorie Nicholas, Manual of Aphasia and Aphasia Therapy, Third Edition, Pro-Ed, 2013

25BM747 BRAIN COMPUTER INTERFACING 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

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

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the basic concepts of EEG and BCI
CO2: To apply signal processing techniques in BCI
CO3: To analyze human cognition using BCI parameters
CO4: To evaluate machine learning methods in BCI applications

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	-	-	2	2	-
CO 2	2	-	2	2	2
CO 3	2	2	3	2	2
CO 4	2	2	3	2	3

Skills Acquired: The application of BCI in classification and automation of human cognition

Course Contents:
Unit 1:

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

Unit 2:

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

Unit 3:

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/References:

[1] Bernhard Graimann, Brendan Allison, GertPfurtscheller, Brain-Computer Interfaces: Revolutionizing Human-Computer Interaction, Springer, 2010

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

25BM748 MULTIVARIATE SIGNAL PROCESSING 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To provide basic concepts of multivariate signals
- To impart knowledge on statistical analysis of multivariate time series data
- To introduce time and spectral domain approaches for analyzing multivariate biomedical data

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the basics of multivariate signal processing
CO2: To apply statistical analysis for multivariate time series data
CO3: To analyze multi-domain features of Biomedical signals
CO4: To evaluate performance of multivariate signal processing algorithms

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	-	-	2	2	2
CO 2	-	-	2	2	2
CO 3	2	2	3	2	3
CO 4	2	2	3	3	3

Skills Acquired: The application of multivariate signal processing aids in understanding of wide range of biomedical signal analysis

Course Contents:

Unit 1:

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

Unit 2:

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)

Unit 3:

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 / References:

[1] Johnson, Applied Multivariate Statistical Analysis, PHI publisher, 2012. [Online] Available: https://tinyurl.com/Johnson-2012
[2] Katarzyn Blinowska, Jaroslaw Zygierewicz, Practical Biomedical Signal Analysis Using MATLAB -Multiple channels (multivariate) signal, CRC press, 2021. [Online] Available: https://tinyurl.com/Katarzyn-Blinowska-2021
[3] Jocelyn Chanussot, Jocelyn Chanussot, Kacem Chehdi, Multivariate Image processing, Wiley Publication, 2009
[4] William W. S. Wei, Multivariate Time Series Analysis and Applications, Wiley, 2019. [Online] Available: https://tinyurl.com/William-W-S-Wei-2019

25BM751 Embedded Computing for Biomedical Applications 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To provide an insight on Cortex-M4 level microcontroller and its applications in biomedical engineering
- To impart knowledge about microcontroller architecture, peripheral interfacing, low power operation, and real-world biomedical applications
- To give comprehensive understanding of embedded systems for biomedical application

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the architecture and features of the Cortex-M4 level microcontroller
CO2: To interface with Cortex-M4 based microcontroller peripherals using embedded C
CO3: To implement low power modes and interface external peripherals
CO4: To design and implement embedded systems for biomedical applications

Skills Acquired: Implementation of battery based medical devices using Microcontrollers

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	-	-	3	2	2
CO 2	-	-	3	2	2
CO 3	2	2	3	2	2
CO 4	2	2	3	2	3

Course Contents:

Unit 1:

Cortex M4 Microprocessor - Introduction to Embedded Systems - Introduction to ARM - Advanced RISC Features - Core Data path - Register Organization - System Architecture - Memory Organization - Low Power Modes - Power Control Registers - Backup Registers - Programming Cortex M4 Microcontroller - Bare-metal programming approaches

Unit 2:
Cortex M4 Microcontroller based Peripherals - Introduction to Embedded C Programming - General Purpose Input Output - UART - ADC - DAC - Timers - Interrupts and Exceptions - PWM - SPI – RTOS

Unit 3:
External Peripheral Interfacing - LCD - Keypad - Sensor Interfacing - DC coreless micromotors for bionic hands control operations - Design case studies: Insulin delivery based on continuous glucose monitoring using MSP430 - Real-time heart rate monitoring using STM32 - Vital signs monitor while maintaining battery life using ARM Cortex-M series microcontrollers

Textbooks / References:

[1] Shuwen Wu and Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C, E-Man Press LLC, 2021
[2] Muhammad Ali Mazidi, Rolin D. McKinlay, and Danny Causey, STM32 Arm Programming for Embedded Systems, MicroDigitalEd, 2019
[3] Jonathan W. Valvano, Embedded Systems: Introduction to Arm Cortex-M Microcontrollers, 5th Edition, CreateSpace Independent Publishing, 2019
[4] STM32F446xx advanced Arm®-based 32-bit MCUs, Reference Manual, 2020
[5] Carl W. Nelson and Richard J. Yost, Biomedical Device Development: A Systems Approach, Academic Press, 2010, 1st edition
[6] Donald Norris, Programming with STM32: Getting Started with the Nucleo Board and C/C++, McGraw-Hill Education, 2018

25BM752 Medical Robotics and Automation in Healthcare 3-0-0-3
(Pre-requisite: Nil)

Course Objectives:

- To introduce the concepts of robotic systems
- To provide an insight on modelling of robotic manipulators
- To provide an insight on design aspects of medical robots and automation

Course Outcomes:
At the end of the course, the student should be able

CO1: understand the basic architecture of a robotic system
CO2: analyze the kinematic modelling of robotic platform
CO3: understand the design concepts of medical robots
CO4: analyze applications of robotics and automation in the field of healthcare
Skills Acquired: Understanding design constraints and modelling of medical robots for automation in healthcare

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	3	-	2	-	-
CO 2	3	-	2	-	-
CO 3	3	2	2	-	-
CO 4	3	3	2	-	2

Course Contents:

Unit 1:
Introduction to robots - robots as mechanical devices - classification of robotic manipulators - robotic systems - accuracy and repeatability - wrists and end-effectors - mathematical modeling 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

Unit 2:
Medical robots - Movement replication - Medical Robotics System Paradigms - Navigation and Image Overlay Systems - Sensorized Instruments and Haptic Feedback - Rehabilitation Robotics - Smart Prostheses and Orthoses - Augmentation for Diagnosis and Monitoring

Unit 3:
Application of medical robots - Superhuman Dexterity and Human–Robot Cooperation - Image-Guided Robotic Surgery - Therapeutic Training and Personal Assistance - Emerging Challenges and Future Trends in Medical Robotics

Textbooks / References:

[1] Achim Schweikard and Floris Ernst, Medical Robotics, Springer, 2015
[2] Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Robot Modeling and Control, John Wiley & Sons, 2020 [Online]. Available: https://tinyurl.com/Mark-W-Spong-2020
[3] Yao Guo, Giulio Dagnino and Guang-Zhong Yang, Medical Robotics History, Challenges, and Future Directions, Springer, 2024
[4] Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics, Springer, 2016

25BM753 Advanced Electronics for Healthcare 3-0-0-3

(Pre-requisite: Principles of Biomedical Electronics)

Course Objectives:

- To design circuits to specifications
- To be able to combine building blocks for bigger sub-systems
- To understand the challenges of designing biomedical electronics

Course Outcomes:
At the end of the course, the student should be able

CO1: To design opamp-based circuits
CO2: To integrate different circuits to build sub-systems
CO3: To design simple circuits for biomedical applications

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	-	3	3	2
CO 2	2	-	3	3	2
CO 3	3	-	3	3	2

Course Contents:

Unit 1:

Inverting and non-inverting amplifiers - summing amplifiers - current-to-voltage amplifiers - voltage-to-current amplifiers - difference amplifiers - instrumentation amplifiers - bridge amplifiers

Unit 2:

Comparators - Schmitt trigger - precision rectifiers - multivibrators - oscillators - triangular wave generators - voltage-to-frequency converters - sample-and-hold amplifiers - log-antilog amplifiers - multipliers

Unit 3:

Voltage references - regulators - analog-to-digital converters - active filters - transfer function - order - standard responses - topology - types of filters - ECG & PPG - signal acquisition and conditioning

Textbooks / References:

[1] K. R. Sandra, A. S. Anusha, N. M. Mohan, and B. George "Simulation study of a contactless, capacitive ECG system," in Proc. IEEE Region 10 Annu. Int. Conf. (TENCON), 2020

[2] A. N. Kumar, S. Sridhar, and S. Jayanthi, "Design and implementation of capacitive ECG measurement system," IETE J. Res., vol. 65, no. 1, pp. 1–8, Feb. 2019, doi: 10.1080/03772063.2018.1562386

[3] Franco S., Design with Operational Amplifiers and Analog Integrated Circuits, 4th ed., McGraw-Hill, New York, NY: McGraw-Hill Education, 2015

[4] Sedra A and Smith K C, Microelectronic Circuits - Theory and Applications, 7th ed. (South Asia Edn). New Delhi, India: Oxford University Press, 2017

[5] Webster J G, Design of pulse oximeters. Philadelphia: Institute of Physics Pub., 1997

25BM754 **IoT IN HEALTHCARE** **3-0-0-3**

(Pre-requisite: Nil)

Course Objectives:

- To introduce the concepts of Internet of Things
- To provide an insight on transfer and analysis of medical sensor data
- To analyze applications of IoT in the field of healthcare

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the basic architecture of an IoT based system
CO2: To understand the routing protocols used for biomedical sensor data transfer
CO3: To understand the techniques for medical data analysis
CO4: To analyze applications of IoT in the field of healthcare

Skills Acquired: Understanding of Acquisition, transfer and analysis of sensor data related to healthcare.

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	3	-	2	-	-
CO 2	3	2	2	-	-
CO 3	3	2	2	-	-
CO 4	3	3	2	-	2

Course Contents:

Unit 1:

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

Unit 2:

Concepts of IoT in Healthcare - Challenges - Big data ecosystem for healthcare - Hadoob Architecture - HDFS in healthcare - Big Data types - Foundations of Big Data Analytics - Wireless Body Area Networks (WBAN) Routing Protocols

Unit 3:

Case Studies - Wearable sensor network for remote health monitoring - 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 - Application of Blockchain in Smart Healthcare - Security and Privacy challenge in Smart Healthcare and Telemedicine systems

Textbooks / References:

[1] Anand J. Kulkarni, Patrick Siarry, Pramod Kumar Singh, Ajith Abraham, Mengjie Zhang, Albert Zomaya, Fazle Baki, Big Data Analytics in Healthcare, Springer 2020.

[2] Arsheep Bahga and Vijay Madisetti, Internet of Things: A Hands-on Approach, Universities Press, 2015.

[3] Hitesh Kumar Sharma, Anuj Kumar, Sangeeta Pant and Mangey Ram, Artificial Intelligence, Blockchain and IoT for Smart Healthcare, River Publishers, 2022. [Online] Available: https://tinyurl.com/Hitesh-2022

[4] Rajkumar Buyya and Amir Vahid Dastjerdi, Internet of Things Principles and Paradigms, Elsevier Inc., 2016.

[5] Valentina Emilia Balas and Souvik Pal, Healthcare Paradigms in the Internet of Things Ecosystem, Academic Press, 2021

25BM755 BIOMEDICAL EQUIPMENT AND SAFETY 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- Introduction of different class of medical equipment, product life cycle and its risks
- Familiarization of concepts and techniques that could be selectively applied to reduce an intolerable rate of unacceptable errors, mistakes, goofs, or shortcomings in expected medical device performance.

- Enable to achieve efficacious treatment by avoiding patient injury and controlling health care costs.
- Familiarization of concepts in safe handling of biomedical equipment and patient safety.

Course Outcomes:
At the end of the course, the student should be able

CO1: To understand the life cycle of a medical equipment and its risk management
CO2: To understand the underlying concepts to reduce the probable error in associating with medical devices
CO3: To apply the ideas associated with safety procedures and risk management
CO4: To analyze the concept of appropriate safety conditions for medical equipment

Skills Acquired: To understand the safe practices and safety measures to use medical equipment

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	3	2	2	2	1
CO 2	3	2	-	1	1
CO 3	3	2	2	-	1
CO 4	3	2	2	1	1

Course Contents:
Unit 1:
Medical equipment and its life cycle - medical device risk and its management - safety in health care - reliability - reliability study - an overview - qualitative and quantitative analysis - types of reliability - concept of failure - causes of failure - types of failures in medical devices - an overview of design and analysis of experiments - basic concepts on Minitab for design and analysis of experiments

Unit 2:
Safety testing - failure assessment and documentation - visual inspection - external and internal visual inspection - measurement - safety parameters - safety and risk management - manufacturer's and physician's responsibilities - design aspects - hardware - software - standards - testing - quality management - regulatory body and system for medical devices

Unit 3:
Safe medical devices - operation - medical application safety - environmental safety - interference with the environment - ecological safety - electrical safety - limitation of voltages - macroshock and microshock - earth and protection - leakage currents - magnetic fields and compatibility

Textbooks / References:

[1] K. Willson, K. Ison, and S. Tabakov, Medical equipment management, Boca Raton: Taylor et Francis, 2014
[2] Signoret JP, Leroy A. Reliability Assessment of Safety and Production Systems: Analysis, Modelling, Calculations and Case Studies. Springer Nature, 2021
[3] Dean AM, Morris M, Stufken J, Bingham D, editors. Handbook of design and analysis of experiments. Boca Raton, FL, USA, CRC Press; 2015

[4] Kenett RS, Zacks S. Modern industrial statistics: With applications in R, MINITAB, and JMP. John Wiley & Sons; 2021
[5] Jacobson and Alan Murray, Medical Devices Use and Safety, Elsevier Limited, 2007
[6] Richard Fries, Reliable Design of Medical Devices – Third Edition, CRC Press, Taylor & Francis Group, 2012
[7] Norbert Leitgeb, Safety of Electro Medical Devices Law – Risks – Opportunities, Springer Verlag/Wein, 2010

25BM756 **BioMEMS** **3-0-0-3**

(Pre-requisite: Nil)

Course Objectives:

- To impart knowledge on microfabrication techniques for BioMEMS applications
- To develop skills in designing, simulating, and analyzing BioMEMS devices
- To introduce an interdisciplinary understanding of biology, engineering, and materials science in BioMEMS development

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the world of microelectromechanical devices and systems
CO2: To apply microfabrication techniques in biomedical contexts
CO3: To design and fabricate BioMEMS devices
CO4: To develop BioMEMS for diagnostic and therapeutic applications

Skills Acquired: Application of microfabrication and design for biomedical purposes

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	2	2	2	2
CO 2	2	2	2	3	2
CO 3	-	-	2	3	2
CO 4	-	-	2	3	3

Course Contents:

Unit 1:

Introduction to BioMEMS - historical perspective and evolution - applications in healthcare and biomedical research - materials for BioMEMS applications - silicon - glass - polymers - bio-compatible materials - biocompatibility issues - surface modification techniques - microfabrication techniques - etching - deposition - photolithography - bonding - advanced lithography techniques

Unit 2:

Design principles of BioMEMS - design considerations and constraints - scaling laws and miniaturization challenges - modelling and simulation of BioMEMS devices - CAD tools for MEMS design - characterisation techniques - electrical - mechanical - biological characterization

Unit 3:
Diagnostic application - lab-on-a-chip systems - wearable systems for health monitoring - biosensors for disease detection - therapeutic application - drug delivery systems - implantable devices - regulatory and commercialisation aspects - intellectual property and patenting

Textbooks / References:

[1] Marc J. Madou, Fundamentals of Microfabrication – The Science of Miniaturization, CRC Press, 2018
[2] Albert Folch, Introduction to BioMEMS. CRC Press, 2013
[3] Tai-Ran Hsu, MEMS and Microsystems – Design, Manufacture, and Nanoscale Engineering, John Wiley & Sons, Inc., Hoboken, New Hersey, 2008
[4] Samira Hosseini, Michelle Alejandra Espinosa-Hernandez, Ricardo Garcia- Ramirez, Ana Sofia Cerda-Kipper, Sofia Reveles-Huizar, Luis Acosta-Soto, BioMEMS – Biosensing Applications, Springer, 2021

25BM757 BIOMEDICAL LASER INSTRUMENTATION 3-0-0-3

(Pre-requisite: Nil)

Course Objectives:

- To introduce the fundamentals of laser and fiber
- To enable understanding of biomedical application of laser technology
- To provide knowledge of Laser instrumentation
- To impart knowledge of laser-based diagnosis techniques

Course Outcomes:

At the end of the course, the student should be able

CO1: To understand the laser and medium technology
CO2: To apply the function of laser in bio-applications
CO3: To analyze biological elements using the knowledge of laser instrumentation
CO4: To evaluate the performance of laser technology in medical diagnosis

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	-	-	-	2
CO 2	2	-	2	-	2
CO 3	2	2	2	-	3
CO 4	2	2	3	-	3

Skills Acquired: Technology ability to apply the knowledge of laser in medical field

Course Contents:
Unit 1:
Fundamentals of wave optics - Devices for fiber-Optic sensing - Principles of fiber-Optic sensing - Intensity-based sensors - Fiberbragg ratings - Distributed sensors - Fabry-Perot interferometers - Standards for medical sensors - Lasers in medicine - Laser-tissue interaction - Response of tissue

to laser light - Types of lasers used in medicine - Solid-state lasers - Gas lasers - Liquid and solid - State tunable organic dye lasers - Semiconductor lasers

Unit 2:
Applications of laser - Laser spectroscopy in medical diagnostics - Optical biopsy for cancer detection - Laser therapy in ophthalmology - Lasers in dermatology - Lasers in cardiology - Lasers in urology -Lasers in dentistry - Orthopedic surgery - Introduction to short pulse laser imaging - short pulse laser based thermal therapy - Use of nanoparticles

Unit 3:
Laser instrumentation - Doppler flowmetry - Laser flow cytometry - single cell separation - micro irradiation - Laser fluorescent micro irradiation - Laser eye instrumentation - Laser tissue transillumination and diaphanography - Speckle interferometry - Reflectance in tumour diagnostics - Holography

Textbooks / References:

[1] Kunal Mitra, Stephanie Miller, Short Pulse Laser Systems for Biomedical Applications, Springer Briefs in Applied Sciences and Technology, 2017
[2] Leon Goldman, The Biomedical Laser Technology and Clinical Applications, Springer Verlag, 2011
[3] Daniele Tosi, Guido Perron, Fiber-Optic Sensors for Biomedical Applications, 2018
[4] Helena Jelínková, Lasers for medical applications - Diagnostics, therapy and surgery, Woodhead Publishing Limited, 2013

25BM758 Virtual Instrumentation for Biomedical Engineering 3-0-0-3

Course Objectives:

- To provide knowledge of virtual instrumentation
- To introduce the concepts of real time data acquisition
- To enable understanding of virtual signal processing tools
- To introduce biomedical applications of virtual instrumentation

Course Outcomes:
At the end of the course, the student should be able

CO1: To understand programming concepts for virtual instrumentation
CO2: To apply data acquisition techniques for biomedical applications
CO3: To analyze bio-signal processing algorithms using virtual instrumentation
CO4: To develop virtual codes for biomedical applications

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO 1	2	-	-	2	-
CO 2	2	-	2	2	2
CO 3	2	-	2	2	2
CO 4	2	-	2	-	3

Skills Acquired: Technology ability in processing and analysis of medical signals

Course Contents:

Unit 1:
Introduction to virtual instrumentation - overview of LabVIEW 2023 - Keysight VEE Pro 9.33 - LabWindows/CVI 2023 - 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 system

Unit 2:
Data handling techniques - signal acquisition and sampling theorem - effect of under sampling - 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 - comb filter

Unit 3:
Processing of ECG, EMG and EOG signals - Adaptive signal processing - Data compression techniques - AZTEC - TP - CORTES and KL transform

Note: A demo of LabVIEW Community Edition to be provided to illustrate the concepts

Textbooks / References:

[1] Robert H. Bishop, Learning with LabVIEW, Pearson,2nd edition,2020
[2] Sanjay Gupta and Joseph John, Virtual Instrumentation Using Labview, Tata McGraw Hill Education Private Limited, 2010
[3] Behzad Ehsani, Data Acquisition using LabVIEW, Packt Publishing, 2016
[4] Kunal Mitra, Stephanie Miller, Short Pulse Laser Systems for Biomedical Applications, Springer Briefs in Applied Sciences and Technology, 2017
[5] Leon Goldman, The Biomedical Laser Technology and Clinical Applications, Springer Verlag, 2011

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25AVP501 MASTERY OVER MIND 1-0-2-2

PG SYLLABUS

COURSE OBECTIVES

Master Over the 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). This program as part of our efforts for sustainable stress reduction introduces immediate and long-term benefits and equips every attendee to manage stressful emotions and anxiety facilitating inner peace and harmony. With a meditation technique offered by Amrita Chancellor and world-renowned humanitarian and spiritual leader, Sri Mata Amritanandamayi Devi (Amma), this course has been planned to be offered to all students of all campuses of AMRITA, starting off with all first years, wherein one hour per week is completely dedicated for guided practical meditation session and one hour on the theory aspects of MAOM. The theory section comprises lecture hours within a structured syllabus and will include invited guest lecture series from eminent personalities from diverse fields of excellence. This course will enhance the

understanding of experiential learning based on 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 OUTCOME

After successful completion of the course, students will be able to:	
S.No.	**Course Outcomes**
1.	Understand the scientific benefits of meditation. (CO1)
2.	Explain the science behind meditation and its effects on physical and mental well-being (CO2).
3.	Understand the meditation techniques to cultivate emotional intelligence and improve relationships (CO3).
4.	Learn and practice MAOM meditation in daily life (CO4).
5.	To apply the effect of meditation to compassion-driven action (CO5)

Syllabus:

Scientific benefits of Meditation (CO1)

Scientific benefits of meditation, exploring its effects on physical and mental wellbeing.

Learn about the different types of meditation practices, the essential elements of meditation, and the empirical evidence supporting its benefits.

Video resource-Swami Atmanandamrita Puri

Science Behind Meditation (CO2)

A: A preliminary understanding of the Science of meditation. What can modern science tell us about this

tradition-based method?

B: How meditation helps humanity according to what we know from scientific research

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.

Role of Meditation in Emotional intelligence (CO3)

Learn how meditation practices can enhance self-awareness, self-regulation, motivation, empathy, and social skills, leading to improved relationships and decision-making. Improve communication, emotional intelligence, and interpersonal skills. Logical and analytical reasoning

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.

Meditation and Compassion-driven Action (CO5)

Understand how meditation can help to motivate compassion-driven action.

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

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

Textbooks / References:

1. Mata Amritanandamayi Devi, "Cultivating Strength and vitality," published by Mata Amritanandamayi Math, Dec 2019

2. Swami Amritaswarupananda Puri," The Color of Rainbow "published by MAM, Amritapuri. 3. Craig Groeschel, "Winning the War in Your Mind: Change Your Thinking, Change Your Life" Zondervan Publishers, February 2019

4. R Nagarathna et al, "New Perspectives in Stress Management "Swami Vivekananda Yoga Prakashana publications, Jan 1986

5. Swami Amritaswarupananda Puri "Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation", August 2019

6. Swami Amritaswarupananda Puri "From Amma's Heart - Amma's answer to questions raised during world tours" March 2018

7. Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.

8. Mata Amritanandamayi Devi "Compassion: The only way to Peace:Paris Speech", MA Center, April 2016.

9. Mata Amritanandamayi Devi "Understanding and collaboration between Religions", MA Center, April 2016.

10. Mata Amritanandamayi Devi "Awakening of Universal Motherhood: Geneva Speech" M A center, April 2016.

GLIMPSES OF INDIAN CULTURE
P/F
22ADM501: GLIMPSES OF INDIAN CULTURE
A. Prerequisite: nil
B. Nature of Course: Theory
C. Course Objectives:

- The course "Glimpses of Indian Culture" aims to provide students with a comprehensive understanding of various aspects of Indian culture, with a focus on its spiritual, philosophical, and religious dimensions.
- Through an exploration of the chapters from the provided book, students will gain insights into the foundational principles, practices, and symbols that shape the diverse cultural landscape of India
- Aligned with the Indian Knowledge Systems (IKS) framework outlined in the National Education Policy, this course serves as an introduction to the vast reservoir of wisdom and knowledge rooted in Indian heritage.
- By engaging with the chapters in the book, students will develop a holistic appreciation for the rich tapestry of Indian culture, spanning from its philosophical underpinnings to its artistic expressions, rituals, and societal values.
- This course aims to cultivate cultural sensitivity, critical thinking, and a deeper understanding of the diverse spiritual and cultural traditions that have shaped India's identity over millennia.

D. Course Outcomes: After successful completion of the course, Students will be able to:

CO	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	**Recall key concepts and terms associated with Sanatana Dharma, scriptures, and core cultural elements of India.** Statement: Demonstrate the ability to remember essential terms, concepts, and principles discussed in the chapters on Sanatana Dharma, scriptures, and cultural aspects.	Remembering
CO02	**Explain the concepts of Īśvara, Guru Tattva, Avatara Tattva, and the Theory of Karma as foundational elements of Indian cultural philosophy.** Statement: Understand the profound meanings of Īśvara, Guru, Avatara, and Karma, elucidating their importance in shaping Indian cultural thought.	Understanding
CO03	**Apply the knowledge of Purusharthas, Sanyasa, and Yajna to analyze real-life ethical and spiritual scenarios.** Statement: Utilize insights from Purusharthas, Sanyasa, and Yajna to navigate ethical dilemmas and make informed decisions**.**	Applying
CO04	**Analyze the symbolism in cultural practices, Nataraja iconography, and temple architecture.** Statement: Deconstruct the layers of symbolism in various cultural aspects, including Nataraja representation and temple architecture, unraveling their deep meanings.	Analyzing
CO05	**Evaluate the significance of temples as cradles of culture and explore alternative systems in India's cultural landscape.** Statement: Assess the role of temples in preserving cultural heritage and critically examine the diversity of cultural and spiritual systems in India.	Evaluating
CO06	**Develop projects or presentations that highlight the essence of Sanatana Dharma, sadhana, and the cultural significance of symbols.** Statement: Create expressive projects that capture the essence of Sanatana Dharma, convey the practices of sadhana, and portray the cultural meanings of symbols.	Creating

POs Programme Outcomes	COs
PO1: Engineering Knowledge **PO2: Problem Analysis** **PO3: Design/Development of Solutions** **PO4: Conduct Investigations of complex problems** **PO5: Modern tools usage** **PO6: Engineer and Society** **PO7: Environment and Sustainability** **PO8: Ethics** **PO9: Individual & Teamwork** **PO10: Communication** **PO11: Project management & Finance** **PO12: Lifelong learning** **B.Tech. EEE Programme Specific Outcome (PSO)** **PSO1:** Awareness of Future Technology: Develop solutions for future systems using smart technologies. **PSO2:** Research and Innovation: Identify engineering challenges, approach using cutting edge research tools and execute innovative solutions.	• CO 1: Recall key concepts and terms associated with Sanatana Dharma, scriptures, and core cultural elements of India. • CO 2: Explain the concepts of Īśvara, Guru Tattva, Avatara Tattva, and the Theory of Karma as foundational elements of Indian cultural philosophy • CO 3: Apply the knowledge of Purusharthas, Sanyasa, and Yajna to analyze real-life ethical and spiritual scenarios. • CO 4: Analyze the symbolism in cultural practices, Nataraja iconography, and temple architecture. • CO 5: Evaluate the significance of temples as cradles of culture and explore alternative systems in India's cultural landscape. • CO 6: Develop projects or presentations that highlight the essence of Sanatana Dharma, sadhana, and the cultural significance of symbols.

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO01	-	-	-	-	-	-	-	2	-	-	-	3	-	-
CO02	-	-	-	-	-	1	-	2	-	-	-	3	-	-
CO03	-	-	-		-	3	3	3	2	-	-	2	-	-
CO04	-	-	-	-	-	3	-	-	-	-	-	3	-	-
CO05	-	-	-	-	-	2	3	-	-	-	-	2	-	-
CO06	-	-	-	-	-	2	2	2	2	-	-	3	-	-
Total														
Average														

F. SYLLABUS GLIMPSES OF INDIAN CULTURE [P/F]

Course Syllabus

Chapter 1 - What is Sanatana Dharma
Chapter 2 - The Heritage ofScriptures
Chapter 3 - The idea of Īśvara
Chapter 4 - Guru Tattva and Avatara Tattva
Chapter 5 - Theory of Karma
Chapter 6 - Purusharthas
Chapter 7 - Sanyasa
Chapter 8 - Yajna
Chapter 9 - Symbolism
Chapter 10 - Understanding Nataraja
Chapter 11 - Temples: The Cradle of Culture
Chapter 12 - Other Heterodox Systems in India

Chapter 13 - Sadhana

GLIMPSES OF INDIAN CULTURE

Reference Books:

The Eternal Truth by Mata Amritanandamayi Devi
Temples: Centers for Spiritual Practice by Mata Amritanandamayi Devi
All About Hinduism by Swami Sivananda
Art of God Symbolism by Swami Chinmayananda
Temples in India by Swami Sivananda

G. Evaluation Pattern: 60:40

Component	Weightage	Remarks
Internal	60	-
External	40	-
TOTAL	100	

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

Prerequisite:

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

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 glossophobia 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
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- 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

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Continuous Assessment (CA)* – Aptitude	10	25
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*CA - Can be **presentations, speaking activities and tests.**