M.TECH – BIOMEDICAL ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Biomedical engineering is an exciting and emerging interdisciplinary field that combines engineering and life sciences. Advanced technological developments in health care is mainly due to the integrated contribution of engineers, mathematicians, physicians, computer scientists and other professionals. The major applications include development of biocompatible prostheses, diagnostics and therapeutic medical devices ranging from clinical equipment to micro-implants.

Due to the advanced developments in electronics and computing domains, medical sciences and its allied areas are being explored to a new paradigm of technological breakthrough. Computational aspects associated with medical equipment have resulted in more significant information to predict and diagnose the progress of diseases in a well-defined manner. Biomedical engineering is playing an important role in interfacing the computational infrastructure with medical domain into supports physicians in decision making.

It is envisaged that at the end of the program, the student would be in a position to understand the fundamental biological and engineering processes involved as well as to develop creative ideas for the early detection and identification of various biological signals. It is also expected that the student of the program would be able to come up with algorithms for the successful and objective interpretation of biological data. The course deals with biomedical electronics, the quantitative and analytical skills required to interpret the data acquired and the processing of medical data including imaging and enhancement techniques. It is intended to equip the engineer with the skills, knowledge and jargon required to interact knowledgeably with medical practitioners so that both professions may benefit.

It is expected that at the end of the program, the student would be equipped with the knowledge and the skills required to embark on a career in the industry or to undertake independent research.

PROGRAMME OUTCOMES

- Creation of expertise and work force in biomedical electronics domain to deal with design, development, analysis, testing and evaluation of the critical aspects of bio-systems and its core concepts to cater to the requirements of the industry and academia.
- Facilitate research opportunities in biomedical electronics with computational emphasis on systems aimed at developing state-of-the-art technologies with value based social responsibility.
- Developing professional competency in healthcare sector and leadership qualities with a harmonious blend of ethics leading to an integrated personality development.
## CURRICULUM

### First Semester

<table>
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**Credits** 22

* Online/video lecture based
**Non-credit course

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**Credits** 20

# Courses can also be taken from other departments
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**Credits** **10**

**TOTAL CREDITS (22+20+12+10)** **64**

L- Lecture; T-Tutorial; P-Practical
FC- Foundation Core; SC- Subject Core; E-Electives; P- Dissertation; P/F- Pass/Fail

### List of Courses

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#### Subject Core

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### Computational Biomedical Systems

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### Artificial Intelligence

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### Healthcare Systems

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### Project Work

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18MA602 MATHEMATICAL METHODS FOR ENGINEERING 3-0-2-4
(Common for VLSI Design, Communication Engineering & Signal Processing and Biomedical Engineering)

Objectives:

• To introduce the mathematical methods applied for VLSI, signal processing and communication systems.
• To provide a unified applied treatment of fundamental mathematics, seasoned with demonstrations using standard tools.
• To develop contemporary techniques for applications in the diverse areas to improve the analytical skills.
• To comprehend the computational concepts learned in mathematical methods through numerical simulations and programming.

Contents:


Outcomes:

• Understanding the mathematical methods and applying it to practical problems by investigating from different perspectives.
• Enabling an analytical approach towards developing mathematical models in various domains.
• To develop competency in implementation of algorithms and numerical analysis.

TEXT BOOKS / REFERENCES:

18CE601  SIGNAL PROCESSING  3-1-0-4
(Common for Communication Engineering & Signal Processing and Biomedical Engineering)

Objectives:
• To understand the basic concepts of signal processing, systems and time-frequency transformation techniques

Contents:


TEXT BOOKS / REFERENCES:

Outcomes:
• Designing of algorithms for signal analysis for various applications
• Extending the concepts of signal processing in modern biomedical and communication systems
• Generating solutions for complex systems related to signals

18BM611  ANATOMY AND PHYSIOLOGY  3-0-0-3

The course will be conducted in online mode (video lectures) from reputed institutions, by adopting the syllabus accordingly.

18BM612  BIOMEDICAL INSTRUMENTATION  3-1-0-4

Objectives:
• To understand the challenges in biomedical signal measurement
To understand various signal conditioning mechanisms and circuits in biomedical devices

Contents:


TEXTBOOKS / REFERENCES:
5. Selected Papers from IEEE Transactions

Outcomes:
- Knowledge of various sensors used for measuring different physiological parameters
- Ability to understand signal conditioning mechanisms for biomedical devices

18BM613 BIOINFORMATICS 3-0-0-3

Objectives:
- To familiarize the methods in bioinformatics
- To acquire the data analytics skills required for excavating the 'new generation databases'.
- To address the challenges in health care informatics

Contents:


TEXTBOOKS / REFERENCES:

Outcomes:
- Knowledge in modern molecular biology and genomics.
- To apply theoretical approaches to model and analyse complex biological systems.
- To familiarize the modern biomedical informatics tools and algorithms.

18BM614 PRINCIPLES OF BIOSENSING 2-0-0-2

Objectives:
- To provide the understanding of operation of Biosensors with applications

Contents:


TEXT BOOKS / REFERENCES:

Outcomes:
After studying this course the student will be able to
• Define and classify biosensors
• Explain the various transducers and Bioreceptors used in biosensors with examples.
• Apply biosensors in medical diagnostics, food analysis, drug development and environmental monitoring

18BM615 MICROSTRUCTURAL SENSORS 1-0-0-1

Objectives:
• To provide an insight into design and fabrication of biosensors

Contents:

TEXT BOOKS / REFERENCES:

Outcomes:
• Develop capacitance based and light based sensors to sense the pH, antioxidant, mercury vapor and action of toxic agents
• Design sensor to detect DNA, viruses and glucose developed through screen printing
• Fabricate micro fluidics devices that works with luminance, microwave and magnetic based sensors

18BM631 BIOMEDICAL ENGINEERING LAB - I 0-0-2-1

Objectives:
• To provide hands-on experience and usage of tools for biomedical systems
• To understand the detailed design aspects of biomedical hardware system
• To become expertise in using various tools and interfacing hardware components

Contents:
Signal Processing Algorithms
Hardware Aspects Of Biomedical Instrumentation
Data Analysis Using Bioinformatics Tools
Characterization Of Biomaterials
Application Of Biosensors In Diagnosis
TEXT BOOK/REFERENCE:
Lab Manuals and online manuals for tools usage

Outcomes:
- Ability to implement the algorithms for complex problems
- Ability to analyse hardware systems and provide solutions

18BM616 BIOMEDICAL IMAGE PROCESSING 3-0-0-3

Objectives:
- To introduce various imaging modalities for biomedical applications and properties of resulting images
- To introduce basic image processing algorithms
- To learn different feature extraction methods and classification algorithms

Contents:


Pattern Classification and Diagnostics – Feature Extraction – Feature Selection – Supervised and Unsupervised Classification – Bayes Classifier – Neural Network and Fuzzy Classification – Support Vector Machines – Selected Applications in Medical Images.

TEXTBOOKS / REFERENCES:

Outcomes:
- Apply appropriate image processing algorithms for different kinds of biomedical images
- Perform operations including enhancement and segmentation, on biomedical images
- Extract suitable features from biomedical images and employ them for pattern recognition

18BM617 BIOMATERIALS 3-0-0-3

Objectives:
- Introduce basic structure and properties of different classes of materials.
• Introduce the basics of molecular and cellular host responses and biocompatibility testing.

Contents:


TEXT BOOKS / REFERENCES:

Outcomes:
• Apply the understanding of materials and biocompatibility in designing materials and devices for some biomedical applications.
• Design materials for biomedical applications including cardiovascular, ophthalmologic, orthopedic, dental and other applications.

18BM618 MEDICAL ETHICS 1-0-0-1

Objectives:
• To understand the various aspects of ethical medical research
• To understand the need for proper control and security of patient/volunteer data
• To be able to knowledgeably participate in the establishment of protocols for the acquisition, processing, storage, analysis and dissemination of patient / volunteer data

Contents:

TEXTBOOKS / REFERENCES:
Outcomes:

- Ability to understand the implications of using medical data, both in the international and national context.
- Understand the importance of safeguarding medical data and patient/volunteer confidentiality.

18RM600 RESEARCH METHODOLOGY 2-0-0-2

Unit I:

Unit II:
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

Unit III:
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

Unit IV:
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

Unit V:
TEXT BOOKS/ REFERENCES:

18BM632 BIOMEDICAL ENGINEERING LAB - II 0-0-2-1

Objectives:
- To provide hands-on experience and usage of tools for biomedical systems
- To understand the detailed design aspects of various allied fields
- To become expertise in using various tools and interfacing hardware components

Contents:
Signal Processing Algorithms
Image Processing Algorithms
Hardware Aspects of Biomedical Instrumentation
Data Analysis using Bioinformatics Tools
Characterization of Biomaterials
Application of Biosensors in Diagnosis
Embedded Systems for Biomedical Applications

TEXT BOOK/REFERENCE:
Lab Manuals and online manuals for tools usage

Outcomes:
- Ability to apply computational aspects for complex problems
- Ability to analyse hardware systems and provide solutions

18BM620 INTERNSHIP 0-0-0-2

Objectives:
- To introduce the real time experience on biomedical equipment and measurement systems in a hospital/biomedical lab environment.
- To understand the technical interfacing with the human signal extraction and processing.

Contents:
Students may attend the internship in hospital or biomedical related research laboratories for any two weeks during third semester. Test, measurement, processing and interpretation of data from hospital resources. Compilation of overall involvement in the internship as a report and review.

**Outcomes:**
- Understanding the complex working principles of biomedical equipment
- Gaining the real time experience in the hospital environment.

18BM701  SPECIAL TOPICS IN BIOSENSOR PROCESSING  3-0-0-3

**Objectives:**
- To learn advanced transform techniques like wavelets and DCT
- To learn statistical parametric and non-parametric modeling of biosignals and power spectrum estimation techniques
- To learn various feature extraction techniques for evaluating the biosignals
- To learn classification techniques for applying in certain diagnosis

**Contents:**

**TEXTBOOKS / REFERENCES:**

**Outcomes:**
- Apply digital filtering and classical spectral analysis to evaluate the biosignals
- Apply modern spectral analysis, wavelet and time-frequency analysis on various biosignals
• To apply appropriate feature extraction techniques for evaluating the signals
• Apply a range of classification techniques

18BM702  SPECIAL TOPICS IN BIOMEDICAL IMAGE PROCESSING  3-0-0-3

Objectives:
• To introduce image restoration and advanced image segmentation techniques
• To understand in detail, the features useful for representing and describing regions of interest in biomedical images
• To learn image processing applications, including reconstruction and registration that deal with multiple images

Contents:

TEXTBOOKS / REFERENCES:

Outcomes:
• Ability to restore biomedical images from their noisy versions
• Application of advanced segmentation techniques to accurately segment regions of interest in biomedical images
• Knowledge in identifying and extracting appropriate features to represent different kinds of biomedical conditions
• Knowledge in reconstructing 3D images from 2D slices
• Ability to register intra-modality/inter-modality images for advanced processing
To lay the engineering foundations for the understanding of planar X-ray, X-ray CT, planar scintigraphy, SPECT and PET, ultrasound imaging and MRI

To introduce in detail the physics, instrumentation, image characteristics, clinical applications and recent developments of each medical imaging modalities

To provide the basic understanding of patient safety and quality in medical imaging

Contents:


Data Acquisition Strategies – Image Characteristics like SNR, Spatial Resolution and CNR – Clinical Applications – Recent Developments of Each Modality.

TEXTBOOKS / REFERENCES:


Outcomes:

- Ability to recognize the need for different imaging modalities and understand the terminology of biomedical imaging
- Ability to understand the basic physics and engineering of each modality
- Knowledge in clinical application of each modality and possibly suggest the most suitable modality for a given clinical case
- Knowledge in the recent developments taking place in each medical imaging modality

18BM704 BIOSTATISTICS 3-0-0-3

Objectives:

- Recognize different kinds of data in public health and clinical studies
- Understand representation and analysis of data distributions
- Understanding graphical and numerical descriptive analysis of data
- Understanding principles involved in statistical hypothesis testing
- Understand and apply concepts of linear regression for modeling correlations

Contents:


TEXTBOOKS / REFERENCES:

Outcomes:
- Ability to design and conduct experiments, and analyze, interpret and report the results
- Ability to plan and execute observational and experimental scientific studies

18BM711  NANOMATERIALS FOR BIOMEDICAL APPLICATIONS  3-0-0-3

Objectives:
- To understand the different methods for studying the properties of nanomaterials.
- To understand the various methods for characterizing nanomaterials.
- To understand the process of nanomaterial synthesis

Contents:


TEXTBOOKS / REFERENCES:

**Outcomes:**
- Understanding of the properties of nanoparticles and their characterisation
- Knowledge of the process of synthesizing nanomaterials
- Knowledge of possible biomedical applications of nanomaterials

18BM712 DRUG DESIGNING AND DELIVERY SYSTEMS 3-0-0-3

**Objectives:**
- To understand the basics of drug design
- To understand the simulation of drug molecules and other criteria
- To understand drug administration and delivery systems

**Contents:**


**TEXTBOOKS/REFERENCES:**

**Outcomes:**
- Knowledge of the fundamentals of drug design and simulation
- Apply different methods of drug study and characterisation
Objectives:
- To introduce the basic concepts of viscoelasticity, mechanical properties and behaviour of skeletal tissues
- To provide the basic knowledge of linear and angular kinematics and kinetics and instruct how to 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

Contents:
Segments of Human Body – Segmental Parameters – Centre of Mass aAnd Centre of Gravity – Biomechanical Analysis of Human Motion – Linear and Angular Kinematics –Linear and Angular Kinetics.

TEXTBOOKS / REFERENCES:
5. Masao Tanaka, Shigeo Wada, and Masanori Nakamura, Computational Biomechanics - Theoretical Background and Biological/Biomedical Problems, Springer, 2012

Outcomes:
- Understanding of the viscoelastic properties and behaviour of biological tissues
- Knowledge in the basic structure, function and mechanical properties of basic skeletal tissues
- Analysis of human body motions and application to gait analysis, sports biomechanics
- Analysis of the muscle and joint reaction forces at a skeletal joint for various static and dynamic human activities
Objectives:
- To study the effect of temperature and pressure on fluid properties and fluid flow
- To learn the types of fluids and fluid flow in different geometries
- To learn about the conservation of mass, momentum and energy in biological systems
- To learn about transport of mixture of fluids and nutrients in biological systems

Contents:


TEXTBOOKS / REFERENCES:

Outcomes:
- Derive the conservation of equations of mass, momentum and energy in single and multi-dimensions
- Apply the conservation equations to the biological systems
• Simplify the generalized conservation equations to the biological systems based on the physics of the system.
• Derive the equations for nutrient and oxygen transport
• Solve simplified conservation equations using suitable techniques

18BM731  LASER INSTRUMENTATION FOR BIOMEDICAL APPLICATIONS  1-0-0-1

Objectives:
• To understand the operation of lasers and their uses in Biomedical instrumentation

Contents:

TEXTBOOKS / REFERENCES:

Outcomes:
After studying this course the student will be able to
• Understand and operation and types of Lasers
• Illustrate the use of Lasers for tissue diagnostics, ophthalmology and Flow cytometry.

18BM732  VIRTUAL INSTRUMENTATION FOR MEDICAL SYSTEMS  1-0-0-1

Objectives:
• To learn the fundamentals of Virtual Instrumentation
• To learn to acquire, analyse and present biomedical data

Contents:

TEXTBOOKS / REFERENCES:
4. Relevant Data Sheets and User Manuals

Outcomes:
- Ability to acquire, analyse and present biomedical data.
- Development of simple biomedical data acquisition systems.

**18BM733 BIOMEMS 1-0-0-1**

Objectives:
To give a broad understanding of the field of BioMEMS and their applications.

Contents:

TEXT BOOKS / REFERENCES:
2. Ellis Meng, Biomedical Microsystems, CRC Press, 2010

Outcomes:
After studying this course the student will be able to
- Understand and explain the advantages and process of making micro sensors with examples
- Understand various terminology in BioMEMS like Microfluidics, Lab-on-chip, with application specific examples.

**18BM734 BIOMEDICAL EQUIPMENT AND SAFTEY 1-0-0-1**

Objectives:
- To understand the operation of various building blocks of biomedical circuits
- To understand the operation of different biomedical equipment

Contents:

TEXTBOOKS / REFERENCES:
Outcomes:
- Better understanding of bioelectric signals
- Ability to design, analyse and troubleshoot simple biomedical circuits
- Understanding of the operation of biomedical equipment

18BM735  DYNAMIC MATHEMATICAL MODELS  1-0-0-1

Objectives:
- To introduce mathematical modeling in the analysis of biological systems
- To introduce programming for the analysis of biological processes and data

Contents:

TEXTBOOKS / REFERENCES:

Outcomes:
- Apply mathematical concepts and principles to perform computations
- Communicate mathematical knowledge and understanding to biomedical applications

18BM736  REACTION NETWORKS  1-0-0-1

Objectives:
To introduce the application of mathematical modeling in the analysis of biological systems.

To integrate mathematics, statistics and computing with biological systems.

Contents:

TEXTBOOKS / REFERENCES:

Outcomes:
- Apply mathematical concepts and principles to perform computations
- Create, use and analyze graphical representations of mathematical relationships
- Communicate mathematical knowledge and understanding to biomedical applications
- Apply technology tools to solve problems

18BM737 GENE REGULATORY NETWORKS 1-0-0-1

Objectives:
- To analyze biological systems including populations of molecules, cells and organisms.
- To integrate mathematics, statistics and computing with biological systems.

Contents:

TEXTBOOKS / REFERENCES:


**Outcomes:**
- Apply mathematical concepts and principles to perform computations
- Create, use and analyze graphical representations of mathematical relationships
- Communicate mathematical knowledge and understanding to biomedical applications
- Apply technology tools to solve problems

**18BM738 BIOMOLECULAR MODELING AND SIMULATION**

**Objectives:**
- To introduce the principles and practices on Molecular Modeling, in particular simulation of biological macromolecules.
- To provide a design strategy for biomolecular systems and to predict the biological processes based upon the simulations of these models

**Contents:**

**TEXT BOOKS/REFERENCES:**

**Outcomes:**
- To learn Molecular Dynamics Simulation, and Potential Energy Functions
- To design biomolecules, biomolecular interactions and biomolecular processes.
MACHINE LEARNING TECHNIQUES

Objectives:
- To strengthen the expertise in machine learning algorithms

Contents:

TEXT BOOKS / REFERENCES:

Outcomes:
- Training the students on the state-of-the-art machine learning algorithms
- Prepare them to apply these algorithms for their further study/research

MEDICAL ROBOTICS

Objectives
- To introduce basic components of a robotic platform
- To learn different forms of robotic control
- To understand the relationship between the manipulator and the manipulated object

Contents:

TEXT BOOKS / REFERENCES:
Outcomes:

- Understand the anatomy of a robot
- Learn different control strategies used in robotic control
- Identify the position of each links of a robotic arm in 3D space

18BM741  ESSENTIALS OF TELEMEDICINE  1-0-0-1

Objectives:
To understand the key principles in telemedicine and health

Contents:

TEXT BOOKS / REFERENCES:


Outcomes:

- Knowledge in telemedical technology
- Knowledge in telemedicine standards, m-health, e-health and its applications

18BM742  ELECTROMAGNETICS FOR BIOMEDICAL ENGINEERING  1-0-0-1

Objectives:

- Understand the significance of Electromagnetic Field Concept in Biomedical Engineering

Contents:

TEXT BOOKS/REFERENCES


Outcomes:

- Design and development of non-invasive Diagnostic and Therapeutic techniques.
• Ability to analyse the pros and cons of Microwave based Non-invasive Diagnostic and Therapeutic techniques.

18BM798  DISSERTATION  0-0-0-10

Objectives:
• To define the problem of the proposed work.
• To apply the concepts of Biomedical Engineering in the selected problem.
• To demonstrate the results of the analytical and measurement concept.

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. Biomedical tools may be used for demonstrating the results with physical meaning and create necessary research components. Publications in reputed journals and conferences may be considered for authenticating the results.

Outcomes:
• Creation of manpower in the Biomedical Engineering domain and specialize in the state-of the art technology.
• Enable design aptitude and complex problem solving in the Biomedical Engineering aspects.
• Research publications and filing of patents.

18BM799  DISSERTATION  0-0-0-10

Objectives:
• To define the problem of the proposed work.
• To apply the concepts of Biomedical Engineering in the selected problem.
• To demonstrate the results of the analytical and measurement concept.

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. Biomedical tools may be used for demonstrating the results with physical meaning and create necessary research components. Publications in reputed journals and conferences may be considered for authenticating the results.

Outcomes:
• Creation of manpower in the Biomedical Engineering domain and specialize in the state-of the art technology.
• Enable design aptitude and complex problem solving in the Biomedical Engineering aspects.
• Research publications and filing of patents.