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 inmore 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 domainto 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

Course Code	Type	Course	L T P	Cr
18MA602	FC	Mathematical Methods for Engineering *(Common for VLSI Design, Communication Engineering & Signal Processing and Biomedical Engineering)*	3 0 2	4
18CE601	FC	Signal Processing *(Common for Communication Engineering & Signal Processing and Biomedical Engineering)*	3 1 0	4
18BM611	SC	Anatomy and Physiology*	3 0 0	3
18BM612	SC	Biomedical Instrumentation	3 1 0	4
18BM613	SC	Bioinformatics	3 0 0	3
18BM614	SC	Principles of Biosensing	2 0 0	2
18BM615	SC	Microstructural Sensors	1 0 0	1
18BM631	SC	Biomedical Engineering Lab - I	0 0 2	1
18HU601	HU	Amrita Values Program**		P/F
18HU602	HU	Career Competency I**		P/F
		Credits		**22**

*** Online/video lecture based**

****Non-credit course**

Second Semester

Course Code	Type	Course	L T P	Cr
18BM616	SC	Biomedical Image Processing	3 0 0	3
18BM617	SC	Biomaterials	3 0 0	3
18BM618	SC	Medical Ethics	1 0 0	1
	E	Fractal Elective 1	1 0 0	1
	E	Fractal Elective 2	1 0 0	1
	E	Fractal Elective 3	1 0 0	1
	E	Live-in Lab /Elective 1	3 0 0	3
	E	Elective 2 / Open Elective#	3 0 0	3
18RM600	SC	Research Methodology	2 0 0	2
18BM632	SC	Biomedical Engineering Lab – II	0 0 2	1
18HU603	HU	Career Competency II	0 0 2	1
		Credits		**20**

 # Courses can also be taken from other departments

Third Semester

Course Code	Type	Course	L T P	Cr
18BM620	SC	Internship		2
18BM798	P	Dissertation		10
		Credits		**12**

Fourth Semester

Course Code	Type	Course	L T P	Cr
18BM799	P	Dissertation		10
		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

Foundation Core

Course Code	Course	L T P	Cr
18MA602	Mathematical Methods for Engineering	3 0 2	4
18CE601	Signal Processing	3 1 0	4

Subject Core

Course Code	Course	L T P	Cr
18BM611	Anatomy and Physiology	3 0 0	3
18BM612	Biomedical Instrumentation	3 1 0	4
18BM613	Bioinformatics	3 0 0	3
18BM614	Principles of Biosensing	2 0 0	2
18BM615	Microstructure Sensors	1 0 0	1
18BM616	Biomedical Image Processing	3 0 0	3
18BM617	Biomaterials	3 0 0	3
18BM618	Medical Ethics	1 0 0	1
18RM600	Research Methodology	2 0 0	2
18BM620	Internship		2
18BM631	Biomedical Engineering Lab - I	0 0 2	1
18BM632	Biomedical Engineering Lab - II	0 0 2	1

Electives

Regular Electives

Course Code	Course	L T P	Cr
Biomedical Signal Processing			
18BM701	Special Topics in Biosignal Processing	3 0 0	3
18BM702	Special Topics in Biomedical Image Processing	3 0 0	3
18BM703	Medical Imaging Techniques	3 0 0	3
18BM704	Biostatistics	3 0 0	3
Biochemical Systems			
18BM711	Nanomaterials for Biomedical Applications	3 0 0	3
18BM712	Drug Designing and Delivery Systems	3 0 0	3
Biomechanics and Allied Systems			
18BM721	Biomechanics	3 0 0	3
18BM722	Biofluid Mechanics	3 0 0	3

Fractal Electives

Course Code	Course	L T P	Cr
Biomedical Instrumentation			
18BM731	Laser Instrumentation in Biomedical Applications	1 0 0	1
18BM732	Virtual Instrumentation for Medical Systems	1 0 0	1
18BM733	BioMEMS	1 0 0	1
18BM734	Biomedical Equipment and Safety	1 0 0	1
Computational Biomedical Systems			
18BM735	Dynamic Mathematical Models	1 0 0	1
18BM736	Reaction Networks	1 0 0	1
18BM737	Gene Regulatory Networks	1 0 0	1
18BM738	Biomolecular Modeling and Simulation	1 0 0	1
Artificial Intelligence			
18BM739	Machine Learning Techniques	1 0 0	1
18BM740	Medical Robotics	1 0 0	1
Healthcare Systems			
18BM741	Essentials of Telemedicine	1 0 0	1
18BM742	Electromagnetics for Biomedical Engineering	1 0 0	1

Project Work

Course Code	Course	L T P	Cr
18BM798	Dissertation		10
18BM799	Dissertation		10

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:

Matrices and Vectors – Inverse and Transpose – Vector Spaces – Subspaces – Linear Independence – Basis and Dimension – Orthogonal Vectors and Subspaces – Matrix Decompositions – QR Decomposition – Singular Value Decomposition – Eigen Values – Eigen Vectors – Diagonalization of Matrix.

Introduction to Optimization – Linear Optimization – Unconstrained Optimization – Constrained Optimization – Nonlinear Optimization.

Introduction to Probability Concepts – Two Dimensional Jointly Distributed Random Variables – Stochastic Random Variables – Convergence and Limit Theorems – Multi Variant Probability Distribution Covariance, and Regression Models – Bayesian Methods of Estimation – Random Process – Power Spectrum – Discrete Time Process – Spectrum Estimation

Lab Component: Gram Schmidt Orthonormalization on Vector Spaces – Solving a System of Linear Equations using QR Decomposition – Image Compression using Singular Value Decomposition – Computation of Basis for Four Fundamental Subspaces for a given System – Optimization using Newton's Method with Line Search and Broydens Update.

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:

1. Gilbert Strang, *Linear Algebra and its Applications*, Fourth Edition, Cambridge University Press. 2009.
2. Todd K. Moon and Wynn C. Sterling, *Mathematical Methods and Algorithms for Signal Processing*, PHI, 2000.
3. C. Bender and S. Orszag, *Advanced Mathematical Methods for Scientists and Engineers,* Springer, 1998.
4. Papoulis. A and S.U. Pillai, *Probability Random Variables and Stochastic Processes,*

Fourth Edition, Mc Graw Hill, 2002

18CE601 SIGNAL PROCESSING 3-1-0-4

(Common for Communication Engineering & Signal Processing and Biomedical Engineering)

Objectives:

- To understand the basic concepts ofsignal processing, systems and time-frequency transformation techniques

Contents:

Review of Signal Processing and Digital Filters – Introduction to Transforms – DFT– DCT– Properties of DFT – FFT – FIR and IIR Filter Design Techniques and Filter Structures.

Introduction to Multi-Rate Digital Signal Processing – The Effect of Up-Sampling and Down Sampling of The Signal – Applications of Multi-Rate Signal Processing – Sub-Band Coding.

Significance of Joint Time – Frequency Domains – Short Time Fourier Transform (STFT) - Continuous Wavelet Transforms (CWT) – DWT – Time-Frequency Tiling – Scaling and Wavelet Functions – Filter Banks.

TEXT BOOKS / REFERENCES:

1. John G Proakis and Dimitris.G.Manolakis, *Digital Signal Processing, Principles,Algorithms, Applications*, Fifth Edition, Prentice Hall India, 2003.
2. N. Ahmed and K. R. Rao, *Orthogonal Transforms for Digital Signal Processing*, Springer, 1975.
3. Soman K. P. and Ramachandran K. I, *Insight into Wavelets from Theory toPractice*,Prentice Hall, 2004.
4. Raghuveer M Rao and Ajit S Bopardikar, *Wavelet Transforms*, Addison Wesley, 1998.

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 / systems

Contents:

Bio Signals – Cell Potential – Sodium Channel – Action Potential – Electrocardiograph – EEG – EMG – ERG – Typical Characteristics – Electrodes – Body – Electrode – Instrument Interface Operational Amplifiers – Typical Op-Amp Characteristics – Operational Amplifier Circuits – Instrumentation Amplifier.

Biomedical Transducers– Basic Sensors and Principles – Measurement of Pressure, Flow, Motion, Force AndTemperature.

Random Noise in Biomedical Measurement Systems – Sources – EMI and EMC – Measurement System Characteristics – Accuracy – Error and Calibration – Grounding – Isolation Amplifiers – Active Filters– An Overview – Digital Interfaces – Analog to Digital Converters and Digital to Analog Converters.

TEXTBOOKS / REFERENCES:

1. Northrop R B, *Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation*, Second Edition, Boca Raton, CRC Press, 2012.
2. Togawa T, *Biomedical Transducers and Instruments*, Second Edition, Boca Raton, CRC Press, 2011.
3. Webster J G, *Medical Instrumentation - Application and Design*, Third Edition, Wiley, New York, 2009.
4. Pallas-Areny R and Webster J G, *Sensors and Signal Conditioning*, Vol. 1, Second Edition, John Wiley and Sons Inc., New York, 2001.
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 challengesin health care informatics

Contents:

Biological Data Acquisition – Bioinformatics Databases, Sequence and Structure Alignment – Protein Structure Prediction – Protein Folding – Protein-Protein Interaction – Standard Search Engines – Data Retrieval Tools – Entrez, DBGET And SRS – Submission of (New And Revised) Data.

Sequence Similarity Searches– Local versus Global – Distance Metrics – Similarity and Homology – Scoring Matrices – Genome Annotation and Gene Prediction– ORF Finding – Phylogenetic Analysis – Comparative Genomics – Orthologs – Paralogs – Methods of

Phylogenetic Analysis – UPGMA – WPGMA – Neighbour Joining Method – Fitch/MargoliashMethod.

Health Informatics– Character Based Methods – Functional Capabilities of a Computerized Health Information System (HIS) – E-Health Services – Application Server Provider – Clinical Information System – Computerized Prescriptions for Patients – Computer Based Medical Information Retrieval – Hospital Management And Information System – Biomedical Data Analytics – Computer Assisted Medical Imaging – Computer Assisted Medical Decision Making – Machine Learning in Data Analysis – Virtual Reality Applications in Medicine – Computer Assisted Surgery – Surgical Simulation – Tele-Medicine – Tele-Surgery.

TEXTBOOKS / REFERENCES:

1. R.D.Lele, *Computers in medicine progress in medical informatics*, Tata McGraw Hill Publishing computers Ltd, New Delhi. 2005.
2. Mohan Bansal, *Medical informatics*, Tata McGraw Hill Publishing computers Ltd, New Delhi, 2003.
3. Edward H Shotliffe, *Biomedical informatics*, Springer, Fourth edition, 2013.

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:

Biosensors – Definition and Classification,Transduction Systems –Optical – Electrochemical – Amperometric– Potentiometric – Conductometric–Mass Sensitive –Piezoelectric – Thermometric–SpectrophotometricSensors.

Bioreceptorsand Biosensor Systems –Enzyme-Nucleic Acid –Cell-Based Systems – Biomimetic Receptors–Immobilization Of Biomolecules–Biosensors for Various Applications – Medical Diagnosis – Food Analysis – Drug Development –Environmental Monitoring.

TEXT BOOKS / REFERENCES:

1. Tuan Vo-Dinh, *Biomedical Photonics Handbook*, CRC Press, 2003
2. Rajmohan Joshi, *Biosensors*, Isha books, 2006
3. Robert S. Marks, Christopher R. Lowe, David C. Cullen, Howard H. Weetall, Isao Karube , *Handbook of Biosensors and Biochips*, Weily, 2007
4. Heather, Marvin, *Handbook of biosensors*, Clanrye International, 2015

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.
- Applybiosensors 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:

Light-Addressable Potentiometric Sensor (LAPS) – Measurement on Human Skin Surface – Dermo-Cosmetics – Chemo Resistor Sensors – Integral Toxicity Sensor –PCB and Screen Printed Electrode Immunosensor–FiberOptic Biosensors – Introduction to Lab-On-A-Chip – Components – Sensing Techniques –CMOS based LOC – Prototype Fabrication and Characterization – Transverse Diffusion – Handling of Micro Channels.

TEXT BOOKS / REFERENCES:

1. R.E. Oosterbroek and A. van den Berg (eds.),*Lab-on-a-Chip*, Elsevier, 2003
2. Jonathan M. Cooper, Anthony E.G . Cass, *Biosensors*, 2nd edition, Oxford university press, 2004
3. S. Alegret, A. Merkoci,*Electrochemical sensor analysis*, volume 49, Elsevier, 2007
4. Yehya H. Ghallab, WaelBadawy, *Lab-on-a-Chip: Techniques, Circuits, and Biomedical Applications*, ARTECH HOUSE, 2010

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 ofbiomedical 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:

Sources of Medical Images – Introduction to X-Ray, CT, PET, MRI – Ultrasound Images – Fundus Images – OCT – Properties – Advantages and Disadvantages – Image Enhancement – Enhancement in Spatial and Frequency Domains.

Morphological Image Processing – Binary and Gray-Scale Morphological Operations – Morphological Algorithms – Thresholding– Region Growing – Region Splitting and Merging – Edge Detection.

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:

1. Meyer-Baese A, *Pattern Recognition and Signal Analyis in Medical Imaging*, Academic Press, Second Edition,2014.
2. Gonzalez R C and Woods R E, *Digital Image Processing*, Third Edition, Prentice Hall, 2010.
3. Rangayyan R M, *Biomedical Image Analysis*, Fifth Edition, CRC Press, 2005.
4. Deserno T M, *Biomedical Image Processing*, Springer, 2011.

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:

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

Testing of Biomaterials – Biomedical Applications of Materials in the Areas – Cardiovascular – Orthopedic– Ophthalmologic – Dental Implants – Sutures – Burn Dressings – Adhesives and Sealants.

TEXT BOOKS / REFERENCES:

1. Ratner B D, Hoffman A S, Schoen F J and Lemons J E, *Biomaterials Science: An Introduction to Materials in Medicine*, Third Edition, Academic Press, 2012.
2. Hill D, *Design Engineering of Biomaterials for Medical Devices*, John Wiley, 1998.

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:

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 –Regulatory Compliance.

TEXTBOOKS / REFERENCES:

1. Shamoo A and Resnik D B, *Responsible Conduct of Research*, Third Edition, Oxford University Press, 2015.

2 Gopalakrishnan B, Khaute M, Bhat B S, Bhat S, Sastry S R, Kaur K, Menon M, Kamath A, Saha M, Sadhya M, *Reflections on Medical Law and Ethics in India*, First Edition, Eastern Law House, 2016

3.Relevant Statutes and Reports

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:

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.

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:

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

TEXT BOOKS/ REFERENCES:

1. Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8th Edition, McGraw-Hill, 2011
2. C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers
3. Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.
4. Michael P. Marder," Research Methods for Science", Cambridge University Press, 2011
5. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6 edition July 2012

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 BIOSIGNAL 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:

Multiresolution Signal and Noise Analysis -–Signal Analysis – DCT – STFT – WT - Spectral Estimation – Parametric and Non-Parametric Methods –Signal Modeling– Auto-Regressive, Moving-Average – Auto-Regressive and Moving-Average – Linear Predictive Modelingand Application to the Biosignals.

Linear and Nonlinear Filtering – Mean-Average Filter – Median Filter - Derivative Filter –FIR and IIR Filters –Weiner Filter –LMS and KalmanFiltering Algorithms –SVD Filtering and Homomorphic Signal Processing –Bio-Signal Processing –Independent and Principal Component Analyses.

Classification Problems –Feature Extraction – Temporal and Spectral Features –DCT Features – STFT Features – Wavelet Features – Higher Order Statistics (HOS) and Information – Theoretic Features –Event Detection and Classification – Classifiers –Linear Discriminants – SVM – NN – GMM.

TEXTBOOKS / REFERENCES:

1. Oppenheim A V, Schafer R W and Buck J R, *Discrete-Time Signal Processing*, Third Edition, Prentice Hall, 2009.
2. Rangayyan R M, *Biomedical Signal Analysis-A Case- Study Approach*, Second Edition, Wiley -IEEE Press, 2015.
3. Kay S M, *Fundamentals of Statistical Signal Processing; Practical Algorithm Development*, Vol . III, Prentice Hall, 2013.
4. Begg R, Palaniswami M and Lai D T H, *Computational Intelligence in Biomedical Engineering*, CRC Press, 2007.

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:

Image Restoration – Spatial Filtering –Frequency Domain Filtering –Inverse Filtering –Wiener Filtering – Constrained Least Squares Filtering –GeometricMean Filter –Wavelet Filtering.

Image Segmentation –Morphological Watersheds –Markov Random Fields –Gaussian Mixture Models –Active Contours –Image Representation and Description –Shape and Texture Features – Oriented Patterns.

Image Reconstruction from Projections –The Fourier Slice Theorem, Back Projection –Algebraic Reconstruction Techniques –Image Registration –Linear Transformation –Non-Linear Transformation –Non-Rigid Transformation –Feature-Based and Voxel-Based Registration – Case Studies in Medical Images.

TEXTBOOKS / REFERENCES:

1. Gonzalez R C and Woods R E, *Digital Image Processing*, Third Edition, Prentice Hall, 2010.
2. Milan Sonka, Vaclav Hlavac and Roger Boyle, *Image Processing, Analysis and Machine Vision*, Fourth Edition, Cengage Learning, 2014.
3. A. ArdheshirGoshtasby, *2-D and 3-D Image Registration for Medical, Remote Sensing, and Industrial Applications*, John Wiley and Sons, 2005.
4. Rangayyan R M, *Biomedical Image Analysis*, Fifth Edition, CRC Press, 2005.

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

18BM703 MEDICAL IMAGING TECHNIQUES 3-0-0-3

Objectives:

- 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:

Introduction to Medical Imaging Signals and Systems – General Image Characteristics – Image Reconstruction – Medical Imaging Modalities – Planar X-Ray – X-Ray Computed Tomography (CT).

Nuclear Medicine (Planar Scintigraphy, PET and SPECT) – Ultrasound Imaging – Magnetic Resonance Imaging (MRI) – Basic Physical Principles – Image Formation – Instrumentation.

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

TEXTBOOKS / REFERENCES:

1. Nadine Barrie Smith and Andrew Webb, *Introduction to Medical Imaging: Physics, Engineering and Clinical Applications*, Cambridge University Press, 2010.
2. Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr. and John M. Boone, *The Essential Physics of Medical Imaging*, Third Edition, Lippincott Williams and Wilkins, 2011.
3. Paul Suetens, *Fundamentals of Medical Imaging*, Second Edition, Cambridge University Press, 2009.
4. Jerry L. Prince, Jonathan Links, *Medical Imaging Signals and Systems*, Second Edition, Pearson, 2014.
5. Jack L. Lancaster and Bruce Hasegawa, *Fundamental Mathematics and Physics of Medical Imaging*, CRC Press, 2016.

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:

Frequency Distribution – Probability in the Health Sciences – Measurement and Measurement Sciences, Bayes' Theorem and Screening Tests – Probability Distributions – Poisson, Binomial and Normal.

Observational Data – Description and Analysis – Random Sampling – Measures of Central Tendency and Dispersion – Population Parameters and Sample Statistics – Sampling and Statistical Inference.

Hypothesis Tests – Test on a Single Mean – Test of Equality of Two Means – Test ona Single Variance – Test of Equality of Two Variances – Test of a Single Proportion – Test of Equality of Two Proportions – Analysis of Variance (ANOVA) – Correlation and Regression.

TEXTBOOKS / REFERENCES:

1. Daniel W.W., *Biostatistics :Basic Concepts and Methodology for the Health Sciences*, Ninth Edition, Wiley India Pvt. Ltd, New Delhi, 2010.
2. Glantz S.A., *Primer of Biostatistics*, Seventh Edition, McGraw-Hill Medical Pub., New York, 2011.

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:

Introduction to Nanomaterials –Size Dependence of Properties – Surface to Volume Ratio and Quantum Confinement –Microscopic Techniques to Study Nano Structures – SEM – AFM – TEM and STM –Spectroscopic Techniques to Characterize Nanostructures – Raman – XPS – Auger – EDAX.

Synthetic Approaches – Colloidal –Self-Assembly (Self Assembled Monolayers-Sams) and Electrostatic Self-Assembly – Electrochemical Methods (CathodicAnd Anodic Processes) – Sol-Gel-Langmuir-Blodgett (LB) Technique – Chemical Vapour Deposition – Plasma Arcing and Ball Milling, Lithography – Electrical – Optical – Mechanical – Chemical and Magnetic Properties of Nanomaterials.

Carbon Clusters – Synthesis – Properties and Biomedical Applications of Fullerenes –Carbon Nanotubes and Graphenes–Quantum Dots, Wells and Wires (Metallic And Semiconducting) – Preparation – Properties and Biomedical Applications –DendrimericStructures and their Applications –Biofunctionalisationof Nanomaterials –Surface Plasmon Resonance – Fluorescence Resonance Energy Transfer (FRET).

TEXTBOOKS / REFERENCES:

1. Nabok A, *Organic and Inorganic Nanostructures*, Artech House, Inc., 2005.
2. Ju H, Zhang X and Wang J, NanoBiosensing, *Principles, Development and Application, Springer, 2011*.
3. Mozafari M R (Ed.), *Nanomaterials and Nanosystems for Biomedical Applications*, Springer, 2007.
4. Wang Z L (Ed.), *Characterisation of Nanophase Materials*, Wiley VCH, 2000.

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:

Introduction – Drug-Likeness – Source of Drugs – Drug-Designing Strategy - DNA-based Drug Designing – RNA-based Drug Designing – Protein-based Drug Designing – Pathway based Drug Designing – Computer Aided Drug Designing (CADD) – Sequence and Structural Analysis – Active Sites – Molecular Interaction – Mechanisms Associated With Drug Actions – Docking Studies – Molecular Dynamic Simulation And Monte-Carlo Simulation Techniques.

Electrostatic Complementarity – Master Equation Approach – Poisson-Boltzmann Calculation – Correlation of Electrostatic Potential – Regression Analysis of Free Energy – Drug Administration and Drug Effectiveness – Diffusion and Drug Dispersion – Diffusion in Biological Systems – Drug Permeation through Biological Barriers – Drug Transport by Fluid Motion – Pharmacokinetics of Drug Distribution – Admetox.

Drug Delivery Systems – Drug Modification – Controlled Drug Delivery Systems – Computational Drug Delivery – Fem Based Modelingof Drug Delivery – Case Studies – Drug Designing – Controlled Delivery of Systematic Therapy – Pharmacogenomics – P4 and P5 Drugs – Retro Metabolic Drug Design – Octopodial Approach.

TEXTBOOKS/REFERENCES:

1. Saltzman W.M, Drug *Delivery-Engineering Principles for Drug Therapy*, Oxford University Press, 2001.
2. Vinter J G and Gardner M, *Molecular Modeling and Drug Design*, CRC Press, 2001.
3. Smith D A, Van de Waterbeemd H and Walker D K, *Pharmacokinetics and Metabolism in Drug Design*, Wiley-VCH, 2001.

Outcomes:

- Knowledge of the fundamentals of drug design and simulation
- Apply different methods of drug study and characterisation

18BM721 BIOMECHANICS 3-0-0-3

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:

Elements of Rheology and Principles of Continuum Mechanics – Viscoelasticity – Generalized Theory of Elasticity – Structure – Properties and Mechanics of Soft and Hard Tissues (Bones, Cartilage, Muscles, Tendon and Ligaments) – Anatomical Positions, Planes and Axes.

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.

Classification of Joints – Mechanics of Joints in Lower and Upper Extremities – Mechanics of Spine – Estimation of Muscle Forces -– Joint Reaction Forces and Moments – Biomechanical Modeling – Simulation and Analysis using Open Source Tools like Opensim – Febio Software Suite and GIBBON.

TEXTBOOKS / REFERENCES:

1. Margareta Nordin and Victor H. Frankel, *Basic Biomechanics of Musculoskeletal System*, Fourth Edition, Lippincott, Williams and Wilkins, 2012.
2. Fung Y C, *Biomechanics: Mechanical Properties of Living Tissues*, Second Edition, Springer-Verlag, 1993.
3. Susan J. Hall, *Basic Biomechanics*, Seventh Edition, McGraw-Hill, 2014.
4. NihatOzkaya, Margareta Nordin, David Goldsheyder, Dawn Leger, *Fundamentals of Biomechanics - Equilibrium, Motion, and Deformation*, Fourth Edition, Springer, 2016.
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
- Analysisof 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

18BM722 BIOFLUID MECHANICS 3-0-0-3

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 system

Contents:

Introductory Fluid Mechanics – Types of Fluids – Fluid Properties – Effect of Temperature and Pressure on Fluid Properties – Conservation Relations and Boundary Conditions – Fluid Statics – Modes of Fluid Transportation – Laminar and Turbulent Flows – Application of Momentum Balances – Flow between Fixed and Moving Parallel Plates – Flow through Cylindrical Pipe – Flow through Annulus – Flow between Rotating Cylinders Internal vsExternal Flows – Boundary Layer Formation and Boundary Layer Theory - Flow around a Fixed Cylinder and Sphere – Flow around a Slowly Rotating Sphere.

Friction Loss in Flow through Pipes – Transport through Porous Media – Introduction to Biological Systems – Constituents and Properties of Blood – Cell Structure – Relative Importance of Convection and Diffusion – Transport Within the Cell – Transport across Cell Membrane – Transcellular Transport – Physiological Transport Systems – Cardio Vascular Systems –Respiratory System – Gastrointestinal Tract – Liver Kidneys – Integrated Organ Function – Fluid Flow in Veins, Arteries and Tissues.

Oscillating Flow an Circular Tubes – Entrance Effects in Circular Tubes – Flow in Rigid and Flexible Tubes – Flow in a Collapsing Pipe Subjected External Force and Pressure Correlations – Flow in Branching Arteries – Flow in Sudden Contraction Enlargements applied to Cardiovascular Systems – Flow through Pipe Varying in Diameter – Heart Pumping Capacities for all the above Studies – Heat and Mass Transport in Biological Systems – Transport of Gases and Vital Nutrients in Between Blood and Tissues – Oxygen-HemoglobinEquilibrium – Oxygen Delivery to Tissues – Drug Transport in Solid Tumors.

TEXTBOOKS / REFERENCES:

1. George A. Truskey, Fan Yuan, David F. Katz, *Transport Phenomena in Biological Systems*, Person Publishers, 2004.
2. Lee Waite, *Biofluid Mechanics in Cardiovascular Systems*, McGraw-Hill Publishers, 2006
3. Kleinstreuer C, *Biofluid Dynamics: Principles and Selected Applications*, CRC/Taylor and Francis, 2006.
4. Truskey G A, Yuan F and Katz D F, *Transport Phenomena in Biological Systems*, Second Edition, Pearson/Prentice Hall, 2009.
5. Sharma K L, *Transport Phenomena in Biomedical Engineering: Artificial Organ Design and Development and Tissue Engineering*, McGraw-Hill, 2010.

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 under the operation of lasers and their uses in Biomedical instrumentation

Contents:

Introduction to Laser Operation –Types of Lasers and their Applications – Pulsed Ruby Laser – Nd-YAG Laser – Helium-Neon Laser – Argon Laser –CO_2 Laser –Excimer Lasers – Semiconductor Lasers Tissue Diagnostics using Lasers – Diagnostic Applications of Lasers in Ophthalmology and Flow Cytometry.

TEXTBOOKS / REFERENCES:

1. R.S. Khandpur, *Handbook of Biomedical Instrumentation*, McGraw Hill Education, Third Edition, 2014
2. Ronald W. Waynant, *Lasers in Medicine*, CRC Press, 2001
3. Tuan Vo-Dinh, *Biomedical Photonics Handbook*, CRC Press, 2003

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:

Concepts of Virtual Instrumentation Systems – Data Acquisition and Analysis – Design and Implementation of Virtual Instrumentation Systems for ECG, Pulse Oximetry and EEG Signal Acquisition and Analysis.

TEXTBOOKS / REFERENCES:

1. Gupta S and John J, *Virtual Instrumentation using LabVIEW*, Second Edition, Tata McGraw-Hill, 2010.
2. Bishop R, *Learning with LabVIEW*, Pearson, 2014.
3. Olansen J B and Rosow E, *Virtual Bio-Instrumentation: Biomedical, Clinical and Healthcare Applications in LabVIEW*, Prentice Hall, 2002.

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:

Introduction T\to MEMS– How to Make Things Small – Micropatterningof Substrates and Cells–Microfluidics –Molecular Biology an aChip –Cell-Based Chips for Biotechnology– BioMEMSfor Cell Biology –Tissue Microengineering– Implantable Microdevices.

TEXT BOOKS / REFERENCES:

1. Albert Folch, Introduction to BioMEMS , CRC Press, 2013
2. Ellis Meng, Biomedical microsystems, CRC Press, 2010
3. Saliterman, Stevens, Fundamentals of BioMEMS and medical microdevices, Cengage Learning, 2006

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:

Classification of Biomedical Instruments – Static and Dynamic Characteristics – Regulation of Medical Devices – Electrocardiograph – Working – Problems in ECG Measurement – Protection and Interference-Reduction Circuits – Amplifiers for Other Biopotential Signals – Cardiac Monitors – Cardiac Pacemakers and Other Electric Simulators – Defibrillators and Cardioverters – Hemodialysis – Lithotripsy – Ventilators – Drug Delivery Devices – Surgical Instrument – .Physiological Effects – Susceptibility Parameters – Macroshock and Microshock Hazards – Electrical Safety Codes and Standards – Basic Approaches to Protection Against Shock – Protection Techniques – Power Distribution and Equipment Design.

TEXTBOOKS / REFERENCES:

1. Webster J G, *Medical Instrumentation: Application and Design*, Fourth Edition, Wiley,

1998.
2. Kutz M, *Biomedical Engineering and Design Handbook,* Second Edition, McGraw-Hill, 2009.
3. Bronzino J, *Biomedical Engineering and Instrumentation: Basic Concepts and Applications,* PWS Engineering,1986.
4. Franco S, *Design with Operational Amplifiers and Analog Integrated Circuits*, Third Edition, McGraw-Hill, 2002.

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:

Introduction– Dynamic Mathematical Models in Molecular Cell Biology – Population Growth and its Limitations – Community Ecology – Environmentally Limited Population Growth – Multiple Species Systems – Molecular Movement – Biological Membrane – Diffusion – Biochemistry Of Cells – Biopolymer – Molecular Information Transfer – Enzyme Kinetics – The Biological Disposition of Drugs And Inorganic Toxins– The Life Cycle of The Malaria Parasite – Mathematical Models for Parasitic Diseases – Cancer Research – Cell Growth and Division – Types and Stages ofCancer – The Role of Proto-Oncogenes and Tumor Suppressor Genes – A Cancer Models.

TEXTBOOKS / REFERENCES:

1. Ronald W Shonkwiler and James Herod, *Mathematical Biology An introduction with Maple and Matlab,* second edition, Springer Dordrecht Heidelberg London New York, 2009.
2. J D Murray, *Mathematical Biology II: Spatial Models and Biomedical Applications*,Third Edition, Springer-Verlag Berlin Heidelberg, 2002.
3. Xin-She Yang, *Introduction to Computational Mathematics*, World Scientific Publishing Company, 2008.

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:

ModelingChemical Reaction Networks – Closed and Open Networks – Numerical Simulation of Differential Equations – Separation of Time Scale and Model Reduction – Biochemical Kinetics –Enzyme Kinetics – Computational Modeling and Transport – Analysis of Dynamic Mathematical Models – Phase Plane Analysis – Limit Cycle Oscillation – Sensitivity Analysis – Metabolic Networking – ModelingMetabolism – Metabolic Pathways – Signal Transduction Pathways – Signal Amplification – Irreversible Decision Making – Frequency Encoding – Frequency Response Analysis.

TEXTBOOKS / REFERENCES:

1. Ronald W Shonkwiler and James Herod, *Mathematical Biology An introduction with Maple and Matlab*, second edition, Springer Dordrecht Heidelberg London New York, 2009.
2. J D Murray, *Mathematical Biology II: Spatial Models and Biomedical Applications*,Third Edition, Springer-Verlag Berlin Heidelberg, 2002.
3. Engquist, Björn, *Encyclopedia of Applied and Computational Mathematics*, Springer, 2015.

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:

Gene Regulatory Networks – ModelingGene Expression – Oscillatory Gene Networks – Cell to Cell Communication – Stochastic Modeling of Biochemical and Genetic Networks – Electrophysiology– Membrane Potential – Excitable Membranes – Inter Cellular Communication – Spatial Modelling – Genetics-Mitosis – Meiosis And Fertilization – Classical Genetics – Genetic Drift – The Fixation of aBeneficial Mutation – Genomics–Structural Genomics– Comparative Genomics – Genomics in Medicine – Protein Substitution Matrices – BLAST for Protein and DNA – Phylogenetics– Branch Lengths Estimate – The Separation of Species – Algebraic Analysis of Maximum Likelihood – Characterizing Trees.

TEXTBOOKS / REFERENCES:

1.Ronald W Shonkwiler and James Herod, *Mathematical Biology An introduction with Maple and Matlab*, second edition, Springer Dordrecht Heidelberg London New York, 2009.
2. J D Murray, *Mathematical Biology II: Spatial Models and Biomedical Applications*,Third Edition, Springer-Verlag Berlin Heidelberg, 2002.
3. Engquist, Björn, *Encyclopedia of Applied and Computational Mathematics*, Springer, 2015.

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 1-0-0-1

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:

Molecular Mechanics – Force Fields – General Features of Molecular Mechanics Force Fields – Types of Force Fields – Bond Stretching – Angel Bending – Torsional Terms – Non Bonded Interactions – Electrostatic and Van Der Waals Interactions – Types of Potentials – Lennard-Jones Potential – Molecular Dynamics Simulation– Introduction – Molecular Units and Timescales – Energies – Equations of Motion – Trajectories – Phase Space – Temperature – Velocity Distributions – Elements of an MD Simulation – Setting Up and Running aMolecular Dynamics Simulation – Visualization and Analysis – BiomolecularModeling – Homology Modeling.

TEXT BOOKS/REFERENCES:

1. Tamar Schlick, *Molecular Modeling and Simulation-an Interdisciplinary Guid*, Springer-Verlag Heidelberg, 2002.
2.Haian Fu, *Protein-Protein Interactions: Methods and Applications,Methods in Molecular Biology*, Humana Press-Totowa, New Jersey, 2008.
3. K.I. Ramachandran. G. Deepaand KrishnanNamboori P. K.,*Computational Chemistry and Molecular Modeling Principles and Applications*, Springer -Verlag Berlin Heidelberg, 2008.

Outcomes:

- To learn Molecular Dynamics Simulation, and Potential Energy Functions
- To design biomolecules, biomolecular interactions and biomolecular processes.

18BM739 MACHINE LEARNING TECHNIQUES 1-0-0-1

Objectives:

- To strengthen the expertise in machine learning algorithms

Contents:

Introduction to Mixture Models and EM – K-Means Clustering, Mixture of Gaussians– Maximum Likelihood and EM for Gaussian Mixtures – Bayesian Neural Networks – Introduction to Linear Algebra – Theory of Optimization – Constrained and Unconstrained Optimization – L1 and L2 Norm Linear SVM– Non-Linear SVM and Kernel Trick – SVM Formulation of Non-Linear Kernels with Soft Margin (L1 Normand L2 Norm) – Introduction to Support Vector Regression – Neural Networks.

TEXT BOOKS / REFERENCES:

1. Christopher Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
2. Bernard Scholkopf and Alexander J Smola, *Learning with Kernel*, MIT Press, London, England, 2002.
3. K. P. Soman, R. Loganathan, and V. Ajay, *Machine Learning with SVM and KernelMethods*, PHI Learning Private Ltd., New Delhi.2011.
4. YoshuaBengio, *Learning Deep Architectures for AI, Foundations and Trends in MachineLearning*,Vol. 2, Now Publishers Inc.

Outcomes:

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

18BM740 MEDICAL ROBOTICS 1-0-0-1

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:

Robots and Embedded Systems – Sensors – Sensor Categories – A/D Converter – Position Sensitive Device – Compass – Gyroscope – Accelerometer – Inclinometer – Actuators – DC Motors – H-Bridge – Pulse Width Modulation – Stepper Motors – Servos – Control – On-Off Control – PID Control – Velocity Control and Position Control – Embedded Controllers – Interfaces – Operating System – Evolutionof Robotics – Robot Anatomy – Design and Control Issues – Manipulation and Control – Direct Kinematic Model – Denavit– Hartenberg Notation – Kinematic Relationship between Adjacent Links – Manipulator Transformation Matrix.

TEXT BOOKS / REFERENCES:

1. Thomas Bräunl, *Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems*, Third Edition, Springer-Verlag Berlin Heidelberg, 2008.
2. R.K.Mittal andI.J.Nagrath, *Robotics and Control*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2003.

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:
Information and Communication Systems in Healthcare – Sensing and Transfer Of Biomedical Data in Telemedicine – Telemedicine Standards – Mobile Telemedicine– Wireless Data Transmission –Internet Applications in Telemedicine – Ethical and Legal Aspects of Telemedicine.

TEXT BOOKS / REFERENCES:

1. Norris, Anthony Charles, and A. C. Norris. *Essentials of telemedicine and telecare*. Chichester: Wiley, 2002.
2. B.Fong, A.C.M Fong A.C.M and C.K. Li. *Telemedicine technologies: Information technologies in medicine and telehealth*. John Wiley & Sons, 2011.
3. H. Eren and J. G. Webster, eds. *Telemedicine and electronic medicine*. CRC Press, 2015.
4. Wootton R. Craig, J., Patterson, V., Introduction to Telemedicine. Royal Society of Medicine Press Ltd, 2006

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:
EM Material Interaction – Reflection and Transmission – Multi Layered Structures – Debye Model – EM Human Body Interaction – Effects and Hazards – Microwave Applicators.

TEXT BOOKS/REFERENCES

1. J.D.Kraus and Fleisch, “Electromagnetics with Applications”, Tata McGraw Hill, Fifth Edition, 2007.

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.