V SEMESTER

Course Title	**MEDICAL IMAGING SYSTEMS**						
Course Code	**21MDT501**						
Category	Professional Core Course(PCC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	00	00	03	39	3
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES:

1. To understand x-ray generation and biological effects.
2. To study different x-ray diagnostic methods.
3. To study CT imaging concepts, fundamental of Magnetic resonance imaging..
4. To study Generation and detection of ultrasound and its techniques.
5. To study the principles of Radionuclide imaging

UNIT No	Syllabus Content	No of Hours
1	**X-RAY IMAGING:** Generation and Detection of X-rays – X-ray generation, X-ray generators, Filters, Beam restrictors and grids, Intensifying screens, fluorescent screens, and image intensifiers, X-ray detectors, X-ray image characteristics – Spatial resolution, Image noise, Image contrast, Biological effects of ionizing radiation.	**7**
2	**X-RAY DIAGNOSTIC METHODS:** Conventional X-ray radiography, Fluoroscopy, Angiography, Mammography and Xeroradiography, Image subtraction. **COMPUTED TOMOGRAPHY:** Conventional tomography, Computed tomography, Algorithms for image reconstruction: parallel and Fan beam data, Spiral CT. Recent developments – Digital radiography.	**8**
3	**ULTRASOUND IMAGING:** Generation and detection of Ultrasound-Piezoelectric effect, Ultrasonic transducers, **ULTRASONIC DIAGNOSTIC METHODS :**Pulse echo systems-Amplitude mode (A-mode), Brightness mode (B-mode), Motion mode (M-mode), Constant depth mode (C-mode), Doppler methods, Duplex imaging, Tissue characterization, Colour Doppler flow imaging, Image characteristics – Ultrasonic texture or speckle, Speckle reduction, Compensation of phase aberration, Biological effects of ultrasound.	**8**

4	**RADIONUCLIDE IMAGING:** Generation & Detection of Nuclear Emission – Radionuclide generators, nuclear radiation detectors, Collimators, Radionuclide imaging systems- Gamma Camera, SPECT, PET. **BASICS OF MAGNETIC RESONANCE IMAGING:** fundamentals of nuclear magnetic resonance- Angular momentum, magnetic dipole moment, magnetization, Larmor frequency, Rotating frame of reference and RF magnetic field, Free induction decay (FID), Fourier spectrum of the NMR signal, Spin density, Relaxation times, Pulse sequences.	**8**
5	**MRI SYSTEM & IMAGING METHODS : M**agnetic field gradients, NMR Coil/Probe, Transmitter, Receiver, Data acquisition. Imaging Methods- Introduction, slice selection, frequency encoding, phase encoding, Spin-Echo imaging- Characteristics of MRI images- spatial resolution, image contrast. Functional MRI.	**8**

COURSE OUTCOMES: On the completion of the course the students will be able to
CO1: Understand the X-ray fundamentals and its characteristics.
CO2: Understand the X-ray diagnostic methods and CT imaging.
CO3: Understand the Ultra sound imaging and diagnostics methods.
CO4: Understand the properties of radio nuclides and its applications.
CO5: Understand the MRI system and imaging methods.

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2					1	1					2	1		1
CO2	1					2						2	1		1
CO3					2							2	1		1
CO4						1		1				2	1		2
CO5										1	1	3	1		1
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOKS:

1. **Principles of Medical Imaging**, Kirk Shung, Michael B. Smith and Banjamin Tsui, Academic Press, 1992.
2. **Handbook of Biomedical Instrumentation**, R.S.Khandpur, Tata McGraw Hill, 2nd Edition, 2003.

REFERENCE BOOK:

1. **Fundamentals of Medical Imaging**, Paul Suetens, Cambridge University Press, 2002.

CHAIRMAN/BOS **DEAN (ACADEMIC)** **CHAIRMAN/ACADEMIC COUNCIL**

Course Title	**PYTHON PROGRAMMING**						
Course Code	**21MDT502**						
Category	Integrated Professional Core Course(IPCC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	02	00	05	65	4
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES :To make the student learn

1. Understanding the syntax and semantics of the Python language.
2. To create Functions in Python.
3. To handle Files & Regular expressions in Python.
4. To apply Object Oriented Programming concepts in Python

UNIT No	Syllabus Content	No of Hours
1	Introduction to Python Programming: Variables, Expressions and Statements: Values and types, Variables, Variable names and keywords, Statements, Operators and operands, Expressions, Order of operations, Modulus operator, String operations, Asking the user for input, Comments, Choosing mnemonic variable names. Conditional Execution: Boolean expressions, Logical operators, Conditional execution, Alternative execution, Chained conditionals, Nested conditionals, Catching exceptions using try and except, Short circuit evaluation of logical expressions.	**7**
2	Functions Iteration, Strings : Function calls, Built-in functions, Type conversion functions, Random numbers , Math functions, Adding new functions, Dentitions and uses, Flow of execution, Parameters and arguments, Fruitful functions and void functions, Iteration: Updating variables, The while statement, Infinite loops and break, Finishing iterations with continue, Definite loops using for, Loop patterns. Strings: Traversal through a string with a loop, String slices, Strings are immutable, Looping and counting, The in operator, String comparison, String method**s,** Parsing strings, Format operator	**8**

3	Files ,Lists, Dictionaries, Tuples, Regular Expressions: Persistence, Opening files, Reading files, Writing files. Lists: A list is a sequence, Lists are mutable, Traversing a list, List operations, List slices, List methods, Deleting elements, Lists and functions, Lists and strings, Parsing lines, Objects and values, Aliasing, List arguments. Dictionaries: Dictionary as a set of counters, Dictionaries and files, Looping and dictionaries, Advanced text parsing. Tuples: Tuples are immutable, Comparing tuples, Tuple assignment, Dictionaries and tuples, Multiple assignments with dictionaries, The most common words, Using tuples as keys in dictionaries, Sequences: strings, lists, and tuples. Regular expressions: Character matching in regular expressions, Extracting data using regular expressions, Combining searching and extracting, Escape character	**8**
4	**Classes and objects, Classes and functions, Classes and methods** User-defined compound types, Attributes, Rectangles, Instances as return values, Objects are mutable, Copying. Classes and Functions: Time, Pure functions, Modifiers, Prototyping development versus planning. Classes and Methods: Object-oriented features, Printing objects, Another example, A more complicated example, The init method, Operator overloading, Polymorphism	**8**
5	**Linked Lists and Stack:** Embedded references, The Node class, Lists as collections, Lists and recursion, Infinite lists, The fundamental ambiguity theorem, Modifying lists, Wrappers and helpers, The Linked List class, Invariants. Stacks: Abstract data types, The Stack ADT, Implementing stacks with Python lists, Pushing and popping, Using a stack to evaluate postfix, Parsing, Evaluating postfix, Clients and providers. Queues: The Queue ADT, Linked Queue, Performance characteristics, Priority queue, The Golfer class	**8**

Note 1: No questions on Review portions from Unit 1
Note 2: Assignment-1 & 2 Programming examples

COURSE OUTCOMES: On Completion of the course the students should be able to:
CO1: Examine Python syntax and semantics and be fluent in the use of Python flow control and functions.
CO2: Demonstrate proficiency in handling Strings and File Systems.
CO3: Create, run and manipulate Python Programs using core data structures like Lists, Dictionaries and use Regular Expressions.
CO4: Interpret the concepts of Object-Oriented Programming as used in Python.
CO5: Implement exemplary applications related to Network Programming, Web Services and Databases in Python

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1								3	1		1
CO2	1	1	2									3	1		1
CO3	2	2	2	2					2				1		1
CO4	1	1	1						1				1		2
CO5	1	1	2	2	2					2		3	1		1
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOKS:

1.**Python for Informatics**, Charles Severance, 1st Edition, CreateSpace Independent Publishing Platform, 2013.

2. **How to Think Like a Computer Scientist: Learning with Python**, Peter Wentworth, Jeffrey Elkner, Allen B. Downey, Chris Meyers 2nd Edition, Open Book Project, 2012.

REFERENCE BOOKS:

1. **Learning Python**, Mark Lutz, 5th Edition, O'Reilly Media, 2013.
2. **Core Python Applications Programming** Wesley Chun 3rd Edition, 2012
3. **Python in a Nutshell**, Alex Martelli, 2nd Edition, 2006 .
4. http://openbookproject.net/thinkcs/python/english2eGardner

LAB COMPONENT

UNIT No	Syllabus Content
1	Introduction to python and installation
Programs illustrating the following concepts	
2	Data , Expressions, statements
3	Control flow, Loops
4	Functions, Arrays
5	Lists, Tuples, Dictionaries
6	Files, Exceptions
7	Modules, Packages

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

Course Title	**PHYSIOLOGICAL CONTROL SYSTEMS**						
Course Code	**21MDT503**						
Category	Professional Core Course(PCC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	00	00	03	39	3
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES:

1. To discuss the mathematical modeling of systems.
2. To distinguish physiological and engineering control system.
3. Learn the time response of feedback control systems.
4. Learn the different methods of stability analysis (in time domain and frequency domain).

UNIT No	Syllabus Content	No of Hours
1	**Modeling of Systems:** The control system, Mathematical models of physical systems – Introduction, Differential equations of physical systems – Mechanical systems, Friction, Translational systems (Mechanical accelerometer, Levered systems excluded), Rotational systems, Electrical systems, Analogous systems.	**7**
2	**Introduction To Physiological Control Systems:** Preliminary considerations, Historical Background, System analysis, Physiological systems-A simple example, Differences between engineering & physiological control systems. **Mathematical Modeling:** Generalized system properties, Models with combination of system elements, Linear models of physiological systems-respiratory and muscle mechanics. Linearized respiratory mechanics. **Simulink experiments on modeling physiological systems**	**7**
3	**Time Response of feedback control systems**: Standard test signals, Unit step response of First and second order systems, Time response specifications, Time response specifications of second order systems, steady – state errors and error constants. **Static Analysis Of Physiological Systems:** regulation of cardiac output, regulation of glucose, chemical regulation of ventilation. **MATLAB Exercise (Practice only) :** **Time domain Analysis of first order and second order system**	**8**

4	**Stability analysis:** Concepts of stability, Necessary conditions for Stability, Routh- stability criterion, Relative stability analysis; More on the Routh stability criterion.. **Root–Locus Techniques**: Introduction, The root locus concepts, Construction of root loci and its plots.	**9**
5	**Stability in the frequency domain:** Mathematical preliminaries, Nyquist Stability criterion, Assessment of relative stability using Nyquist criterion **Frequency domain analysis:** Introduction, Correlation between time and frequency response, Bode plots. **MATLAB Exercise (Practice only) :** **Verifying the parameters computed for numerical examples using MATLAB for Root locus, Bode Plot and Nyquist Plot**	**9**

Note1: Assignment-1 from unit 1 and 2.
Asssignment-2 from unit 3, 4 and 5 and simulation experiments using MATLAB

COURSE OUTCOMES: The students will be able to

CO1: Understand and develop mathematical modeling of mechanical & electrical systems.
CO2: Mathematically model the physiological systems & relate it to the Engineering control system.
CO3: Understand and determine the time domain parameters of first and second order system.
CO4: Apply the different methods of stability analysis in time domain.
CO5: To understand the stability in frequency domain.

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		3										1		1
CO2	2		3										1		1
CO3			3	2		2							1		1
CO4			3	2		2							1		2
CO5					2							2	1		1
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOK :

1**. Control Systems Engineering**, J. Nagarath and M.Gopal, New Age International (P) Limited, Fourth edition ,2005.
2. **Physiological Control Systems – Analysis, Simulation & Estimation**, Michael C Khoo, Wiley IEEE press.

REFERENCE BOOKS:

1. **Modern Control Engineering ,** K. Ogata, Pearson Education Asia/ PHI, 4th Edition, 2002.
2. **Concepts of Control Systems,** P. S. Satyanarayana; Dynaram publishers, 2001.

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

Course Title	**BIOMEDICAL EQUIPMENTS**						
Course Code	**21MDT504**						
Category	Professional Core Course(PCC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	00	00	03	39	3
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES:

1. To study spectrophotometer, clinical flame photometer.
2. To study different blood gas analyzers
3. To study different types of Audiometers
4. To understand the working principle of surgical diathermy.
5. To study hemodialysis and different ventilators

UNIT No	Syllabus Content	No of Hours
1	**CLINICAL LABORATORY INSTRUMENTS:** Medical diagnosis with clinical tests, spectrophotometry-components, clinical flame photometer, ion-selective electrode based analyzers.	**7**
2	**BLOOD GAS ANALYZERS:** Acid-base balance, blood pH measurement, measurement of blood pCO2, measurement of blood pO2, intra-arterial blood gas monitoring, complete blood gas analyzer. **BLOOD CELL COUNTERS**: Types of blood cells, Coulter counter, automatic recognition and differential counting of cells.	**8**
3	**AUDIOMETER AND HEARING AIDS:** Mechanism of hearing, measurement of sound, basic audiometer, pure-tone audiometer, speech audiometer, audiometer system Bekesy, evoked response audiometer system, hearing aids-digital hearing aid, cochlear implants.	**8**
4	**INSTRUMENTS OF SURGERY:** Principles of surgical diathermy, surgical diathermy machine, automated electro-surgical systems, electrodes used with surgical diathermy, safety aspects in electro-surgical units, surgical diathermy analyzer. **PHYSIOTHERAPY AND ELECTROTHERAPY EQUIPMENTS:** High frequency ,heat therapy, short wave diathermy, microwave diathermy, ultrasound therapy unit, electro diagnostic therapeutic apparatus, pain relief through electrical stimulation ,bladder and cerebral stimulators.	**8**

5	**HAEMODIALYSIS MACHINE:** Function of kidney, artificial kidney, dialyzer, membranes for hemodialysis, portable kidney machine. **VENTILATORS:** Mechanics of respiration, artificial ventilation, ventilators, types of ventilators, ventilator terms, classification of ventilators, pressure volume flow diagrams, modern ventilators, high frequency ventilators, humidifiers, nebulizers and aspirators	**8**

Note1: Assignment-1 from unit 1 and 2.
Asssignment-2 from unit 3, 4 and 5.

COURSE OUTCOMES: On the completion of the course the students will be able to

CO1: Understand the working & application of clinical lab instruments.
CO2: Understand the measurement of blood gas analyzers, blood cell counters.
CO3: Understand the human hearing mechanism, identify the defects in hearing mechanism and adapt the hearing aids.
CO4: Understand the working of surgical equipments and the functioning of various physiotherapy equipments.
CO5: Understand the functioning of kidney and working of artificial kidney and the functioning of breathing mechanism and ventilators .

.

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	1									1		1
CO2	1	1	1	1									1		1
CO3	1	1	1	2								3	1		1
CO4	1	1	1	2								2	1		2
CO5	1	2	2	2								3	1		1
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOK:

1. **Handbook of Biomedical Instrumentation** – by R.S.Khandpur, 2nd Edition, Tata McGraw Hill, 2003

REFERENCE BOOK:

1. **Biomedical Instrumentation and Measurement** – by Leslie Cromwell, Fred J Weibell and Erich A. Pfeiffer, Prentice-Hall India Pvt. Ltd.

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

Course Title	**BIOMEDICAL INSTRUMENTATION LAB**						
Course Code	**21MDL505**						
Category	Professional Core Lab(PCL)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	00	00	02	00	02	26	1
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES: The student will understand

1. The transducer principle, type,measurement of physiological parameter
2. The bio signal measurement
3. Analytical instruments such as colorimeter, pH meter
4. Medical Instrumentation such as X- ray, Ultrasound, Recorders

UNIT No	Syllabus Content
1	Plotting the characteristics & Determination of parameters of: a) Resistive strain gage (b) Photoelectric transducer (c) Temperature transducers: RTD / thermocouple / thermistor.
2	Determination of characteristics of: (a) Polarized electrode; (b) Non-polarized electrode (c) Multipoint electrode.
3	Design & Testing of: (a) DC amplifier (b) Isolation amplifier.
4	Design & Testing of: (a) Instrumentation amplifier; (b) Transducer bridge with amplifier.
5	Recording of ECG: (a) Determination of time & amplitude of QRS complex, (b) Calculation of Heart Rate, (c) Determination of Cardiac Vector.
6	Recording of EEG.
7	Measurement of Hearing threshold using Audiometer and plot its characteristics.
8	Measurement of pH of a given solution using pH meter.
9	Determination of solution concentration using Colorimeter/Spectrophotometer.
10	Measurement of Blood Pressure using Sphygmomanometer & Digital meter.
11	Study of (a) Ultrasound transducers & Ultrasonic blood flow meters, (b) X-ray

COURSE OUTCOMES: The student will be able to

CO1: Measure the parameters, temperature, PH, Blood pressure using the transducers
CO2: Design & test instrumentation amplifier for physiological parameters
CO3: Record EEG, ECG signal & measure hearing threshold using the recorders available in the lab
CO4: Understand the working concepts of ultrasound transducers

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1		1						3	2	3	1
CO2	1	1	2	2		1						3	2	3	1
CO3	1	1	1	1	2	1						3	1		
CO4	1	1	1	1		1						3			
Strength of Correlation: Low-1, Medium-2, High-3															

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

Course Title	**MEDICAL IMAGE PROCESSING LAB**						
Course Code	**21MDL5081**						
Category	Ability Enhancement Course (AEC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	00	00	02	00	02	26	1
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hour**		

COURSE OBJECTIVES:

Familiarizing the student with the basic concepts of image processing such as enhancement and segmentation using MATLAB.

UNIT No	Syllabus Content
1	Basic operations on an image: Logical operations, Resizing, Rotation, Translation, Negative of an image
2	Relationship between pixels
3	Contrast stretching
4	Histogram and histogram equalization
5	Intensity Slicing
6	Bit planes of an image
7	Image Segmentation: Threshold, multiple threshold
8	Spatial domain filters: LP, Median, HP
9	Edge detection using gradient filters
10	FFT of an image
11	Computation of Mean, Standard Deviation, Correlation coefficient
Open End Experiment	

COURSE OUTCOME: The student will be able

CO1: To implement basic operations

CO2: To Implement image enhancement techniques

CO3: To implement image segmentation techniques

CO4: Design and develop any biomedical image processing application using MATLAB

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2				3							3	1		
CO2			3		3							3	1		2
CO3			3		3							3	1		
CO4	2	3	3		3						3	3	2		3
Strength of Correlation: Low-1, Medium-2, High-3															

CHAIRMAN/BOS **DEAN (ACADEMIC)** **CHAIRMAN/ACADEMIC COUNCIL**

VI SEMESTER

Course Title	**BIOMEDICAL DIGITAL SIGNAL PROCESSING**						
Course Code	**21MDT602**						
Category	Integrated Professional Core Course(IPCC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	02	00	05	65	4
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES:

1. To learn the nature of various biomedical signals and its analysis.
2. To know about neurological signal generation.
3. To study sleep EEG types and their features.
4. To study adaptive filters and their applications in biomedical signal processing.
5. To gain knowledge about various artefacts and methods to eliminate it.
6. To study cardiological signal processing

UNIT No	Syllabus Content	No of Hours
1	**INTRODUCTION TO BIOMEDICAL SIGNALS:** The nature of biomedical signals, the action potential, objectives of biomedical signal analysis, Difficulties in biomedical signal analysis, computer aided diagnosis. Neurological signal processing: The brain and its potentials, The electrophysiological origin of brain waves, The EEG signal and its characteristics, EEG analysis.EMG signal characteristic and analysis	**7**
2	**SLEEP EEG:** Data acquisition and classification of sleep stages, The Markov model and Markov chains, Dynamics of sleep-wake transitions, Hypnogram model parameters, and Event history analysis for modeling sleep.	**8**
3	**ADAPTIVE FILTERS:** Principle of an adaptive filter, the steepest descent algorithm, adaptive noise canceller, cancellation of 60 Hz interference in electrocardiography, applications of adaptive filters. Canceling donor - heart interference in heart-transplant electrocardiography, Cancellation of ECG signal from the electrical activity of the chest muscles, canceling of maternal ECG in fetal ECG, Cancellation of High frequency noise in Electro - surgery.	**8**
4	**SIGNAL AVERAGING:** Basics of signal averaging, a typical signal averager, signal averaging as a digital filter, Removal of artifacts by averaging. Filtering for removal of artifacts**:** Introduction, Random noise, structured noise and physiological interference, stationary versus non stationary process, high frequency noise in ECG, motion artifact in ECG, power line interference in ECG signals, muscle contraction interference in VAG signals.	**8**

5	**CARDIOLOGICAL SIGNAL PROCESSING:** Pre-processing. ECG QRS Detection techniques. Rhythm analysis. Arrhythmia detection Algorithms. Automated ECG Analysis. ECG Pattern Recognition. Heart rate variability analysis, ST–segment analyzer, portable, arrhythmia monitors.	**8**

Note 1 : Assignment-1 from unit 1 and 2.
Asssignment 2- from unit 3,4 & 5.

COURSE OUTCOMES: The students would have learnt to
CO1: Analyze and interpret Electro-physiological signals.
CO2: Acquire EEG & interpret the models of sleep EEG
CO3: To understand principle of Weiner filter, design and implementation of adaptive filters.
CO4: Identify noise sources in ECG signal & apply filtering using averaging technique
CO5: Classify & detect abnormality in ECG signals.

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2										3	1		1
CO2	1	2										3	1		1
CO3	1		3									3	1		1
CO4	1	2	3									3	1		2
CO5		3	3									3	1		1
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOKS:

1. **Biomedical Digital Signal Processing**,Willis J.Tompkins, PHI.
2. **Biomedical Signal Processing- Principles and Techniques**, Tata McGraw-Hill, D.C.Reddy, 2005.
3. **Biomedical Signal Analysis**, Rangaraj M. Rangayyan, IEEE Press, 2001.
4. **Wavelet Transforms** , Raghuveer M. Rao and Ajit S. Bopardikar, Pearson, 1998.

REFERENCE BOOKS:

1. **Biomedical Signal Processing ,** Akay M, Academic Press ,1994
2. **Biomedical Signal Processing ,** Cohen.A, Vol. I , CRC Press, 1986.

LAB COMPONENT

UNIT No	Syllabus Content
1	Analysis of ECG data: Original signal, Noise signal and filtered signal
2	Realization of IIR and FIR filters for ECG
3	PSD estimation for ECG, EEG, and EMG
4	R-R interval sequence interpretation
5	Analysis of Real time ECG signals acquired through Power Lab data acquisition system

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

Course Title	**NEURAL NETWORK & MACHINE LEARNING**						
Course Code	**21MDT603**						
Category	Professional Core Course(PCC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	00	00	03	39	3
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES: The student will understand

1. The concepts of biological neuron and analogy to the artificial neuron model
2. Different neural network architecture
3. Various learning paradigms and comparisons

UNIT No	Syllabus Content	No of Hours
1	**INTRODUCTION TO BIOLOGICAL NEURAL NETWORK:** Classic neuron, Bioelectric potential, Electrochemical mechanism of action potential, Nernst equation-electrochemistry give rise to electrical events. **ARTIFICIAL NEURAL NETWORK:** introduction to ANN, model of a neuron, Types of activation function, neural networks viewed as directed graphs, architectural graph of a neuron with feedback, Network Architectures.	**8**
2	**LEARNING PROCESSES**: Learning in context to neural Networks, learning paradigms, supervised & unsupervised learning, Five basic learning rules Hebbian learning, learning tasks, Memory, adaptation, Statistical nature of learning processes.	**8**
3	**SINGLE LAYER PERCEPTION:** Introduction, Adaptive filtering problem, Unconstrained optimization techniques, Newton's method, Gauss-Newton method, Linear least square filter, Least mean square algorithm, Learning curves, Learning Rate, Annealing techniques, Perceptron.	**7**
4	**MULTILAYER PERCETRON:** Introduction, Some Preliminaries, Back propagation algorithm, XOR Problem, Hessian matrix, generalization, Cross validation.	**8**
5	**Statistical Decision Making:** Introduction, Bayes' theorem, multiple features, conditionally independent features, Decision boundaries: Two Dimensional decision boundaries **Clustering** Introduction, Hierarchical clustering-agglomerative, single linkage, average linkage, ward's method. Partitional clustering-Forgy's, k-means, **CNN :** Introduction, architecture, application.	**8**

Note: Assignment-1 from unit 1 and 2.
Asssignment-2 from unit 3, 4 and 5

COURSE OUTCOMES: The student would have learnt
CO1: The concepts of artificial intelligence and neural network.
CO2: The different learning algorithms and neural network architecture
CO3: To apply perceptron and multiple perceptron for classification
CO4: The probability and distribution of random variables
CO5: To apply clustering techniques to perform classification

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1		1							3	1		1
CO2	1	2	2		2						2	3	1		1
CO3	1	2	2		2						2	3	1		1
CO4	1	2	3									3	1		2
CO5	1	2	3		3						2	3	1		1
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOKS:

1. **An Introduction To Neural Networks,** James A. Anderson, PHI, 2nd edition ,1995.
2. **Neural Networks**, Simon Haykin Pearson Education/PHI, 2001.
3. **Neural Networks** , Satish Kumar, Tata Mcgraw-hill 2009
4. **Pattern Recognition & Image Analysis**, Earl Gose, Richard Johnsonbaugh Steve Jost, Prentice Hall of India, 2002.

REFERENCE BOOKS:-

1. **Introduction To Artificial Neural Systems**, Jacck M Zurada, Jaico publishing
2. **Artificial Neural Networks**, B Yegnanarayana, PHI, 2001
3. **Pattern Recognition**, Robert Schalkoff, Wiley India Pvt. Ltd.

CHAIRMAN/BOS **DEAN (ACADEMIC)** **CHAIRMAN/ACADEMIC COUNCIL**

Course Title	**INFRARED IMAGING & APPLICATIONS**						
Course Code	**21MDT6041**						
Category	Professional Elective Course-I(PEC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	00	00	03	39	3
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES: To enable the student learn

1. To Understand the scope and practice of the field of infrared imaging system
2. To Understand the basic techniques used in thermography
3. To Examine and grasp the principle of camera and image acquisition techniques
4. To identify and Demonstrate proficiency in developing applications

UNIT No	Syllabus Content	No of Hours
1	**Introduction to thermography:** Principles of black body radiation laws: Blackbody, Plank's law, Wien's displacement law, Stefan Boltzmann Law, Emissivity, IR absorption characteristics, Radiometric measurements.	08
2	**Heat Transfer Mechanisms and measurements:** Heat and Temperature, Heat Transfer Mechanism, Principle of Conduction, Convection and Radiation, Temperature measurements: Contact and Non contact.	07
3	**Principle of Infrared Camera:** Detector performance parameters: Responsivity, Noise Equivalent Power, Specific detectivity, System performance parameters: Temperature range, Accuracy, Thermal sensitivity,Minimum Resolvable Temperature Difference (MRTD), Calibration of IR camera.	08
4	**Passive and Active Techniques:** Passive Thermography, Active Thermography: Pulsed Thermography, Pulsed Phase Thermography, Vibro Thermography, Frequency Modulated Thermal Wave Imaging	08
5	**Applications:** Diagnosis and Monitoring of Pain-Acupuncture-Breast Thermography and Detection of Breast Cancer-Other Medical Applications-Raynaud's Phenomenon- Pressure Ulcers.	08

Note 1 : Assignment-1 from unit 1 and 2.
Asssignment 2- from unit 3,4 & 5.

COURSE OUTCOMES: On completion of the course the student will be able to

CO1: Identify the objectives and background of infrared imaging

CO2: Apply the temperature measurements for various applications

CO3: Demonstrate the working operation of IR Camera

CO4: Analyze the various thermography calibration procedure.

CO5: Design of basic thermography imaging procedure for various clinical applications

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1					1	1	1					1		1
CO2		2	2		2								1		1
CO3	1	1					1						1		1
CO4							1				1	2	1		2
CO5			1								1	2	1		1
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOKS:

1. **Infrared Thermal Imaging: Fundamentals,** Michael Vollmer, Klaus-Peter Mollmann ,Research and Applications, John Wiley, 2010.
2. **Common sense approach to thermal imaging,** Holst, Gerald C. Washington, DC, USA: SPIE Optical Engineering Press, 2000.
3. **Infrared Imaging: A casebook in clinical medicine**, Francis Ring , Anna Jung , Janusz Zuber, IOP Publishing, Temple Circus, Temple Way, Bristol, BS1 6HG, UK 2015.

REFERENCE BOOKS:

1. **Medical Infrared Imaging**, Nicholas A. Diakides, Joseph D. Bronzino, CRC Press,2007
2. **Nondestructive Evaluation of Materials by Infrared Thermography**, Xavier P.V. Maldague, Springer Science & Business Media

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

Course Title	**MEDICAL INFORMATICS**						
Course Code	**21MDT6042**						
Category	Professional Elective Course-I(PEC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	00	00	03	39	3
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES: To make the student learn

1. Identify the fundamentals of medical informatics
2. Hospital Information system
3. Utilise knowledge, skills and concepts on health information technology
4. Cloud computing services
5. Telemedicine and virtual reality applications

UNIT No	Syllabus Content	No of Hours
1	**Medical Informatics:** Introduction - Structure of Medical Informatics –Internet and Medicine -Security issues, Computer based medical information retrieval, Hospital Management Information System(HMIS)-need, benefits ,capabilities, development. **Cloud computing:** Introduction, characteristics, deployment models, requirements, architecture, security measures, application in medical field	**08**
2	**Computerised Patient Record** : Introduction - History taking by computer, Dialogue with the computer, Components and functionality of CPR, Development tools, CPR in Radiology- Application server provider, Clinical information system, Computerized prescriptions for patients.	**07**
3	**Computers in Clinical Laboratory Medical Imaging**: Automated clinical laboratories-Automated methods in hematology, cytology and histology, Intelligent Laboratory Information System - Computerized ECG, EEG and EMG, **Computers in Medical Imaging** Computer assisted medical imaging- nuclear medicine, ultrasound imaging ultrasonography-computed X-ray tomography, Radiation therapy and planning, Nuclear Magnetic Resonance	**08**
4	**Computer Assisted Medical Decision-Making:** Neuro computers and Artificial Neural Networks application, Expert system – General model of CMD, Computer –assisted decision support system-production rule system, cognitive model, semantic networks , decisions analysis in clinical medicine-computers in the care of critically patients	**08**

5	**Recent Trends in Medical Informatics**: Virtual reality(VE),VE applications in medicine, Computer assisted surgery, Surgical simulation, Tele-medicine , Tele-surgery, Computer assisted patient education and medical education .	**08**

Note 1 : Assignment-1 from unit 1 and 2.
Asssignment 2- from unit 3,4 & 5.

COURSE OUTCOMES: On the completion of the course the students will be able to
CO1: Understand the concepts of medical information systems and cloud computing
CO2: Develop Computerized Patient Record (CPR)System
CO3: Application of computers for data storage in clinical laboratory, medical imaging
CO4: Application of computers for education & decision making
CO5: Understand the concepts of telemedicine and its applications

COs	**Mapping with Pos**
CO1	PO1,PO6,PO7,PO8
CO2	PO2,PO3,PO5
CO3	PO1,PO2,PO7,PO12
CO4	PO10, PO12
CO5	PO1,PO2,PO7,PO12

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1					1	1	1					1		1
CO2		1	1		2								1		1
CO3	1	1					1					3	1		1
CO4	1	1	1							1		3	1		2
CO5	1	1					1					3	1		1
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOKS:
1.Medical Informatics, Mohan Bansal, T M H, 2003.
2.Computers in Medicine Progress in Medical Informatics, R. D. Lele, TMH, 2005.

REFERENCES:
1.**Introduction to Bioinformatics** , T. K. Attwood & D. J. Parry-Smith, Pearson Education Low Price Edition, 2004.
2. **Essentials of CLOUD COMPUTING**, K. Chandrasekaran, Taylor & Francis Group, CRC Press is an imprint of Taylor & Francis Group, an Informa business, 2015.
3. **Medical Informatics**, Dinesh Bhatia, PHI Learning, India, 2015

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

Course Title	**VLSI DESIGN**						
Course Code	**21MDT6043**						
Category	Professional Elective Course-I(PEC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	00	00	03	39	3
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES: The objectives of the course is to enable students to:

1. Impart knowledge of MOS transistor theory and CMOS technologies
2. Learn the operation principles and analysis of inverter circuits.
3. Design Combinational, sequential and dynamic logic circuits as per the requirements
4. Infer the operation of Semiconductors Memory circuits.
5. Demonstrate the concepts of CMOS testing

UNIT No	Syllabus Content	No of Hours
1	**Introduction**: A Brief History, MOS Transistors, CMOS Logic **MOS Transistor Theory:** Introduction, Long-channel I-V Characteristics, Non-ideal I-V Effects, DC Transfer Characteristics.	08
2	**Fabrication:** CMOS Fabrication and Layout, VLSI Design Flow, Introduction, CMOS Technologies, Layout Design Rules, MOSFET Scaling and Small-Geometry Effects, MOSFET Capacitances	08
3	**Delay:** Introduction, Transient Response, RC Delay Model, Linear Delay Model, Logical Efforts of Paths. **Combinational Circuit Design:** Introduction, Circuit families	08
4	**Sequential Circuit Design**: Introduction, Circuit Design for Latches and Flip-Flops Dynamic Logic Circuits: Introduction, Basic Principles of Pass Transistor Circuits, Synchronous Dynamic Circuit Techniques, Dynamic CMOS Circuit Techniques	08
5	**Semiconductor Memories:** Introduction, Dynamic Random Access Memory (DRAM) and Static Random Access Memory (SRAM) **Testing and Verification:** Introduction, Logic Verification Principles, Manufacturing Test Principles, Design for testability	07

Note 1 : Assignment-1 from unit 1 and 2.
Asssignment 2- from unit 3,4 & 5

Course Outcomes : On completion of the course the student will be able to

CO1: Demonstrate understanding of MOS transistor theory, CMOS fabrication flow and technology scaling.

CO2: Draw the basic gates using the stick and layout diagrams with the knowledge of physical design aspects.

CO3: Demonstrate ability to design Combinational, sequential and dynamic logic circuits as per the requirements

CO4:Interpret Memory elements along with timing considerations

CO5: Interpret testing and testability issues in VLSI Design

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1		2		2								1		1
CO2	1	2	2		2								1		1
CO3		2	2	1									1		1
CO4		1	1	1									1		2
CO5		1	2	2									1		1
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOKS:

1. "CMOS Digital Integrated Circuits: Analysis and Design" - Sung Mo Kang & Yosuf Leblebici, Third Edition, Tata McGraw-Hill.
2. "CMOS VLSI Design- A Circuits and Systems Perspective"- Neil H. E. Weste, and David Money Harris4th Edition, Pearson Education.

REFERENCE BOOKS:

1. Adel Sedra and K. C. Smith, "Microelectronics Circuits Theory and Applications", 6th or 7th Edition, Oxford University Press, International Version, 2009.
2. Douglas A Pucknell & Kamran Eshragian, "Basic VLSI Design", PHI 3rd Edition, (original Edition – 1994).
3. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", TMH, 2007.

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

Course Title	**JAVA LAB**						
Course Code	**21MDL606**						
Category	Professional Core Lab(PCL)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	00	00	02	00	02	26	1
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES: To enable the students learn the fundamentals of programming language Java and also develop programming skills in Java

UNIT No	**Syllabus Content**
1	Simple Java Programs to illustrate the data operators
2	Program for string reversal
3	Program for demonstration of control statements
4	Program for demonstrating constructors
5	Program for demonstrating Overloading and overriding
6	Program for demonstrating multilevel Inheritance
7	Program for exception handling (try & catch methods and nested try statement and)
8	Program for demonstrating event handling
9	Developing Applet program
10	Simple Java Programs to illustrate the data operators

COURSE OUTCOME: The students would have
CO1: Acquired programming skills in Java and will be able to develop applications using Java

COs	**Mapping with POs**
CO1	PO1,PO2,PO3,PO4,PO5,PO8,PO9,PO10,PO11,PO12

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	3								2	3	1
CO2	1	1	2	2	2						2	2	2	3	1
CO3					3						3	3	1		
Strength of Correlation: Low-1, Medium-2, High-3															

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

Course Title	**MINI PROJECT**						
Course Code	**21MDM607**						
Category	Mini Project(MP)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	00	00	02	00	02	26	2
CIE Marks:100	**SEE Marks:-**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES: To enable the students to come up with their own innovative ideas and realize it.

1. PCB soldering and Testing: Learning any of the Open source PCB software
2. Practice the skills of Soldering and Testing simple circuits
3. Develop a working hardware model for any of the biomedical applications

Note:

- Mini project should be carried by a group of 3 or 4 and not more than 4 in a group.
- Evaluation should be based on the demonstration, viva-voce and final report.

COURSE OUTCOME: The students would have learnt

CO1: To build working prototype models based on their innovative ideas in the field biomedical applications
CO2: PCB designing software tools
CO3: The skills of soldering & testing
CO4: The ability to work in a group
CO5: To prepare documentation and convey their ideas through presentation

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3						2	2	2	3	2
CO2					3							2	2	3	2
CO3		3	3									3	2		2
CO4									3	3		3	2		2
CO5									3	3		3	2		2
Strength of Correlation: Low-1, Medium-2, High-3															

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL

OPEN ELECTIVE

Course Title	**BIOMEDICAL ENGINEERING**						
Course Code	**21MDT6051**						
Category	Open Elective Course-I(OEC)						
Scheme and Credits	No of Hours/Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	03	00	00	00	03	39	3
CIE Marks:50	**SEE Marks:50**		**Total Max.marks=100**		**Duration of SEE:03 Hours**		

COURSE OBJECTIVES: The objectives of the course is to enable students to:

1. To learn the nature of various physiological signals.
2. To learn about the measurement of blood pressure, pulse rate etc. and cardiac pacemakers & defibrillators
3. To learn basics of auditory mechanisms and the hearing aids.
4. To learn the basics of surgical systems.
5. To learn the medical imaging modalities such as ultrasonic and MRI.

UNIT No	Syllabus Content	No of Hours
1	**FUNDAMENTAL CONCEPTS:** Sources of biomedical signals, Basic medical instrumentation system, performance requirements of medical instrumentation systems, General constraints in design of medical instrumentation systems. Bioelectric Signals and Electrodes: Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrodes for ECG, Electrodes for EEG, Electrodes of EMG. EOG, EGG,	8
2	**BIOMEDICAL RECORDERS:** Electrocardiograph-block diagram description, ECG leads, Artefacts, blood pressure measurement: korotkoff's method measurement of respiratory rate: Impedance Pneumograpy. **OXIMETERS**: Principle, pulse oximeter **Cardiac Pacemakers and Defibrillators**: Need for cardiac pacemaker, Implantable Pacemaker, Types of implantable pacemaker, defibrillators: Need for defibrillators and dc defibrillators	8
3	**AUDIOMETER AND HEARING AIDS:** Mechanism of hearing, measurement of sound, basic audiometer, pure-tone audiometer, speech audiometer, hearing aids- conventional, digital hearing aid, cochlear implants. **VENTILATORS:** Mechanics of respiration, artificial ventilation, ventilators	7
4	**INSTRUMENTS OF SURGERY:** Principles of surgical diathermy, surgical diathermy machine, automated electro-surgical systems, electrodes used with surgical diathermy **HAEMODIALYSIS MACHINE:** Function of kidney, artificial kidney, dialyzer, membranes for hemodialysis, portable kidney machine	7

5	**ULTRASOUND IMAGING:** Fundamentals of acoustic propagation - Stress strain relationship, Characteristic impedance, Intensity, Reflection and refraction, Attenuation, absorption & scattering, Doppler effect, Generation and detection of Ultrasound-Piezoelectric effect, Ultrasonic transducers, **ULTRASONIC DIAGNOSTIC METHODS :**Pulse echo systems- Amplitude mode (A-mode), Brightness mode (B-mode), Motion mode (M-mode), Constant depth mode (C-mode), , Colour Doppler flow imaging, **BASICS OF MAGNETIC RESONANCE IMAGING:** fundamentals of nuclear magnetic resonance- Angular momentum, magnetic dipole moment, magnetization, Larmor frequency, Rotating frame of reference and RF magnetic field, Free induction decay (FID), Fourier spectrum of the NMR signal, Spin density, Relaxation times, Pulse sequences	**9**

Note 1 : Assignment-1 from unit 1 and 2.
Asssignment 2- from unit 3,4 & 5

COURSE OUTCOMES: The students would have learnt to

CO1: Interpret a typical biomedical measuring system, its constraints & precautions .
CO2: Understand the origin of biomedical signals and the sensor mechanisms
CO3: Apply the principles of audiometers, ventilators, haemodialysis etc. to evolve new devics
CO4: To study the fundamental of Ultrasound Imaging & Magnetic Resonance Imaging

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1		1		2							1		1
CO2	1	1	1	1		2							1		1
CO3	2	2	2	2		2							1		1
CO4	1			1								2	1		2
Strength of Correlation: Low-1, Medium-2, High-3															

TEXT BOOK:

1. **Handbook of Biomedical Instrumentation**, R.S.Khandpur, Tata McGraw Hill, 2nd Edition, 2003.
2. **Medical Instrumentation Application and Design,** John G WebsterJohn Wiley and Sons, New York 2004
3. **Principles of Medical Imaging**, Kirk Shung, Michael B. Smith and Banjamin Tsui, Academic Press, 1992

REFERENCE BOOK:

1. Biomedical Instrumentation and Measurement – by Leslie Cromwell, Fred J Weibell and Erich A. Pfeiffer, Prentice-Hall India Pvt. Ltd.
2. Biomedical Transducers And Instruments, Tatsuo Togawa, Toshiyo Tamura and P. Ake Oberg, CRC Press, 1997.
3.Introduction to Biomedical Equipment Technology , Joseph J Carr and John M Brown , Pearson Education ,4th Edition , 2001 .

CHAIRMAN/BOS DEAN (ACADEMIC) CHAIRMAN/ACADEMIC COUNCIL