Course Code and Title with L-T-P Structure: **BE-504: Neuroengineering (3 0 0)**
Semester : **2nd Semester**
Programme : **M Tech in Bioelectronics**
Course Offering Department : **Electronics and Communication Engineering**

Syllabus

Biology of the neuron, biophysical description of the action potential, synapses, neuron as a threshold device, networks, neuroelectronic junctions, silicon neurons, SPICE modeling of Silicon neurons, Neural coding, models and methods, goal functions and time dependent learning rules, neural interfaces, EEG recording for brain computer interface applications, coding and decoding of neural information in bi-directional neural interfaces, Neuroengineering of mind : neural models of higher functions, large scale brain models, neural modeling and neural coding in the brain.

Course Outcomes (COs)

1. After completing the course BE 504, student is expected to have the basic knowledge of the Bio-neuro-engineering
2. After completion of this course, students will have knowledge to develope artificial circuit models that simulate the behavior of biological neuron is one of today's most promising directions of investigation in the field of neurobio and neuromorphic engineering.
3. Students will have knowledge to analyze the function of the nervous system, developing methods to restore damaged neurological function & creating artificial neuronal systems by integrating physical, chemical, mathematical & engineering tools.
4. Students are expected to work in the field of Bio-neuro engineering as project work or as per their interest

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

SN	Program Outcome (PO)	CO		SN	Program Outcome (PO)	CO
1	The graduates will demonstrate knowledge and concepts which are competitive for application in bioelectronics and allied disciplines.	1,2,3		7	The graduates will have knowledge in Biomedical signal analysis, biomedical image processing and their hardware implementation with exploration through computer vision and Instrumentation.	2
2	The graduates will demonstrate an ability to analyze, formulate and solve problems related to Bioelectronics devices and system design.	3		8	The graduates will have good background for progression onto research programs and competitive examinations of national and international repute.	4
3	The graduates will develop an ability to design and implement projects and carry out research in interdisciplinary and emerging areas for application in health care, food safety and bio-inspired systems.	4		9	The graduates will have a good understanding of professional and ethical responsibility.	
4	The graduates will display an	3		10	The graduates will be able to	

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	ability to contribute in the transformation of the economy through knowledge-based initiatives.				demonstrate effective communication skills, both written and oral.	
5	The graduates will have knowledge and exposure on different phenomena occurring in semiconductor materials, biological materials, aqueous solutions, solid-solid junction, and motion in solution and chemical reactions.	Nil		11	The graduates will have a good understanding for the need of life long learning and will be able to work in teams.	4
6	The graduates will have knowledge to use, fabrication and characterize bioelectronic devices such as ISFET, CNTISFET, BioFETs, CNTBioFETs.	2				

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Course Code and Title with L-T-P Structure: **BE-528: MEMS and Nanotechnology (3-0-0)**
Semester : **2nd Semester**
Programme : **M Tech in Bioelectronics**
Course Offering Department : **Electronics and Communication Engineering**

Syllabus

Introduction to MEMS: Micro and Nano-scale size domains; Evolution of MEMS Technology in Early Days, Moore's Law in MEMS, Prospects and Challenges in Commercialization of MEMS Technology Scaling laws in Miniaturization, MEMS materials and Processes; MEMS devices and Applications
(3 Lectures)

Introduction to Submicron Technology: Semiconductor materials; Photolithography; Doping; Thin film growth and Deposition; CVD and Ion Implantation, Metallization; Wet and Dry Etching; Silicon Micromachining; Metal MEMS Processes; Submicron Optical Lithography; Electron Beam Lithography; Soft Lithography and Printing.
(3 Lectures)

Mechanics of beam and diaphragm: Elasticity, Stress-Strain Relation, Bending Moment, Beam Bending Theory, Micro-cantilever Beam, Analysis of Deformation of Membranes.
(4 Lectures)

Sensing and actuation principles: Sensing Principles in MEMS: Piezoresistive, Capacitive, Thermoelectric, Thermoresistive etc. Actuation Principles in MEMS: Electrostatic, Thermal, Piezoelectric etc. Microactuators based on various principles: electrostatic, electromagnetic, piezoelectric, Capacitive and SMA; Pull in Effect, Actuator applications: Inkjet, Electrical and Optical Switching, Micropump.
(8 Lectures)

Case Studies: Physical sensor like pressure, chemical, flow sensor, accelerometer and gyroscope, inkjet nozzle, electrical and optical switching, micropumps etc.
(3 Lectures)

BioMEMS: Introduction, Chemical and Biomedical Sensing Mechanisms and Principles, Chem-Lab on a Chip, Chemoresistors, Chemocapacitors, Chemotransistors, DNA sensors.
(4 Lectures)

Microfluidics: transport in micro-channels; microfluidic components (filters, mixers, valves, and pumps)
(3 Lectures)

Nanotechnology: Nanomaterials: Quantum wire, quantum well, quantum dots, fullerenes, graphene, carbon nanotube; Synthesis of Nanomaterials: Physical methods (electrodeposition, sputtering, molecular beam epitaxy, spary pyrolysis), chemical methods (CVD, solvothermal etc) Top down and bottom up approach for nanofabrication: electron beam lithography, FIB lithography, soft lithography, nanoimprint, nanosphere, Dip-pen nanolithography, self assembly and chemical synthesis.
(4 Lectures)

Characterization Technique: scanning electron microscopy, scanning tunnelling microscopy, X-ray photoelectron spectroscopy, Surface enhanced Raman spectroscopy etc.
(2 Lectures)

Medical Application of Nanotechnology: Nano-biosensor, Nanotechnology in drug delivery

(2 Lectures)

Course Outcomes (COs):

1. Elucidate the principles of different types of MEMS sensors and actuators.
2. Explain the concept of MEMS design, and fabrication technology.
3. Acquire and apply new knowledge as needed to work in the area of microelectromechanical systems.
4. Apply the contemporary knowledge into the area of Biomedical Engineering.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) of M. Tech. in BioElectronics

Sl No	Program Outcome (PO)	CO
1	The graduates will demonstrate knowledge and concepts which are competitive for application in bioelectronics and allied disciplines.	1
2	The graduates will demonstrate an ability to analyze, formulate and solve problems related to Bioelectronics devices and system design.	
3	The graduates will develop an ability to design and implement projects and carry out research in interdisciplinary and emerging areas for application in health care, food safety and bio-inspired systems.	1,2
4	The graduates will display an ability to contribute in the transformation of the economy through knowledge-based initiatives.	1
5	The graduates will have knowledge and exposure on different phenomena occurring in semiconductor materials, biological materials, aqueous solutions, solid-solid junction, and motion in solution and chemical reactions.	
6	The graduates will have knowledge to use, fabrication and characterize bioelectronic devices such as ISFET, CNTISFET, BioFETs, CNTBioFETs.	3
7	The graduates will have knowledge in Biomedical signal analysis, biomedical image processing and their hardware implementation with exploration through computer vision and Instrumentation.	
	The graduates will have good background for progression onto research programs and competitive examinations of national and international repute.	1,2
9	The graduates will have a good understanding of professional and ethical responsibility.	
10	The graduates will be able to demonstrate effective communication skills, both written and oral.	
11	The graduates will have a good understanding for the need of life long learning and will be able to work in teams	3, 4

Course Code and Title with L-T-P Structure: **BE-524: Advanced Bioelectronic Devices (3-0-2)**
Semester : **2nd Semester**
Programme : **M Tech in Bioelectronics**
Course Offering Department : **Electronics and Communication Engineering**

Syllabus:

Metal - Oxide - Semiconductor (MOS) : MOS Structure, Modes of operation, Metal Oxide Semiconductor Field effect Transistor (MOSFET). Electrolyte – Insulator – Semiconductor (EIS) : EIS Structure, Site binding Theory, Electrical double layer theory. MOSFET Based Bioelectronic devices : Biosensor overview, Ion Sensitive Field Effect Transistor (ISFET), Enzyme Field Effect Transistor (ENFET), Chemical Field Effect Transistor (CHEMFET), Reference Field Effect Transistor (REFET), Immune Field Effect Transistor (IMFET), Organic Thin Film Transistor (TFT), Cell-Based Biosensors & Sensors of Cell Metabolism, Light Addressable Potentiometric Sensors (LAPS); Interfacing of Biological Systems with electronic systems, non-conventional bioelectronic devices, conducting polymer based ISFET, Modeling & Simulation : SPICE and Electrochemical models of ISFET & CHEMFET.

Course Outcomes (COs):

At the end of this course students will demonstrate the ability

2. To use engineering concepts for transformation of basic solid phase building block to liquid-solid based structure like the transformation of MOS structure to EIS structure.
3. To acquire conceptual frame work for the design of Hybrid biological devices (bioelectronic devices).
4. To acquire conceptual frame work for electrochemical modeling of bioelectronic devices.
5. To know about the fabrication process along with hands on training involved in bioelectronics device fabrication.
6. To exhibit the capability of knowledge required to develop software for modeling and simulation of bioelectronic devices

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

SN	Program Outcome (PO)	CO		SN	Program Outcome (PO)	CO
1	The graduates will demonstrate knowledge and concepts which are competitive for application in bioelectronics and allied disciplines.	1,2		7	The graduates will have knowledge in Biomedical signal analysis, biomedical image processing and their hardware implementation with exploration through computer vision and Instrumentation.	
2	The graduates will demonstrate an ability to analyze, formulate and solve problems related to Bioelectronics devices and	3,4		8	The graduates will have good background for progression onto research programs and competitive examinations of	2,3,4

	system design.				national and international repute.	
3	The graduates will develop an ability to design and implement projects and carry out research in interdisciplinary and emerging areas for application in health care, food safety and bio-inspired systems.	3,4,5		9	The graduates will have a good understanding of professional and ethical responsibility.	
4	The graduates will display an ability to contribute in the transformation of the economy through knowledge-based initiatives.	4,5		10	The graduates will be able to demonstrate effective communication skills, both written and oral.	1,2,3,4
5	The graduates will have knowledge and exposure on different phenomena occurring in semiconductor materials, biological materials, aqueous solutions, solid-solid junction, and motion in solution and chemical reactions.	1		11	The graduates will have a good understanding for the need of life long learning and will be able to work in teams.	2,3,4,5
6	The graduates will have knowledge to use, fabrication and characterize bioelectronic devices such as ISFET, CNTISFET, BioFETs, CNTBioFETs.	2,3				

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Course Code and Title with L-T-P Structure: **BE-506: Biomedical Image Processing (3-0-2)**
Semester : **2nd Semester**
Programme : **M Tech in Bioelectronics**
Course Offering Department : **Electronics and Communication Engineering**

Syllabus

Medical Imaging: X-ray imaging, computer assisted tomography magnetic resonance imaging, nuclear magnetic resonance imaging.
Image enhancement: Fundamental enhancement techniques, medical image enhancement with nonlinear filters.

Segmentation: Image segmentation basics, medical image segmentation by clustering, fuzzy clustering, segmentation by neural network, deformable modules and gradient vector flaw deformable modules, case studies of segmentation of brain, heart etc.

Image reconstruction from projections: Principle of tomography, algebraic and Fourier domain reconstruction technique .

Image registration: Physical basics of spatial distortion in medical images, fundamental of registration; application of image registration for image guided surgery.
Medical image compression: Fundamental and standards of image compression; issues related with medical image compression; medical image.

Course Outcomes (COs)

1. Understand the medical imaging technologies
2. Understand the concept of image transforms
3. Understand the medical image enhancement, restoration, segmentation techniques
4. Understand the medical image registration, compression techniques
5. Simulation of various medical image processing techniques in MATLAB

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) of M.Tech (Bioelectronics)

SN	Program Outcome (PO)	CO		SN	Program Outcome (PO)	CO
1	The graduates will demonstrate knowledge and concepts which are competitive for application in bioelectronics and allied disciplines.	1,2,3,4,5		7	The graduates will have knowledge in Biomedical signal analysis, biomedical image processing and their hardware implementation with exploration through computer vision and Instrumentation.	1,2,3,4,5
2	The graduates will demonstrate an ability to analyze, formulate and solve problems related to Bioelectronics devices and system design.	Nil		8	The graduates will have good background for progression onto research programs and competitive examinations of national and international repute.	1,2,3,4,5
3	The graduates will develop	1,2,3,4,5		9	The graduates will have a	1,2,3,4,5

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	an ability to design and implement projects and carry out research in interdisciplinary and emerging areas for application in health care, food safety and bio-inspired systems.				good understanding of professional and ethical responsibility.	
4	The graduates will display an ability to contribute in the transformation of the economy through knowledge-based initiatives.	1,2,3,4,5		10	The graduates will be able to demonstrate effective communication skills, both written and oral.	nil
5	The graduates will have knowledge and exposure on different phenomena occurring in semiconductor materials, biological materials, aqueous solutions, solid-solid junction, and motion in solution and chemical reactions.	nil		11	The graduates will have a good understanding for the need of life long learning and will be able to work in teams.	1,2,3,4,5
6	The graduates will have knowledge to use, fabrication and characterize bioelectronic devices such as ISFET, CNTISFET, BioFETs, CNTBioFETs.	nil				

Course Code and Title with L-T-P Structure: **BE-515: Basic Bioelectronics (3-0-0)**
Semester : **1st Semester**
Programme : **M Tech in Bioelectronics**
Course Offering Department : **Electronics and Communication Engineering**

Syllabus

Theory:

Basic Electronics: Semiconductor Materials, chemical and physical bonds, Intrinsic and extrinsic semiconductors, carrier motion in semiconductors – Drift, Diffusion And Recombination – Generation process, Boltzmann Transport equation, P-N junction diode, Bipolar Junction Transistor (BJT), Field Effect Transistor (FET), Operational Amplifier (OPAMP). Digital Logic: Boolean Algebra and logic gates, Combinational logic circuit, sequential logic circuit – flip flops. Biological materials: analogy between semiconductor and biological materials, water and electrolyte solutions; biological molecules - Proteins, Nucleic acids, Phospholipids; cell membrane; Eucaryotic cell. Motion in solution and chemical reaction: Diffusion, Brownian motion, electrophoresis, enzyme kinetics; Solid electrolyte junctions: electrode-electrolyte interfaces, Poisson –Boltzmann equation, Membrane transport, Nernst-Plank equation and solution.

Course Outcomes:

At the end of this course students will demonstrate the ability

1. For transformation of the conception acquired from the knowledge of properties exhibited by semiconductor materials to the Biological domain.
2. For transformation of conception acquired from the knowledge of characteristics shown by solid-solid junction to liquid-solid junction.
3. To acquire conceptual frame work for modeling bio-chemical activities compatible with semiconductor domain.
4. To exhibit the capability of knowledge required to hybridize electronics domain with bio-chemical domain.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) of M.Tech. in Bioelectronics

SN	Program Outcome (PO)	CO		SN	Program Outcome (PO)	CO
1	The graduates will demonstrate knowledge and concepts which are competitive for application in bioelectronics and allied disciplines.	1,2		7	The graduates will have knowledge in Biomedical signal analysis, biomedical image processing and their hardware implementation with exploration through computer vision and Instrumentation.	
2	The graduates will demonstrate an ability to analyze, formulate and solve problems related to Bioelectronics devices and system design.	3,4		8	The graduates will have good background for progression onto research programs and competitive examinations of national and international repute.	2,3,4

3	The graduates will develop an ability to design and implement projects and carry out research in interdisciplinary and emerging areas for application in health care, food safety and bio-inspired systems.	4		9	The graduates will have a good understanding of professional and ethical responsibility.	
4	The graduates will display an ability to contribute in the transformation of the economy through knowledge-based initiatives.			10	The graduates will be able to demonstrate effective communication skills, both written and oral.	1,2,3,4
5	The graduates will have knowledge and exposure on different phenomena occurring in semiconductor materials, biological materials, aqueous solutions, solid-solid junction, and motion in solution and chemical reactions.	1,2		11	The graduates will have a good understanding for the need of life long learning and will be able to work in teams.	3,4
6	The graduates will have knowledge to use, fabrication and characterize bioelectronic devices such as ISFET, CNTISFET, BioFETs, CNTBioFETs.					

Course Code and Title with L-T-P Structure: **BE-517: Biomedical Signal Processing (3-0-1)**
Semester : **1st Semester**
Programme : **M Tech in Bioelectronics**
Course Offering Department : **Electronics and Communication Engineering**

Syllabus

Unit 1: Biomedical Signals:

- Genesis of bioelectric potential, ECG, EEG, and EMG
- Measurement of ECG, EEG and EMG
- Overview of analog signal analysis: time and frequency domain representation of signal
- Fourier series and Fourier transform
- Correlation, convolution and filtering
- Random signal-correlation and spectral representation

Unit 2: Digitization of Signal:

- Sampling theorem, quantization, quantizing effects
- A/D conversion, aliasing artifacts in biomedical signals

Unit 3: Discrete transforms:

- Discrete time Fourier transform, DFT and FFT
- Z-transform and properties

Unit 4: Digital filters:

- FIR and IIR filter
- Biomedical applications of digital filtering- removal of power line interference from ECG data, reducing ECG artifact from EMG data.
- ECG preprocessing, wave form recognition, morphological studies and rhythm analysis
- Automated diagnosis based on decision theory
- Optimal and adaptive filtering theory

Unit 5: Event Detection:

- Detection of events and waves in ECG
- Correlation analysis of EEG channels for EEG rhythm detection
- Matched filter for detection of EEG spikes

Course Outcomes (COs)

Towards the end of the course the student will be expected to –

1. Explain the basic principles of quantization and sampling for conversion of an analog signal to a digital signal.
2. Explain the concepts of discrete Fourier transform (DFT), z-transform, and Laplace transform.

3. Extend analog domain filter design to discrete-time using impulse invariance, bilinear transformations, etc.
4. Explain the formation of an electrical signal in any living system.
5. Identify different biomedical signals and explain how they are acquired from a human body.
6. Explain artifacts of biomedical signals and their removal using signal processing algorithms.
7. Explain detection of important physiological events from a biomedical signal.
8. Understand how bio-signals (after acquisition) are processed in one and higher dimensions.
9. Acquire basic skills needed to design a bioelectric signal analysis tool in MATLAB/Python and report their findings effectively.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) of M.Tech. in Bioelectronics

SN	Program Outcome (PO)	CO
1	The graduates will be able to apply the concepts of Engineering mathematics through Laplace, z-transform, linear algebra, probability and statistics, differential equations etc. and basic knowledge of engineering physics and chemistry.	1,2,3
2	The graduates will be able to understand, interpret the problem, design and perform the experiments to meet the desired solution of the problem within the context of electronics and communication engineering.	4,5,6,7,9
3	The graduates will have a good understanding of professional and ethical responsibility.	7,9
4	The graduates will be able to express themselves effectively through written and oral communication.	9
5	The graduates will have a good understanding and knowledge in applying the engineering solutions to society.	7,9
6	The graduates will have a good understanding for the need of lifelong learning and will be able to work in teams.	7,9
7	The graduates will show good proficiency in applying the techniques and knowledge of modern engineering skills in tackling contemporary technological challenges.	5,6,7
8	The graduates will have good background for admission to post graduate programs (in same domain), management degree programs and also research programs in various organizations of national and international repute.	1,2,3,6
9	The graduates will be able to participate and succeed in competitive examinations.	1,2,3

Course Code and Title with L-T-P Structure: **BE-519: Bioinspired Systems and Engineering (3-0-0)**
Semester : **1st Semester**
Programme : **M Tech in Bioelectronics**
Course Offering Department : **Electronics and Communication Engineering**

Syllabus

Biologically inspired artificial devices: artificial Heart and circulatory assist devices, artificial lungs, artificial kidney, artificial cell, artificial muscle.

Artificial vision: Computer vision – word recognition, feature extraction based on biological visual system, stereo vision; speech recognition.

Biologically inspired systems : Robotic systems and devices, acoustical systems, computing system such as neural network, bioinspired exploration, bioinspired computer architectures.

Course Outcomes (COs)

Upon completion of the course, the student will be able to

1. Understand the concept of biologically inspired artificial devices.
2. Understand the basic concept of biologically inspired computational methods.
3. Comprehend the concepts of feed forward neural networks and application of neural networks to real world systems.
4. Understand the basic concept of robotics and applications.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) of M.Tech. in Bioelectronics

SN	Program Outcome (PO)	CO		SN	Program Outcome (PO)	CO
1	The graduates will demonstrate knowledge and concepts which are competitive for application in bioelectronics and allied disciplines.	1,2,3,4		7	The graduates will have knowledge in Biomedical signal analysis, biomedical image processing and their hardware implementation with exploration through computer vision and Instrumentation.	2,3
2	The graduates will demonstrate an ability to analyze, formulate and solve problems related to Bioelectronics devices and system design.	3,4		8	The graduates will have good background for progression onto research programs and competitive examinations of national and international repute.	1,2,3,4
3	The graduates will develop an ability to design and implement projects and carry out research in interdisciplinary and emerging areas for application in health care, food safety and bio-inspired systems.	1,2,3,4		9	The graduates will have a good understanding of professional and ethical responsibility.	
4	The graduates will display an ability to contribute in the			10	The graduates will be able to demonstrate effective	

	transformation of the economy through knowledge-based initiatives.				communication skills, both written and oral.	
5	The graduates will have knowledge and exposure on different phenomena occurring in semiconductor materials, biological materials, aqueous solutions, solid-solid junction, and motion in solution and chemical reactions.			11	The graduates will have a good understanding for the need of life long learning and will be able to work in teams.	
6	The graduates will have knowledge to use, fabrication and characterize bioelectronic devices such as ISFET, CNTISFET, BioFETs, CNTBioFETs.					

Course Code and Title with L-T-P Structure: **BE-509: Biomathematics: (3-0-0)**
Semester : **1st Semester**
Programme : **M Tech in Bioelectronics**
Course Offering Department : **Electronics and Communication Engineering**

Syllabus

Modeling of biophysical systems, differential equation formulation-linear and non-linear, solution techniques, finite element analysis, engineering design concept of some systems of human body, mathematical modeling of muscles, modeling the dynamic of human extremities, arm movement and its model, eye movement, cardiovascular modeling ,dynamics of heart, blood flow, respiratory modeling, mechanics of heart valves, mechanics of blood vessels.

Course Outcomes (COs)

At the end of this course students will demonstrate the ability to

1. Apply differential equation in engineering design of some systems of human body
2. Apply for mathematical modelling of human diseases
3. Apply cardiovascular respiratory modeling in different diseases of human body
4. Apply mathematical model in engineering solutions in different biological species
5. Discuss the standard protocols based on the biomathematical model in diagnosis of diseases

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) of Electronics and Communication Engineering

SN	Program Outcome (PO)	CO		SN	Program Outcome (PO)	CO
1	The graduates will demonstrate knowledge and concepts which are competitive for application in bioelectronics and allied disciplines.	2,3,4,5		7	The graduates will have knowledge in Biomedical signal analysis, biomedical image processing and their hardware implementation with exploration through computer vision and Instrumentation.	1
2	The graduates will demonstrate an ability to analyze, formulate and solve problems related to Bioelectronics devices and system design.	1,2,3,4,5		8	The graduates will have good background for progression onto research programs and competitive examinations of national and international repute.	1,2
3	The graduates will develop an ability to design and implement projects and carry out research in interdisciplinary and emerging areas for application in health care, food safety and bio-inspired systems.	3,4,5		9	The graduates will have a good understanding of professional and ethical responsibility.	2,3
4	The graduates will display an ability to contribute in the transformation of the			10	The graduates will be able to demonstrate effective communication skills, both	12,3,4

	economy through knowledge-based initiatives.				written and oral.	
5	The graduates will have knowledge and exposure on different phenomena occurring in semiconductor materials, biological materials, aqueous solutions, solid-solid junction, and motion in solution and chemical reactions.			11	The graduates will have a good understanding for the need of life long learning and will be able to work in teams.	
6	The graduates will have knowledge to use, fabrication and characterize bioelectronic devices such as ISFET, CNTISFET, BioFETs, CNTBioFETs.					

Course Code and Title with L-T-P Structure: **BE-513: Biomedical Electronics (3-0-0))**
Semester : **1st Semester**
Programme : **M Tech in Bioelectronics**
Course Offering Department : **Electronics and Communication Engineering**

Syllabus

Physiological systems and Signals: Biology of the heart, circulatory and respiratory systems, auditory systems, physiology of nerve and muscle cells, fundamental organization of brain and spinal cord. Biosignals: Origin of bioelectric signals, electrocardiogram (ECG), phonocardiogram (PCG), encephalogram (EEG) and electromyogram (EMG).

(10 Lectures)

Physiological Transducers: Electrodes: silver-silver chloride electrodes, electrodes for ECG, EEG, EMG, Microelectrodes. Performance characteristics of transducers, classification of transducers based on Electrical principle involved: Resistive position transducer, resistive pressure transducer, inductive pressure transducer, capacitive pressure transducer; Self generating inductive transducer: linear variable differential transformer (LVDT), Piezoelectric Transducer.

(8 Lectures)

Recording Systems: Preamplifier, Signal conditioning: Differential amplifier, current to voltage converter, instrumentation amplifier; biomedical filters: LPF, HPF, bandpass, band stop (Notch filter); source of noise in low level measurement, Recording systems for ECG, PCG, EEG and EMG.

(6 Lectures)

Medical Imaging Systems: X-ray imaging, Computed tomography, ultrasonic imaging systems, Magnetic resonance imaging system, thermal imaging systems. Therapeutic equipments: Cardiac pacemaker, cardiac defibrillators, haemodylysis machine.

(6 Lectures)

Course Outcomes (COs)

Towards the end of the course the student will be able to –

1. Identify, formulate, and solve multi-disciplinary problems in the area of biomedical engineering by applying principles and technologies learned in BE-513.
2. Design a system, component, or process, and synthesise solutions to achieve desired needs for solving a problem in biomedical engineering.
3. Acquire and apply new knowledge as needed to work in the area of biomedical engineering.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) of M. Tech. in BioElectronics

SN	Program Outcome (PO)	CO	SN	Program Outcome (PO)	CO
1	The graduates will demonstrate knowledge and concepts which are competitive for application in bioelectronics and allied disciplines.	1	7	The graduates will have knowledge in Biomedical signal analysis, biomedical image processing and their hardware implementation with exploration through computer vision and Instrumentation.	
2	The graduates will demonstrate an ability to analyze, formulate and solve problems related to Bioelectronics devices and system design.		8	The graduates will have good background for progression onto research programs and competitive examinations of national and international repute.	1,2
3	The graduates will develop an ability to design and implement projects and carry out research in interdisciplinary and emerging areas for application in health care, food safety and bio-inspired systems.	1,2	9	The graduates will have a good understanding of professional and ethical responsibility.	
4	The graduates will display an ability to contribute in the transformation of the economy through knowledge-based initiatives.	1	10	The graduates will be able to demonstrate effective communication skills, both written and oral.	
5	The graduates will have knowledge and exposure on different phenomena occurring in semiconductor materials, biological materials, aqueous solutions, solid-solid junction, and motion in solution and chemical reactions.		11	The graduates will have a good understanding for the need of life long learning and will be able to work in teams.	3
6	The graduates will have knowledge to use, fabrication and characterize bioelectronic devices such as ISFET, CNTISFET, BioFETs, CNTBioFETs.				