Scheme of Instruction, Evaluation

and

Syllabi of

M.E. (BIOMEDICAL ENGINEERING)

With Specialisation

in

MEDICAL DEVICES

With effect from Academic Year 2022-23

DEPARTMENT OF BIOMEDICAL ENGINEERING

UNIVERSITY COLLEGE OF ENGINEERING

(Autonomous)

Osmania University

Hyderabad – 500 007, TS, INDIA

Estd. 1917

Estd. 1929

UNIVERSITY COLLEGE OF ENGINEERING

The University College of Engineering (UCE) has the distinction of being the oldest and the biggest among the Engineering Colleges of the State of Andhra Pradesh. Established in the year 1929, eleven years after the formation of Osmania University, it was the 6th Engineering College to be established in the whole of British India. The College moved to its present permanent building in the year 1947. Today it is the biggest among the campus colleges of Osmania University. The Golden Jubilee of the College was celebrated in 1979, the Diamond Jubilee in 1989 and the Platinum Jubilee in 2004. The College was made autonomous in 1994.

The College offers four-year engineering degree courses leading to the award of Bachelor of Engineering (B.E.) in Biomedical Engineering, Civil Engineering, Computer Science and Engineering, Electrical and Electronics Engineering, Electronics and Communications Engineering and Mechanical Engineering. The College also offers courses leading to Master of Computer

Applications, Master of Science by Research and also Ph.D., in the various branches of Engineering. Part-time courses are offered both at undergraduate and postgraduate levels. As of today, there is a yearly intake of 320 undergraduate students (full-time) and 140 (part-time) students and 290 postgraduate students (full-time and part-time). There are 109 teaching staff members, including 24 professors.

Vision

The Vision of the institute is to generate and disseminate knowledge through harmonious blending of science, engineering and technology. To serve the society by developing a modern technology in students‟ heightened intellectual, cultural, ethical and humane sensitivities, fostering a scientific temper and promoting professional and technological expertise.

Mission

- To achieve excellence in Teaching and Research
- To generate , disseminate and preserve knowledge
- To enable empowerment through knowledge and information
- Advancement of knowledge in Engineering, Science and Technology
- Promote learning in free thinking and innovative environment
- Cultivate skills, attitudes to promote knowledge creation
- Rendering socially relevant technical services to the community
- To impart new skills of technology development
- To inculcate entrepreneurial talents and technology appreciation programmes
- Technology transfer and incubation

DEPARTMENT OF BIOMEDICAL ENGINEERING

Biomedical Engineering (BME) constitutes human beings earliest efforts to understand the living world in terms of the basic sciences and to comprehend the body mechanism in terms of their technological creations. Biomedical Engineering involves the study and application of engineering processes for diagnosis and therapy. It is a rapidly changing interdisciplinary domain, in which each branch of engineering interacts with a number of other disciplines to yield a fundamental understanding of health maintenance processes for improved diagnosis and optimal interventional (surgical, therapeutic & rehabilitative) procedures.

Osmania University is the first University to start Biomedical Engineering at undergraduate level in the country. The course was started in the year 1982 with an intake of 10 students in the Department of Electronics and Communications Engineering. An exclusive Biomedical Engineering Department was formed in the year 1993 to give the much needed thrust to Programme. The student intake was enhanced to 30 in the year 1996.The Department moved to its present premises in the year 1997. The Department has also started Post Graduate program in Biomedical Electronics in the academic year 2006-2007. The total floor space of 10800 sft. houses class rooms, laboratories and other amenities. The **B.E (BME) programme of the department has been accredited by the NBA for Six years with effect from November 2019.** A special appreciation was given by the visiting expert team.

Vision

To coherently work with medical professionals in providing effective and affordable healthcare

Mission

- To produce biomedical engineering graduates who can understand and apply basic engineering principles to solve the problems of the medical field.
- To develop biomedical engineers to conceive innovative strategies for designing and developing medical equipment, implants, and other devices of immense use to the society.

Programme Educational Objectives (PEO):

The graduating students of the Medical Devices program will be able to:

PEO1	Exhibit strong skills in problem solving, leadership, teamwork and enterprise management.
PEO2	Able to effectively communicate with healthcare professionals to know their problems and provide effective solutions.
PEO3	Use the skills to contribute to the scientific and engineering needs of the society in general and the Biomedical field in particular.
PEO4	Pursue research degrees and practice technical competency as professionals in Biomedical Engineering or allied fields.
PEO5	Sustain professional development in their fields and advance to positions of greater responsibility with life-long learning.

Programme Outcomes (PO):

PO1	An ability to design and conduct experiments, analyze and interpret medical data.
PO2	An ability to communicate effectively in multidisciplinary research and diverse teams and provide leadership.
PO3	An ability to identify the needs of the medical fraternity and use the techniques, skills, and modern engineering tools to solve biomedical engineering problems.
PO4	An ability to understand contemporary issues and be instrumental in designing new medical gadgets within economic, environmental, social, ethical, health and safety constraints.
PO5	An ability to recognize the need for, and engage in life-long learning.
PO6	An ability to establish a small scale enterprise.

Mapping of PEOs with POs

PROGRAMME EDUCATIONAL OBJECTIVES	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
PEO-1	3	2	2	2	1	3
PEO-2	1	3	3	2	1	2
PEO-3	2	1	3	2	1	2
PEO-4	2	1	1	3	3	2
PEO-5	2	1	3	3	3	2

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

DEPARTMENT OF BIO MEDICAL ENGINEERING, U.C.E., O.U
M. E. BME (MEDICAL DEVICES) AICTE Model

Sl. No	Course Code	Course Name	Contact hours per week		Scheme of Evaluation		Credits
			L	P	CIE	SEE	
SEMESTER-I							
1.	BM 101	Core-I	3	-	40	60	3
2.	BM 102	Core-II	3	-	40	60	3
3.	BM 103	Core-III	3	-	40	60	3
4.		Program Elective-I	3	-	40	60	3
5.		Program Elective-II	3	-	40	60	3
6.		Program Elective-III	3	-	40	60	3
7.	BM 151	Medical Sensors & Signal Conditioning lab	0	2	50	-	1
8.	BM 152	Embedded Medical Product Design Lab	0	2	50	-	1
TOTAL			**18**	**4**	**340**	**360**	**20**
SEMESTER-II							
1.	BM 104	Core-IV	3	-	40	60	3
2.	BM 105	Core – V	3	-	40	60	3
3.	BM 106	Core - VI	3	-	40	60	3
4.		Program Elective-IV	3	-	40	60	3
5.		Program Elective-V	3	-	40	60	3
6.		Open Elective	3	-	40	60	3
7.	BM 153	Biomedical Signal & Image Processing Lab	0	2	50	-	1
8.	BM 154	Medical Equipment Lab	0	2	50	-	1
9.	BM 162	Mini Project	0	4	50	-	2
TOTAL			**18**	**8**	**390**	**360**	**22**
SEMESTER-III							
1.	AC 030 BM	Audit Course - I	2	-	40	60	0
2.		Audit Course - II	2	-	40	60	0
3.	BM 181	Dissertation Phase - I	0	20*	100		10
TOTAL			**4**	**20**	**180**	**120**	**10**
SEMESTER-IV							
1.	BM 182	Dissertation Phase - II	0	32*	100	100	16
GRAND TOTAL			**40**	**64**	**1010**	**940**	**68**

LIST OF SUBJECTS FOR M.E. (BME)
WITH SPECIALIZATION IN MEDICAL DEVICES

S. NO.	SYLLABUS REF. NO.	SUBJECT TITLE	PERIODS PER WEEK
		CORE SUBJECTS	
1	BM 101	Medical Sensors & Signal Conditioning	3
2	BM 102	Embedded Medical Product Design	3
3	BM 103	Medical Instrumentation	3
4	BM 104	Diagnostic And Therapeutic Equipment	3
5	BM 105	Advanced Biomedical Signal Processing	3
6	BM 106	Advanced Medical Imaging	3
		PROGRAMME ELECTIVE SUBJECTS	
1	BM 111	Physiology For Engineers	3
2	BM 112	Bioinformatics	3
3	BM 113	Medical Informatics	3
4	BM 114	Medical Device Regulations	3
5	BM 115	Advanced Biomaterials	3
6	BM 116	Biotransport Processes	3
7	BM 117	Hospital Management Systems	3
8	BM 118	Physiological Control Systems	3
9	BM 119	Electromagnetic Biointeraction	3
10	BM 120	Biostatistics	3
11	BM 121	Medical Image Processing	3
12	BM 122	Enterprise Management	3
13	BM 123	Medical Product Design	3
14	BM 124	Tissue Engineering	3
15	BM 125	Bio Nano Technology	3
16	BM 126	Medical Optics	3
17	BM 127	Lasers In Medicine	3
		LABORATORIES	
1	BM 151	Lab-I- Medical Sensors & Signal Conditioning lab	2
2	BM 152	Lab II - Embedded Medical Product Design Lab	2
3	BM 153	Lab III - Biomedical Signal & Image Processing Lab	2
4	BM 154	Lab-IV - Medical Equipment Lab	2
5	BM 162	Mini Project	4
		OPEN ELECTIVE SUBJECTS	
1	OE 941 BM	Medical Assistive Devices	3
2	OE 942 BM	Medical Imaging Techniques	3
3	OE 941 CE	Green Building Technology	3
4	OE 942 CE	Cost Management of Engineering Projects	3
5	OE 941 CS	Business Analytics	3
6	OE 941 EC	Elements of Embedded Systems	3

7	OE 941 EE	Waste To Energy	3
8	OE 942 EE	Power Plant Control and Instrumentation	3
9	OE 941 ME	Operation Research	3
10	OE 942 ME	Composite Materials	3
11	OE 943 ME	Industrial Safety	3
12	OE 941 LA	Intellectual Property Rights	3
		AUDIT COURSE I	
1	AC 030 BM	Medical Research & Ethics	3
		AUDIT COURSE II	
1	AC 031	English for Research Paper Writing	3
2	AC 032	Disaster Management	3
3	AC 033	Sanskrit for Technical Knowledge	3
4	AC 034	Value Education	3
5	AC 035	Stress Management by Yoga	3
6	AC 036	Personality Development through Life Enlightenment Skills	3
7	AC 037	Constitution of India	3
8	AC 038	Pedagogy Studies	3
9	AC 039	E-Waste Management	3
		DISSERTATION	
1	BM 181	Dissertation Phase - I	20 *
2	BM 182	Dissertation Phase - II	32 *

Note:

i. Dissertation-II has two parts, CIE - I and CIE - II, at the end of 8th week and 16th week respectively for evaluation of 50 marks each.

ii. Audit Course will be offered in ONLINE mode and SEE will be conducted in Computer Based Test Mode.

iii. Engineering Research Methodology workshop will be conducted for one week to the Ph.D scholars.

* The Student has to work minimum of 20 Hr/Week and 32 Hr/Week At Major Project Phase -I And Major Project Phase -II Respectively.

BM 101	**MEDICAL SENSORS & SIGNAL CONDITIONING**					
(CORE - I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	This course facilitates the students to understand the principles of various sensors.
2	They learn the classification of sensors such as temperature, pressure, displacement and piezoelectric sensors
3	They learn signal conditioning and processing, noise reduction techniques and medical applications.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the classification of sensors and application in medical environment
CO-2	Able to use the capacitive and other sensors in signal conditioning
CO-3	Understand the concepts of self generating sensors
CO-4	Able to measure conductivity, flow rate using various sensors and understand the concepts of Electrochemical and enzyme based sensors.
CO-5	Understand the data acquisition, ADC and noise filtering concepts.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

Unit – I
Sensor Classification, Modifying inputs, Functional specifications of medical sensors; static and dynamic characteristics of measurement systems. Primary sensors. Resistive sensors. Potentiometers, Strain gages, RTDs, Thermister, LDR. Signal conditioning. Wheatstone bridge, balance and deflection measurements. Instrumentation amplifier. Interference types and reduction. Shield grounding. Isolation amplifiers. Medical Applications.

Unit – II
Reaction variation and electromagnetic sensors. Capacitive sensors, inductive sensors, LVDT, electromagnetic sensors. Signal conditioning, AC bridges, AC amplifiers, electrostatic shields, carrier amplifiers, phase-sensitive detectors, Medical Applications.

Unit – III
Self-generating sensors. Thermoelectric sensors, thermocouples, piezoelectric sensors, photovoltaic sensors. Signal conditioning. chopper and low-drift amplifiers, Noise in op-amps. Digital sensors. Telemetry and data acquisition, Medical Applications.

Unit – IV
Electrochemical transducers: Potentiometric sensors, Ampero-metric sensors, Electro-Chemical gas sensors. Biosensors – Enzyme–based biosensors, immuno sensors, microbial sensors, Ph sensors, measurement of Conductivity, viscosity, flow transducers, conductivity, Humidity, signal conditioning and Medical Applications.

Unit –V
Noise reduction techniques. Types of noise, Types of filters for medical applications, Data acquisition, Sample and Hold Conversion, Multi Channel acquisition, Selection of drive amplifier for ADC performance, Gain setting and level shifting, ADC input protection, Types of ADC.

Suggested Reading:

1.	John G. Webster, *Medical Instrumentation-Application and Design*, John Wiley and Sons Inc., 3rd Ed., 2003.
2.	Richard S.C. Cobbold, *Transducers for Biomedical Measurements: Principles andApplications*, John Wiley & Sons, 1974.
3.	Ramon Pallas-Areny and John G.Webster, *Sensors and signal conditioning*, John Wiley and Sons, 1991.

BM 102	**EMBEDDED MEDICAL PRODUCT DESIGN**					
(CORE –II)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make the students learn the concepts of embedded systems, device drivers and memory management.
2	To enable the students gain knowledge on the architecture of 8051 and PIC microcontrollers
3	To facilitate the students to design basic medical embedded devices

Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	Understand the concept of an embedded system with different interface and communication protocols
CO-2	Write simple 8051 microcontroller programs in embedded C environment.
CO-3	Design a simple 8051 microcontroller based system through interfacing peripherals
CO-4	Implement simple PIC microcontroller programs in embedded C environment
CO-5	Develop an embedded system through interfacing medical sensors

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

Unit - I Introduction to Embedded Systems
Embedded system architecture, classification of embedded system, challenges and design issues in embedded systems, skills required for embedded system designer, CISC vs. RISC, Direct Memory access, I/O devices, Serial interfaces-RS-232, 422, 485, Serial Communication Protocols - I2C, SPI, CAN, Bluetooth Protocol, LCD & Keypad Controllers for biomedical applications.

Unit - II 8051 Microcontroller
Architecture, Internal and External Memories, Counters and Timers, Register Set, Synchronous and Asynchronous Serial Communication, Interrupts, Instruction Set, Basic C Programming in 8051 Microcontroller, Application of 8051 microcontroller.

Unit - III Interfacing with 8051
Memory and I/O interfacing by 8051, ADC, DAC, seven segment display, stepper motor, traffic light control, LEDs, 7 segment LED's, LCD, Touch screen and Keypad interfacing.

Unit - IV PIC Architecture
Introduction to PIC microcontrollers, PIC 16F/18F architecture, comparison of PIC with other CISC and RISC based systems and microprocessors, memory mapping, assembly language programming, addressing modes, instruction set. PIC I/O ports, I/O bit manipulation programming, timers/counters, programming to generate delay and wave form generation, I/O programming.

Unit - V I/O Programming
Interfacing of medical sensor circuits: Carbon dioxide and oxygen sensors, respiration, force, flow, differential voltage and current probes and humidity sensors. Features, Specifications and their interfacing. Interface pulse-Oximeter with PIC & 8051 microcontroller.

Suggested Reading:

1	Dr. K.V.K.K.Prasad, *Embedded Real time Systems,* Dreamtech Press, 2003.
2	Muhammed Ali Mazidi, *8051 Microcontrollers and Embedded Systems*, 2nd Edition Pearson Pub, 2018
3	Chuck Helebuyck, *Programming PIC microcontrollers with PIC Basic*, Newnes Pub., 2003.
4	Milan verle, *PIC microcontrollers-programming in Basic*, Mikro Elektronika; 1st edition 2010.

BM 103	**MEDICAL INSTRUMENTATION**					
	(CORE - III)					
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the students to the basic concepts of medical instrumentation
2	To make the students understand the generation of biopotential signals
3	To make the students learn the principles of basic medical instruments

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Elucidate the generation of biopotential signals, electrodes and their amplifiers.
CO-2	Understand the recording of ECG and other cardiovascular parameters
CO-3	Comprehend the recording of EEG and EMG
CO-4	Understand the concepts of Oximeters, Pulmonary Function Analyzers and measurement of Pressure and Gas flow.
CO-5	Differentiate the analytical instruments based on their principle and applications

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit - I

Generalized Medical Instrumentation System, Origin of bio-potentials – ECG, EEG, EMG, EOG, ENG, ERG, EGG.

Bio-potential Electrodes: Half cell potential, Offset voltage. Types of External, Internal and Microelectrodes.

Bio-potential Amplifiers of ECG, EEG, EMG, Electric Interference, Common-mode and other interference reduction circuits, Cardiotachometer, Fetal ECG, Electromyogram intergrators, Evoked potentials and signal averagers, Cardiac Monitors.

Unit - II
ECG: Block diagram & circuits, electrode placement, lead configuration, Types of ECG recorders. Blood pressure measurement: Direct and indirect methods. Blood flow measurement: Electromagnetic & Ultrasonic techniques. Heart sounds: Origin, Phonocardiography.

Unit - III
EEG- Block diagram & circuits, electrode placement, Evoked potentials and their measurement. EMG-Block diagram & circuits, electrode placement, Nerve conduction velocity determination, EMG stimulators.

Unit - IV
Measurement of the Respiratory system: Measurement of Pressure, Gas flow, Gas Concentration, Lung Volume, Respiratory Plethysmography, Oximeters: Oximetry, Ear Oximeter, pulse Oximeter, Skin Reluctance and Intravascular Oximeter, Pulmonary Function Analyzers: Spirometry, Pneumotachometers, Respiratory Gas Analyzers.

Unit - V
Analytical Instrumentation. Methods of Chemical analysis, Absorption, Photometry: Emission photometry, Fluorometry. Chromatography for blood gas analysis. Colorimeters, Spectrophotometers, Electrophoresis, auto analyzer, Hematology analyzers (Blood cell counters).

Suggested Reading:

1	John G. Webster, Medical Instrumentation-Application and Design, John Wiley and Sons Inc., 3rd Ed., 2003.
2	Khandpur R.S., Hand Book of Biomedical Instrumentation, Tata McGraw Hill Pub Co. Ltd., 2nd ed., New Delhi, 2003.
3	Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology, Pearson Education, 2001.

BM 104	**DIAGNOSTIC AND THERAPEUTIC EQUIPMENT**					
	(CORE –IV)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make the students understand the operating principles of a wide range of Biomedical Equipment.
2	To familiarize the students with the operating principles of the equipment.
3	To enable the students to gain knowledge on the applications of various medical equipment.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Assess use of electrical stimulation principles to overcome cardiac rhythm disturbances and principles of Defibrillator.
CO-2	Comprehend the principles of Anesthesia machine, functions of respiratory equipment and ventilators and sterilization equipment.
CO-3	Assess the need and operating principle of equipment used in audiometry, Neonatology and drug delivery.
CO-4	Comprehend the principles of Hemodialysis machine, Lithotripter and Endoscopy.
CO-5	Perceive the governing principles of surgical diathermy and radiotherapy

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	1	3	2	1	1
CO-2	3	1	2	3	2	-
CO-3	1	2	3	3	2	2
CO-4	1	2	1	3	1	1
CO-5	2	1	3	2	1	2

Unit – I
Cardiac Pacemakers - Need for Cardiac Pacemaker, Principle of operation, Classification of pacemakers, Cardiac Defibrillators -Need for a Defibrillator – Types of Defibrillator - Defibrillator analyzer. Cardiac Valves, different types Mechanical and Tissue types. Angioplasty. Balloon and Stent Angioplasty., Stents, different types – coil, slotted tubular, drug eluting stents.

Unit – II
Need for Anesthesia – Anesthesia machine - Electronics in Anesthesia machine. Ventilators - Need for a Ventilators, Classification of Ventilators, High frequency ventilators, CPAP, BiPAP, Humidifiers, Nebulizers and Aspirators, Heart Lung machine. Sterilization techniques: Autoclave, Gas, Dry Heat, Radiation, Dry Steam sterilization

Unit – III
Audiometry: Common tests and procedures, audiometer. Hearing Aids: Different types, comparison of microphones receivers and amplifiers, cochlear Implants. Neonatal instrumentation: incubators, apnea monitor, photo-therapy devices. Syringe Pump, Infusion Pump.

Unit – IV
Haemodialyzers - Artificial Kidney, Dialyzers, principle of dialyzers, Membranes of the haemodialyzers, Types of Dialysis and merits and demerits. Lithotripters - need of lithotripsy, types of lithotripter systems, techniques, applications and limitations. Endoscopy, Laparoscopy, Keyhole surgery

Unit – V
Clinical applications of electrotherapy, principle of surgical diathermy, surgical diathermy machine, safety aspects in Electro-Surgical diathermy Unit, short wave diathermy, ultrasonic diathermy, microwave diathermy, Pain relief through Electrical Stimulation Principles of Cryogenic technique and application, Radio Therapy: Principles of radiotherapy, Cobalt UNIT, Treatment planning system. Types of radiation detectors, biological effects of radiotherapy.

Suggested Reading:

1	John G. Webster (Editor-in-Chief), Encyclopedia of Medical Devices and Instrumentation Vol.1 to Vol.4, John Wiley and Sons, 1988.
2	Khandpur R. S., Handbook of Bio-Medical Instrumentation, Tata McGraw Hill, 2nd Ed., 2003.
3	Joseph Bronzino (Editor-in-Chief), Handbook of Biomedical Engineering, CRC Press, 1995.
4	Harry Bronzino E, Handbook of Biomedical Engineering and Measurements, Reston, Virginia.
5	Joseph J.Carr and John M.Brown, Introduction to Biomedical equipment technology, John Wiley and sons, New York, 1997

BM 105	**ADVANCED BIOMEDICAL SIGNAL PROCESSING**					
(CORE – V)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	This course facilitates the students to understand the design of filters for bio signals.
2	They learn the Feature extraction methods of various bio signals like EG, EEG, HRV.
3	This course enables the students to learn algorithms required for the automated diagnosis of various cardiovascular and neuro-muscular disorders.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Design filters for the pre-processing of Bio signals.
CO-2	Able to apply wavelet transforms for the bio signals.
CO-3	Understand and implement features extraction of ECG and HRV signals.
CO-4	Able to analyze the EEG and EMG signals by using Time and frequency domain analysis.
CO-5	Comprehend the concept of brain computer interface and built some applications.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I Fundamentals of Discrete-Time signals and systems
Concepts of signal, system, Sampling Process, Impulse Response, Z-Transform, Discrete Transfer function, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Short time Fourier Transform, Autocorrelation and cross correlation functions, Cross correlation coefficient, cepstrum analyzer, medical applications.

Unit – II Wavelets and applications
Continuous Wavelet Transform, Discrete wavelet transform, Recursive multi resolution decomposition Reconstruction, Types of wavelets-Haar wavelet, Daubechies wavelet, Biorthogonal wavelet, Coiflet wavelet, Morlet wavelet, Mexican Hat wavelet, Symlet wavelet, De-noising of physiological signals, Medical Image fusion, Wavelet based compression methods.

Unit – III Cardiac Signal Processing (ECG)
ECG characteristics, sources of Noise (Baseline Wander, Power line interference, Muscle Noise Filtering and Artifacts), Preprocessing techniques, QRS Detection techniques, Wave Delineation, Data Compression, Heart Rate Variability, Spectral Analysis of Heart Rate Variability, Adaptive Noise cancellation, and applications.

Unit – IV Neuro Muscular Signal Processing (EEG & EMG)
Characteristics of EEG and EMG, Evoked Potential Modalities Sources of Noise and artifacts in EEG recording, Preprocessing techniques, Noise reduction by Ensemble Averaging and Linear Filtering, Linear prediction theory, Auto regressive method, levinson algorithm, Model based analysis of EEG, EEG segmentation, Joint Time-Frequency Analysis, Spectral analysis, Modeling the EMG, Amplitude Estimation in the surface EMG, Spectral Analysis of the surface EMG

Unit – V ICA & PCA Applications
Geometry of mixing and un mixing, methods for blind source separation, Gaussian distribution, Probability density function, mean, covariance, kurtosis, negentropy, and applications of ICA, including voice mixtures, EEG, fMRI, and fetal heart monitoring. PCA and applications, EMD process and applications.

Suggested Reading:

1	Leif Sornmo and Pablo Laguna, Bioelectrical Signal Processing in Cardiac and Neurologica Applications, Academic Press, 2005
2	Willis J. Tompkins, Biomedical Digital Signal Processing, Prentice-Hall, 1993.
3	Rangaraj M.Rangayyan, AkayMetin(Editor),Biomedical Signal Analysis: A Case Study Approach, Wiley Inderscience, 2001.
4	James V. Stone, Independent Component Analysis: A Tutorial Introduction-MIT press, 2004.

BM 106	**ADVANCED MEDICAL IMAGING**					
	(CORE – VI)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To learn physical principles of Imaging Techniques and applications.
2	To learn the protocol of procedures for different equipment.
3	To make the students learn physical principles of medical Imaging equipment.
4	To make the students understand image reconstruction techniques.
5	To make the students gain knowledge on the medical applications of imaging modalities.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain the principle and components of X-ray imaging system.
CO-2	Describe an angiography system and its applications
CO-3	List the principle and applications of MRI Scan
CO-4	Interpret principles and applications of ultrasound scanner
CO-5	Understand the concepts of nuclear medicine

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I

X ray Imaging: Introduction to Electromagnetic spectrum and their properties, Production of X-rays-X-ray tubes-Insert housing, filtration, grid, and collimation, -X-ray generator circuit design - Image production. Computed radiography Charge coupled device flat panel detectors - Direct and Indirect detection. Fluoroscopy - Chain components - peripheral equipment - Flat panel digital fluoroscopy.

Unit – II
Basics of digital angiography - Image processors for digital angiography - processor architecture - Digital subtraction angiography. Mammography - X-ray tube design - X-ray generator and photo timer system - Image production. Digital mammography.X-Ray computed tomography - Basic principles Tomographic acquisition and reconstruction-Historical Development - scanner - image formation principles - conversion of x-ray data in to scan image - 2D image reconstruction techniques - Iteration and Fourier methods. Applications - CT Angio, Osteo, Dental, Perfusion (Body & Neuro), Virtual Endoscopy, Coronary Angiography).

Unit – III
Magnetic Resonance Imaging: Introduction - principles of MRI - MRI instrumentation, magnets - gradient system - RF coils and receiver system. Relaxation processes, pulse sequence, image acquisition and reconstruction techniques, Image acquisition in magnetic resonance imaging - T1, T2, proton density weighted images, Artifacts in imaging Various types of pulse sequences for fast acquisition of imaging. Functional MRI - The BOLD effect - intra - and extra vascular field offsets, source of T2* effects, Creating BOLD contrast sequence optimization Sources and dependences of physiological noise in FMRI.

Unit – IV
Ultrasound Scanner: Physics of ultrasound - Principles of image formation - Capture and display, Basic Ultrasound instrumentation, Imaging techniques and their modes of operation (A mode, B Mode, 2B, B/M, 4B , Gated Mode, 3D, 4D, M-Mode, Echocardiography).Design of scan converters, Design of frame grabbers. High line and low line monitoring of ultrasound displays, Doppler Ultra sound and Color flow mapping of scan conversion (real time imaging) - image processing. , Image artifact, Biological effects and Application in medicine

Unit – V
Nuclear Medicine - Radionuclide production - radiopharmaceuticals - Mechanism of localization - Physics of Gamma camera, basic Instrumentation, Anger scintillation camera - Design principles of operation - Image formation. Emission Tomography imaging - SPECT - Image acquisition and reconstruction - PET - Design and principles of operation - Two and three dimensional data acquisition - comparison of SPECT, PET and combined PET/ X-ray CT.

Suggested Reading:

1	S Webb, "The Physics of Medical Imaging", Adam Highler, Bristol Published by CRC Press, 1988
2	A C Kak, "Principle of Computed Tomography", IEEE Press New York, 1988
3	Hykes, Heorick, Starchman, Ultrasound physics and Instrumentation MOSBY year book, 2nd Ed., 1992.
4	Stewart C.Bushong, Magnetic Resonance Imaging- physical and biological principles, MOSBY, 2nd Ed., 1995.
5	Zhi-Pei Laing and Paul C.Lauterbur, Principles of Magnetic Resonance imaging –A signal processing perspective, MetinAkay (Editor), IEEE press, New York, 2000.

PROGRAM ELECTIVES

BM 111	**PHYSIOLOGY FOR ENGINEERS**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make the students understand the cellular mechanisms.
2	To enable the students to have fundamental knowledge of physiological system function and dysfunction.
3	To make students analyze physiological systems from an engineering perspective

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Gain knowledge on the functioning of nerve and muscle cells.
CO-2	Appreciate the cardiovascular system and the dynamics of circulation.
CO-3	Explain the respiratory mechanism and the transport of gases in blood.
CO-4	Identify the functions of the renal system and temperature regulation.
CO-5	Recognize the functions of the different parts of the brain.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
General Physiology: Introduction-Evolutionary aspects and thermodynamics of living systems. Cellular physiology-digital and analog molecules and patterning of activity, active and passive process, optimization principles, macromolecular self assembly, molecular homeostasis. DNA, RNA, chromosomes, Gene. Genetic inheritance and epigenetics. Gene expression and its regulation: Endogeneous feed-forward circuitry and stochastic models. Intracellular physiology-structure and function. Transport across cell membrane.
Nerve Physiology: Genesis of membrane potentials, Nernst equation, Goldman-Katz equation, cable properties, local, analog signaling. Action potentials, Digital/propagative signaling. Hodgkin-Huxley model, differential equation of action potentials. Electrophysiology of cell membrane, experimental studies(Voltage clamp and patch clamp methods)

Muscle Physiology: Types of muscle fibers-Structure and function. Neuro-muscular junction, Excitation-contraction coupling, Molecular basis of muscle contraction, motor UNIT and muscle contraction. Smooth, cardiac and skeletal muscles, Biophysics of musculoskeletal systems, Experimental study of electrical activity.

Unit - II

Cardiovascular system: Introduction to cardiovascular physiology. Functional anatomy of heart and vessels. Electro Physiology of heart. Electrocardiogram and magneto cardiogram. Cardiac cycle. Blood as a non-Newtonian fluid. Dynamics of circulation, regional circulations. Cardiac output and methods of estimation. Control systems; neural and humeral regulation. Applied aspects.

Unit – III

Overview of respiratory physiology. Ventilation, Biophysics of transport across respiratory membrane. Perfusion and diffusion limited process. Ventilation, alveolar, shunt and dead space equations. Ventilation perfusion inequalities. Biophysics of transport of gases in blood. Applied aspects.

Unit – IV

Renal system: Overview of renal physiology. Clearance equation and biophysics of filtration, re-absorption and secretion. Counter-current multiplication and exchange, acid base balance, Regulation of body temperature. Applied aspects. Endocrine and Reproductive systems.

Unit – V

Neurophysiology: Overview, sensory system, signal generation, conduction processing and transduction. Synapse, signal integration at spinal cord, brain stem, sub-cortical and cortical levels. Motor systems, planning, programming and execution. Cognitive functions. Language, speech, thought, sleep, learning and memory. Experimental study of electrophysiology. Near field and far field potentials, EEG, Nerve conduction studies and evoke potentials

Suggested Reading:

1	Best and Taylor, Physiological basis of Medical practice, *The Living Body*, B.I. Publication, 1980.
2	Mount castle Textbook of medical physiology Better World Books, IN, USA
3	Walter F. Boron, Textbook of medical physiology, W.B. Saunders Company
4	Zipes, Jalife, Cardiac Electrophysiology ,
5	Eric R. Kandel, Principles of Neural Science, Elsevier science division
6	un Kimura, Electro diagnosis in diseases of nerve and muscle, W.B. Saunders Company.

BM 112	**BIOINFORMATICS**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To give students an introduction to the basic techniques of bioinformatics.
2	To make the students develop bioinformatics programs for comparing &analysing biological sequence data.
3	To make the students understand the computational challenges and their solutions in the analysis of large biological data sets.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain the major steps in pairwise and multiple sequence alignment, explain the principle and execute pairwise sequence alignment by dynamic programming.
CO-2	Predict the secondary and tertiary structures of protein sequences.
CO-3	Work with commonly used bioinformatics tools for analyzing the data.
CO-4	Implement bioinformatics tools in understanding protein structures. Understanding the classification of protein databases.
CO-5	Implement machine learning algorithms for classification and prediction of protein sequences.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Prediction of protein molecular function and structure: Primary sequence of a protein and its analysis, Secondary , Tertiary and quaternary structures and their prediction methods, Fold recognition methods, Homology /comparative modeling of proteins, Energy calculations, local and global minimization, Energy Minimizations: Conjugate, steepest and Powell , Molecular dynamics and simulation studies.

Unit - II
Algorithms: Algorithms and complexity, Biological algorithms, computer algorithms, The change problem, Correct, incorrect algorithms, Recursive algorithms, Iterative, recursive algorithms, Fast and slow algorithms, Big-O notation, Algorithm designing techniques- Exhaustive search, Branch-and-bound algorithms, Dynamic programming, Divide-and-conquer algorithms, Randomized algorithms, Gibbs sampling.

Unit – III
Computer algorithms for prediction of protein structures. DNA Sequence Comparison, Algorithms for alignment of sequences and structures of proteins and protein families, PAM, BLOSUM, Bayesian modeling and networks, Probabilistic models or Hidden Markov models, Needleman Wunch and Smith Waterman algorithms, Global sequence alignment, Scoring alignments, Local sequence alignment, Alignment with gap penalties. Multiple alignment, Gene prediction-Statistical and Similarity-based approaches. Spliced alignment.

Unit – IV
Genetic algorithms: Genetic algorithms for the prediction of multiple sequence alignment, Gene expression analysis, Hierarchical clustering, K-Means clustering, clustering and corrupted cliques. Evolutionary trees- Distance-based tree reconstruction, Reconstructing trees from additive matrices, Evolutionary trees and hierarchical clustering. Character-based tree reconstruction- Small parsimony problem, large parsimony problem.

Unit – V
Neural Networks: Biological neurons and neural networks. Networks of artificial neurons. Learning in single layer and multi-layer perceptrons. Back-propagation. Radial basis function networks: Algorithms and applications. Committee machines. Self-organizing maps: algorithms and applications. Learning vector Quantization. Machine Learning, Statistical learning, Decision trees. Inductive logic programming, Computation learning, Unsupervised learning, temporal difference learning, Delayed reinforcement learning, Explanation based learning.

Suggested Reading:

1	Bioinformatics – *Sequence and Genome Analysis*. David W. Mount.
2	Beale and T.J. Jackson, *Introduction to Neural Networks*, IOP Publishing Company, 1990
3	Baeck, D.B. Fogel and Z. Michalewicz ,*Genetic Algorithms*, IOS Press, 1997.

BM 113	**MEDICAL INFORMATICS**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make students understand the approaches in hospital design and medical equipment management.
2	To enable the students to have fundamental knowledge of database management and modeling techniques.
3	To make students learn hospital information systems and computerization

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Gain knowledge on design and medical equipment maintenance and appreciate the role of biomedical engineer.
CO-2	List the various data structures and data representation.
CO-3	Compare the types of data bases and data modeling techniques.
CO-4	Appreciate the need for computerization of hospital services and records.
CO-5	Evaluate specific test cases.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	3	3	3	2	2
CO-2	1	2	2	2	1	1
CO-3	3	2	1	3	2	2
CO-4	2	1	2	3	1	2
CO-5	2	1	2	1	1	1

Unit - I

Planning and designing of Hospital systems: Financial aspects, Equipment, Building, Organization of the Hospital, various medical services in a Hospital,

BME services and technical aspects: pole and responsibilities. Layout, Setting and Functions of Biomedical Engineering Department in a Hospital.

Biomedical Equipment Management: Procurement process, Training to Medical staff on technical capabilities, Biomedical Equipment maintenance procedures.

Unit - II
Database Management (DBMS): Introduction to Data structures, Elements, Arrays, Records, Sets, Tables, Singly and Doubly linked Data, Stacks, Queues and Trees, Need for a Database, Architecture of DBMS. Representation of Data, Physical Record Interface, Data models, Relational, Hierarchical and Network approach.

Unit - III
Data Modeling Techniques: Relational, Hierarchical and Network normalization techniques for Data handling. Relational, Distributed and Other types of Databases. Data Indexing and Structuring Techniques, Integrity and Security of Databases, Information Searching and Retrieval. Operators: Relational, Logical and Boolean.

Unit - IV
Hospital Information Systems: Need for Computerization in Hospitals. Functional capabilities of a computerized Hospital Information System. Cost effectiveness of Information processing by a Computer, Security of Computer Records, Source of Data for decision making. Computerized Patient Database Management: Methods of History taking by Computers, Computerized Medical Record: Evaluation Computers in Clinical laboratory: Database approach to Laboratory computerization/automation.

Unit - V
Practice: Case studies- Emergency handling systems, insurance handling, data analysis, IVRS applications, Telemedicine, Equipment maintenance management.

Suggested Reading:

1	G.D. Kunders, *Hospitals Planning, Design and Management*, Tata McGraw-Hill Publications, New Delhi, 2003.
2	Date C.J, *An Introduction to Database Systems*, Addisson Wesley, 1998.
3	J.D Ullman, *Principles of Database Systems*, Galgotia Publications, 1990.
4	R.D.Lele, *Computers in Medicine*, Tata McGraw- Hill Publications, New Delhi, 1988.

BM 114	**MEDICAL DEVICE REGULATIONS**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the medical device classes and regulatory efforts
2	To understand the of national and international medical device regulations and standards
3	To know about the patents and intellectual property rights.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Differentiate the medical devices under their respective classes.
CO-2	Design medical products using different methodologies
CO-3	Deliver the rules of Indian Medical Device Regulations-2017
CO-4	Understand the product safety and legal issues
CO-5	Apply the concepts in design of medical equipment.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit - I

Definition of Testing, Parsing Test Requirements, Test Protocol, Test Methodology, Purpose Of The Test, Failure Definition, Determining Sample Size And Test Length, Types Of Testing. Analysis of Test Data- Failure Rate, Mean Time between Failure, Reliability, Confidence Level, Confidence Limits, Minimum Life, Graphical Analysis, Reliability And Liability- Negligence, Strict Liability, Breach Of Warranty, Defects, Failure To Warn Of Dangers, Plaintiff's Conduct, Defendants' Conduct, Defendant Related Issues, Manufacturers And Physicians Responsibilities, Accident reconstruction and forensics.

Unit - II
Food And Drug Administration- History of Device Regulation, Device Classification, Registration And Listing, 510(K) Process, Declaration Of Conformance To A Recognized Standard, PMA Application , Investigational Device Exemptions, Good Laboratory Practices, Good Manufacturing Practices, Human Factors, Design Control, FDA And Software, Software Classification, FDA Inspection, Advice On Dealing With The FDA Regulations And Standards- Definition OFA Medical Device, MDD, United States Domestic Standards, Rest Of The World Standards.

Unit - III
Indian Medical Device Rules and Regulations-2017 Licensing Patents Copyrights And Trade Secrets Patents, Copyrights, Trademarks, Trade Secrets. Manufacturing and quality control- GMP regulations, design for manufacturability, design for assembly, manufacturing process

Unit - IV
Miscellaneous Issues- Learning From Failure, Design For Failure, Design For Convenience, Universal Design, Design For Assembly, Prevention Through Design, Design For The Environment, Poka-Yoke, Product Life Issues, Product Testing Issues. Product Issues- Product Safety And Legal Issues, Accident Reconstruction And Forensics, Biomechanics And Traffic Accident Investigations. Professional Issues- BME – Related Professional Societies, Standards Setting Groups, Professional Engineering Licensure, Rules Of Professional Conduct, Codes Of Ethics, Forensics And Consulting, Continuing Education.

Unit - V
Design of Case studies: Multidetector brain scanning system development, testing of anesthetists, apnea detection system, cancer clinic charting, EKG analysis techniques & module.

Suggested Reading:

1	Design of Biomedical Devices and systems (Paul H. King & Richard C. Fries)

BM 115	**ADVANCED BIOMATERIALS**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To enable the students to understand the surgical principles of biomaterial implantations.
2	To make the students gain knowledge about biocompatibility and biodegradability.
3	To make the students learn about surface characterization and applications of biomaterials

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	List the requirements for surgical implantation of biomaterials
CO-2	Compare the different levels of biocompatibility and analyze the host reactions
CO-3	Assess different methods of biodegradability
CO-4	Use appropriate methods of surface characterization
CO-5	Describe the applications of biomaterials in various areas of medicine.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	-	1	2	2	2	1
CO-2	1	2	3	3	2	1
CO-3	-	2	2	2	1	-
CO-4	3	2	3	3	2	1
CO-5	1	3	3	3	2	2

Unit – I
Surgical principles of biomaterials Implantation: Introduction, Principal Considerations for experimental surgical Procedures and Material Selection. Physiological models for evaluation of Implantable Devices-An Engineer's Choice. Implantable Biomaterials in Plastic, Reconstructive and Esthetic Surgery.

Unit - II
Biocompatibility and Tissue response: Biocompatibility Hierarchy- Ramifications in Implant

Design and Applications. Host Reactions to particulate Biomaterials: Type of Reactions, Particle Surface; cell Surface and Signaling Mechanism, Chemical Mediators.

Unit – III

Biodegradability, Resorption and Stability: Biodegradable suture materials, Factors affecting Biodegradation Phenomena, Intrinsic Factors –Substituent Effect, Morphological Effect, Annealing Effect. Extrinsic Factors – Effect of media pH, Effect of Electrolytes.

Unit – IV

Physiochemical Characterization of surface and interface on biomaterials and coatings, Methods of surface characterization, Surface and Interface structure. Investigations-Transmission Electron Microscopy, Ion Beam Techniques. Characteristics of Plasma Gas Discharge. Plasma Systems and Processes.

Unit – V

Applications of materials in medicine and Dentistry: Cardiovascular Applications, Dental Implants, Orthopedic Applications. Drug Delivery Systems, Sutures, Ophthalmologic Applications.

Suggested Reading:

1	Buddy D.Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Eds, *Biomaterials Science – An Introduction to Materials in Medicine*, Academic Press, 1996.
2	Donald L. Wise, Debra J. Trantolo, David E. Altobelli, Michael .J. Yaszemski, Joseph D. Gresser, Edith R. Schwartz (Editors), *Hand book of Biomaterials and Bioengineering*, Parts A&B, Marcel Dekker Inc, 1995.

BM 116	**BIOTRANSPORT PROCESSES**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the students to the mass and heat transport processes in the human body
2	To make the students understandmass transfer mechanisms in artificial kidneys and lungs
3	To make the students gain basic knowledge of compartmental models and their physiological applications

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the basic laws governing mass and heat transport
CO-2	Discuss the mechanisms for heat transfer in the human body
CO-3	Analyze the mass transfer in the kidneys and lungs
CO-4	Apply mass transfer principles to artificial kidneys and artificial lungs
CO-5	Describe the one- and two- compartmental models and their physiological applications

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Basic concepts of transport processes. Relationship between flow and effort variables. Chemical balances, force balances, general flow balances, Kirchhoff's laws, Conservation of mass, conservation of energy, momentum balance.

Unit – II
Heat transfer systems. Modes of heat transfer, conduction, convection and radiation. Heat production, heat loss to the environment, role of blood circulation in internal heat transfer, models for heat transfer within the body.

Unit – III
Mass transfer principles. Mass balance, molecular diffusion, Transport through cell membranes. Mass transfer in kidneys, models of nephron function, gas transport mechanisms in the lungs and blood. Modelling of oxygen and inert gas uptake in the lungs.

Unit – IV
Mass transfer in artificial kidney devices, modeling of patient-artificial kidney system. Comparison of natural and artificial lungs. Models for blood oxygenation, analysis of gas transport in membrane oxygenators.

Unit – V
Compartmental models. Approaches to pharmacokinetic modeling and drug delivery, one and two compartmental models. Physiological applications-intravenous injection, constant intravenous infusion, determination of regional blood flow volumes and blood flow rates.

Suggested Reading:

1	Arthur T. Johnson, Biological process Engineering- An analogical approach to fluid flow, heat transfer, mass transfer applied to Biological systems, John Wiley and Sons, 1999.
2	David O. Cooney, Biomedical Engineering Principles-An introduction to fluid, heat and mass transport processes, Marcel Dekker Inc., 1976.

BM 117	**HOSPITAL MANAGEMENT SYSTEMS**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make the students know the about the administration of all the departments in the hospitals.
2	To make the students understand hospital planning and information management.
3	To make the students learn about equipment maintenance management

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain the significance of various departments present in the hospital
CO-2	Analyze the planning of location, budgeting and other facilities in a hospital
CO-3	Recognize the role of computerization in a hospital
CO-4	Evaluate the power supply requirements for various services and equipments in a hospital
CO-5	Schedule the routine preventive maintenance procedures and maintain log books

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit - I
Administration of Hospital Systems: Teaching-cum-Research Hospitals. General Hospital. Specialist Hospitals. P.H.C. – Role, Layout and Functions.Hospital Services: Emergency; Outpatient; supporting; auxiliary; Dietary; Drugs and Medical Supply. Nursing Services. Records Management. BME Services in Hospitals: Role and Responsibilities

Unit - II
Hospital Planning. Technical Considerations: Size and kind of Hospitals; Principles of Planning – Selection; Location; Site and Orientation. Budgeting, Equipment Plans. Power Supply. Air-conditioning and Water Supply requirements. Elevators, Ambulance, Fire

Fighting and Safety services. Disposables. Hospital Infection and Control.

Unit - III
Computers and Information Management in Hospitals: Computer Aided Hospital management – Applications: Admission/Discharge Records. Patient Billing. In-patient medical records. Pharmacy Management. Operation Theaters and ICCU. OPD Registration, Purchase and Inventory Control.

Unit - IV
Electrical factors in Hospital Design, Layout and Centralisation of Technical Services: Electrical Power Supply: Reliability, Three Phase Systems. Voltage stabilisation. Proper location of Air Conditioners, Elevators, Transformers, other electrical machinery and Electrical Shielding techniques to prevent 50Hz power supply interference on sensitive Electro Medical / Diagnostic / Monitoring / Therapeutic Equipment. Standby power supply arrangements. Centralisation: Commonality of technical services and centralisation for optimum utility of equipment and staff. Efficient operation and cost effectiveness.

Unit - V
Bio-Medical Equipment Maintenance Management: Procurement Procedures: Proper Selection, Safety, Spares, Evaluation, Testing and Installation. Purchase and Contract Procedures. Training of medical staff on technical capabilities and proper use of Biomedical equipment. Biomedical Equipment Maintenance: Procedures & Policy, Mandatory Requirements. Maintenance Procedures. Preventive Maintenance and Periodical Servicing Procedures: Servicing Schedules. Fault Diagnosis. Repairs and Modifications. Maintenance of Log Books. Implementation of Electrical Safety Codes and Standards, Stores Management. Functional Organisation of a BME/Clinical Engineering Department. Layout and Setting of Clinical Engineering Lab, Workshop. Test and Servicing Equipment. Staff, In-house R & D.

Suggested Reading:

1	Goel S.L., and Kumar R., *Hospital Administration and Management* Vol. 1,2,3, Deep and Deep, New Delhi.
2	G.D. Kunders, *Hospitals Planning, Design and Management*, Tata McGraw-Hill, 2003.

BM 118	**PHYSIOLOGICAL CONTROL SYSTEMS**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To study system concept and different mathematical techniques applied in analyzing any given system.
2	To learn to do the analysis of given system in time domain and frequency domain.
3	To develop an understanding of the fundamental principles behind control of various biological systems.
4	To apply these analysis to study the biological systems.
5	To study system concept and different mathematical techniques applied in analyzing any given system.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Analyze the concepts that are generally useful in all other engineering disciplines.
CO-2	Apply quantitative approaches for the analysis of physiological system.
CO-3	Ability to create simple models of physiological systems.
CO-4	Ability to understand complex physiological models.
CO-5	

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit - I
Physiological Systems with feedback, modeling of physiological systems, model based noise reduction and feature extraction. Physiological control systems analysis. Differences between engineering and physiological control systems, Mathematical modeling, linear models of physiological systems, distributed parameter and lumped parameter models

Unit - II
Static analysis of physiological systems, Determination of steady state operating point, Steady state analysis, Regulation of cardiac output, Chemical regulation of ventilation. Time domain analysis of linear control systems. Transient response analysis- dynamics of neuromuscular reflex motion. Frequency domain analysis of linear control systems, frequency response of circulatory control and glucose insulin regulation.

Unit - III
Relative stability, Stability analysis of pupilary light reflex, model of Cheyne-Stokes breathing. Identification of physiological control systems, parametric estimation, identification of closed loop system, optimization of physiological control, single parametric optimization, constrained optimization, and adaptive control of physiological variables.

Unit - IV
Modeling the nerve action potential, voltage clamp experiment and its interpretation, model for the strength duration curve, modeling skeletal muscle contraction, cross bridge theory of muscle contraction, linear model of muscle contraction, applications of skeletal muscle contraction, modeling myoelectric activity

Unit - V
System identification in physiology, modeling of sensory receptors and pupil control system. Modeling cardiovascular system, Modeling blood flow, systemic blood flow and coronary circulation. Behavior of the immune system, linearized model of immune response to disease.

Suggested Reading:

1	Michael C.K. Khoo, *Physiological Control Systems-Analysis Simulation and Estimation*, IEEE Press Series in Biomedical Engineering, 2000.
2	Suresh R. Devasahayam, *Signals and Systems in Biomedical Engineering-Signal Processing and Physiological Systems Modeling*, Kluwer Academic/Plenum Publishers, 2000.

BM 119	**ELECTROMAGNETIC BIOINTERACTION**					
	(PROGRAM ELECTIVE)					
Pre-requisites	Advanced Structural Analysis		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the students to the biological effects of Electromagnetic radiation
2	To make the students understand the interaction mechanisms of EM radiation with biological substances
3	To make the students gain basic knowledge of biological effects of Electromagnetic radiation

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the coupling of human body to EM radiation
CO-2	Discuss the interaction mechanisms of EM radiation with human body
CO-3	Describe the instrumentation used in bioelectromagnetics
CO-4	Assess the biological effects and health implications of EM radiation
CO-5	Describe the cellular and sub cellular effects of EM radiation

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Electromagnetic Spectrum, Exposure and absorption parameters, International guidelines, Currents induced in standing human being for vertically polarized plane wave exposure conditions, contacts hazards in VLF to HF band, thermal implications of high SARs. Coupling of human body to RF magnetic fields, Radio Frequency protection guide(RFPG).

Unit – II
EM bio engineering: Extremely LF, EM fields, dielectric heating, broadcast radiation, MW ovens, EM fields in medicine, electrical properties of biological substances, Interaction mechanisms. Application of the finite-differences time domain and the SINC-function Fast Fourier Transform method of moments.

Unit – III
Role of Experimental Techniques and Instrumentation in bioelectromagnetics: Irradiation systems for bioeffects experiments, Far-field exposure techniques, Instrumentation, Measurements of internal fields and radiofrequency absorption in biological systems, Instruments for measuring Specific Absorption Rates.

Unit – IV
EM energy absorption in human and animals: Measurement techniques, Free space irradiation conditions, Ground effects, SAR exposure assessment and safety guidelines. Biological effects and Health implications: Effects due to extremely LF and 60 Hz fields.

Unit –V
Biological effects of millimeter wave radiation: Experimental approaches, frequency specific effects, genetic systems, cellular and sub cellular effects. Electromagnetic methods for medical applications.

Suggested Reading:

1	Gandhi Om.P, Biological effects and medical applications of Electromagnetic Energy Biophysics and Bioengineering series, Prentice Hall Advanced reference series, Englewood cliffs, New Jersey,1990
2	Franceschetti G, Om P Gandhi and Matini Grandlfo, Electromagnetic biointeraction, Plenum Press, New York,1989.

BM 120	**BIOSTATISTICS**					
(PROGRAM ELECTIVE)						
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce basic statistical methods like curve fitting, correlation and regression.
2	To provide the knowledge of probability distributions like normal, Poisson and tests of significance.
3	To introduce basic statistical methods like curve fitting, correlation and regression.
4	To provide the knowledge of probability distributions like normal, Poisson and tests of significance.
5	Recognize the importance of data collection and its role in determining scope of inference.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Apply various probability distributions to solve practical problems,
CO-2	Estimate unknown parameters of populations and apply the tests of hypotheses.
CO-3	Analyze variance to randomize.
CO-4	Perform regression analysis and to compute and interpret the coefficient of correlation.
CO-5	Carry out the chi-square test and interpret its results.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit - I
Concepts of Biostatistics. Basic statistical measures, measures of central tendency, measures of dispersion, variance, standard deviation, properties of probability, probability distributions, sampling distributions.

Unit - II
Estimation and hypothesis testing. confidence intervals for data, t distribution, determination of sample size for estimating means and proportions. Hypothesis testing for a single population mean/proportion difference between two population means/proportions, sample size to control type I and type II errors.

Unit - III
Analysis of variance. The completely randomized design, random sized complete block design, repeated measures design.

Unit - IV
Regression and correlation. Simple linear regression model, regression equation, the correlation model, multiple linear regression model, multiple regression equation, multiple correlation model, additional techniques of regression analysis.

Unit - V
Chi-square distribution, tests of good fit, independence, homogeneity, non-parametric statistical procedures, regression analysis.

Suggested Reading:

1	Stanton A. Glantz, *Primer of biostatistics*, Mc GrawHill , 2nd Ed.
2	Wayne S. Daniel, *Biostatistics: A foundation for analysis in the health sciences*, John Wiley & Sons, 6th Ed. 2012.

BM 121	**MEDICAL IMAGE PROCESSING**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make the students have clear understanding on the principles of Digital Image processing.
2	To make students learn and understand image enhancement in spatial and frequency domain.
3	To familiarize the students with the image restoration and segmentation algorithms.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Good understanding of the mathematical foundations for digital manipulation of images: image acquisition; preprocessing; segmentation.
CO-2	Comprehend the principles of image preprocessing.
CO-3	Perceive the governing principles of image segmentation.
CO-4	Evaluate the image restoration and registration methods.
CO-5	Realize how to implement morphological principles to the medical images.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Digitized image functions, Dirac distributions, convolution, Fourier transform, Images as linear system. Image digitization, sampling, Quantization, color images. Digital image properties, Metric and topological properties, Histogram visual perception, Image quality, Noise. Data structures for image analysis, data representation, traditional and hierarchical data structures.

Unit - II
Image Enhancement. Contrast manipulation, histogram equalization, Laplacian derivatives, Sobel and Klisch operators, rank operators –textural analysis. Image pre processing – pixel brightness transformations, Geometric transformations, local pre processing, Image restoration. Imaging filters.

Unit – III
Thresholding and Segmentation. Detection methods, optimal thresholding, multi-spectral thresholding. Edge based segmentation, Region based segmentation, Matching, Advanced optimal border and surface detection approaches.

Unit – IV
Restoration. Deterministic, geometric linear filtration, inverse filtering, power spectrum equalization, stochastic. Wiener filtering. Registration, anatomy based, object based, scene based.

Unit – V
Mathematical morphology. Basic morphological concepts, Morphological principles: Binary dilation and erosion, Gray scale dilation and erosion, skeletons and object marking, graundometry, Morphological segmentation and water sheds.

Suggested Reading:

1	John C Russ, *The image processing handbook,* CRC and IEEE press –1999.
2	Milan Sonka, Vaclav Hlavac,Roger Boyle, *Image processing, analysis and machine vis* 2nd edition,Brooks/Cole publishing Co., 1999.
3	Jayaram, Kudupa and Gabor,T Herman, *3D imaging in medicine*, 2nd edition, CRC 2000.
4	Craig A.Hindley, *Practical image processing in C,* John Wiley and Sons 1991.

BM 122	**ENTERPRISE MANAGEMENT**					
	(PROGRAM ELECTIVE)					
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To provide students with a background of Indian industry and factors that has major influence on business.
2	To promote first generation entrepreneurs.
3	To encourage patent applications.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Appraise the business environment and its scope
CO-2	Understand the concepts, functions and growth of entrepreneurs
CO-3	Identify elements of project management to plan, control and organize the resources
CO-4	Acquire knowledge on time management
CO-5	Learn formalities and documentation required for registration of patents.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit - I

Indian Industrial Environment-Competence, opportunities and Challenges, entrepreneurship and economic growth, Small Scale Industry in India, Objectives, Linkage among small, Medium and heavy Industries, Types and forms of enterprises.

Unit - II

Identification and Characteristics of entrepreneurs, Emergence of First generation entrepreneurs, environmental influence and women Entrepreneurs, Conception and evaluation

of ideas and their sources. Choice of Technology-Collaborative interaction for Technology development.

Unit - III
Project formulation, analysis of market demand, demand - supply gap, Financial and Profitability analysis and technical analysis, project financing in India. Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques. Human aspects of project management, Assessment of tax burden.

Unit - IV
Behavioral aspects of entrepreneurs: Personality - determinants, attributes and models, leadership concepts and models, values and attitudes, Motivation aspects, change behavior, Various approaches of time management, their strengths and weaknesses. The urgency addiction and time management matrix

Unit - V
Property Rights: intellectual property rights- Nature of I.P- Protection of I.P rights- Kinds of Intellectual Property Rights- International conventions of Intellectual property rights- Patent treaty 1979, GATT 1994, TRIPS & TRIMS- International organization for protection of IPR- WTO, WIPO, UNESCO. Patents: Meaning of patent- commercial significance- obtaining of patent- patentable subject matter- rights and obligations of patentee- specification- registration of patents – compulsory licensing and licenses of rights- Revocation.

Suggested Reading:

1	Vasant Desai, *Dynamics of Entrepreneurial development and Management*, Himalay Publishing house, 1997.
2	Prasanna Chandra, *Project planning, analysis, selection, implementation and review*, Ta Mc-Graw Hill, 1995.
3	Sudha G.S., *Organizational behaviour*, National publishing house, 1996.
4	Cornish W.R., *Intellectual property; Patents, Copyright, Trademarks and Allied Rights* Sweet & Maxwell Publications.

BM 123	**MEDICAL PRODUCT DESIGN**					
	(PROGRAM ELECTIVE)					
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make students understand the basic design rules in designing the Medical Products.
2	To make students learn the Medical device directives.
3	To make students learn the medical device standards and regulations.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Learn the classification and Overview of Medical devices.
CO-2	Know the software and hardware design of products.
CO-3	Knowledge of Testing and data analysis of medical devices
CO-4	Knowledge of Good Manufacturing process and regulations.
CO-5	Knowledge of ISO standards and regulations.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit - I
Medical devices. Overview of product .Product definition process. Quality function deployment process. Materials-Biocompatibility, International regulatory efforts. Device category and choice of test programs. Biological control tests. Test for biological evaluation.

Unit - II
Specifying and designing the product. Engineering requirements-design specification, risk management, intellectual property-patents, human factors, Hardware design-component selection, design of experiments, software design- object oriented design, software coding.

Unit - III
Testing and data analysis. Basis and types of testing, hardware verification and validation-standard tests , software verification and validation, reliability evaluation, analysis of test results-failure rate, Mean Time Between Failures (MTBF).

Unit - IV
Manufacturing and Maintenance process. Good manufacturing process (GMP), the GMP Regulation, Design for manufacturability, manufacturing process, Quality systems regulation, configuration management, Quality system audit, analysis of field data.

Unit - V
Medical device regulations and standards. Food and Drug Administration, Medical device directives ISO 9001 series of standards, Domestic standards, International standards.

Suggested Reading:

1	Richard C.Fries, *Reliable design of medical devices*, Marcel Dekker Inc., 1997.
2	Richard C.Fries, *Handbook of medical device design*, Marcel Dekker Inc., 2001.

BM 124	**TISSUE ENGINEERING**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make students understand the tissue development and in vivo synthesis.
2	To make students gain basic knowledge on the models and approaches in engineered issues.
3	To make students appreciate the applications of tissue Engineering

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Articulate the scientific vocabulary used to communicate information in tissue engineering.
CO-2	Understand the fundamental role of tissue engineering in cells, scaffold and growth factors.
CO-3	Acquire knowledge on stem cells and their importance in tissue regeneration.
CO-4	Memorize the concepts and properties of various biomaterials used in biomedical applications.
CO-5	Apply tissue engineering concepts in clinical studies.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	3	3	1
CO-2	2	3	3	3	3	1
CO-3	-	2	2	2	2	1
CO-4	3	3	3	3	3	2
CO-5	3	3	3	3	3	2

Unit – I

Growth and Differentiation, Organization of cells into Higher ordered structures, Dynamics of cells-ECM interactions, Matrix molecules and Their ligands, Inductive Phenomena, Cell Determination and Differentiation, Mechanical and Chemical determination of Tissue Development , Animal Cell Culture, Regulations of cell Behaviours cellular proteins, Growth factors , Tissue Assembly in Micro Gravity, In vivo Synthesis of Tissues and Organs.

Unit - II
Organotypic and Histiotypic Models of Engineered Tissues, Quantitative aspects of Tissue Engineering: Basic Issues in Kinetics, Transport and Mechanics, Patterning of cells and their environment, Cell Interactions with Polymers, Matrix Effects , Polymer Scaffold Processing, Biodegradable Polymers.

Unit – III
Approaches to transplanting Engineered cells and Tissues, Cryopreservation, Immunomodulation, Immuno- isolation, Engineering challenges in immuno-isolation, Fetal tissue Engineering, Pluri potent stem cells, Gene Therapy.

Unit – IV
Applications: Breast Reconstruction, Cardiovascular Systems-Blood Vessels, Small diameter Vascular Grafts, Cardiac Prosthesis. Cornea. Endocrinology and Metabolism-Bioartificial Pancreas, Parathyroid.

Unit – V
Musculoskeletal System-Structural Tissue Engineering, Bone Regeneration through Cellular Engineering. Gastrointestinal System –Alimentary tract, Liver, Hepato Assist liver support system, Linage Biology and liver. Hematopoitic Systems-Red Blood Cell Substitutes, Lymphoid Cells, Hemapoietic Stem Cells. Kidney and Genitourinary system-Renal Replacement Devices, Genitourinary System.

Suggested Reading:

1	Robert P. Lanza, Robert P. Langer, Joseph P. Vacanti, *Principles of Tissue Engineering*, Academic Press, 2nd ed. 2000.
2	FarshidGuilak, David L. Butler, Steven A. Goidstein, *Functional Tissue Engineering*, Springer Verlag, 2004.
3	Frederick H. Silver, *Biomaterials, and Medical Devices & Tissue Engineering: An integrated approach*, Chapman & Hall, London, 1994.

BM 125	**BIO NANO TECHNOLOGY**					
	(PROGRAM ELECTIVE)					
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the students to fabrication processes of MEMS and NEMS.
2	To make the students learn the properties, characteristics, classification and applications of Nano devices.
3	To make the students understand the importance of Nano materials and their medical applications.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain the fabrication and applications of MEMS and NEMS
CO-2	Compare the bottom-up and top-down approaches in nanomaterials fabrication.
CO-3	list the types of Carbon nanoparticles nanotubes and their fabrication
CO-4	Describe the applications of Nanomaterials in cancer treatment, drug delivery and imaging applications.
CO-5	Explain the biosensor applications of Nanomaterials.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	2	2	2	2	1
CO-2	2	2	3	3	3	1
CO-3	-	1	2	2	2	-
CO-4	2	2	3	3	3	2
CO-5	2	2	3	3	3	2

Unit - I MEMS & NEMS:

Definition of MEMS, materials for MEMS (Silicon, Polymers and metals) and their properties, Deposition processes, Photolithography, and etching processes, Limitations of MEMS, NEMS, difference between MEMS and NEMS, properties of NMES, fabrication processes, applications.

Unit - II Introduction to Nanotechnology:

Nanomaterials, Fullerenes and carbon forms. Nanoparticles and Colloids, structure and

bonding in nanoparticles, Nanomaterials fabrication by Bottom-up and Top down approaches, Classification of nanodevices based on the characteristics, Quantum dots and their properties.

Unit - III Carbon nanotubes:

Carbon nanoparticles, types of carbon nanotubes, single-walled, multi-walled, torus, nanobud, properties of carbon nanotubes, and synthesis by Arc discharge, laser ablation, chemical vapor deposition techniques

Unit - IV Nanomedicine:

Medical use of Nanomaterials, Drug delivery systems. Cancer treatment, Surgery. Drug tracking systems. Targeted drug delivery systems. Applications of Nanomaterials in Medical imaging. Neuro-electronic interfaces.

Unit - V Bio molecular nanotechnology:

Nanorobots and their application, nanosensors based on biomolecules such as DNA and proteins, nanoparticles for gene delivery systems, Computational genes, Biosensors for Glucose and measurement, Optical biosensors and their application.

Suggested Reading:

1	Lynn E. Foster, Foreword by George Allen, Foreword by Joe Lieberman, Nanotechnology: Science, Innovation, and Opportunity, Nanomedicine: Basic Capabilities, Vol. 1 by Robert A. Freitas Jr. 1999 Rev
2	Neelina Malsch , Biomedical nanotechnology by CRC press release, *Malsch Techno Valuation, Utrecht, The Netherlands*
3	GeroDecher, Joseph B. Schlenoff, Multilayer Thin Films, Wiley-VCH Verlag GmbH & Co. KGaA, 2003
4	David S. Goodsell, Bio-nanotechnology : Lessons from Nature, Wiley-Liss , 2004. Kenneth J. Klabunde, Nanoscale Materials in Chemistry. , John Wiley & Sons, Inc., 2001

BM 126	**MEDICAL OPTICS**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To familiarize students with optical fibers and their properties.
2	To offer students with clear understanding of photonic instrumentation
3	To make students understand the properties and working of optical sources and detectors used in light transmission through optical cables.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamental working principles of optical fibers and their types.
CO-2	Analyze the tissue characteristics when the light interacts with tissues.
CO-3	Design photonic instrumentation for medical applications
CO-4	Provide adequate knowledge about various optical sources used for diagnostic applications.
CO-5	State various optical therapy techniques used in medicine

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I Introduction to Optical Fibers

Introduction: Basic optical laws and definitions, optical fiber modes and configuration, single mode fibers, graded index fiber structure, fiber materials, attenuation, signal distortion in optical waveguides, pulse broadening in graded index waveguides.

Unit - II Optical properties of tissues
Tissue properties – refractive indices, scattering and absorption properties, light transport inside the tissue, light interactions with a strongly scattering tissue – continuous wave light, short light pulses, diffused photon density waves, Temperature rise and tissue damage – optothermal and opt acoustic effects. Fluorescence speckles.

Unit – III Instrumentation in Photonics
Instrumentation for absorption, scattering and emission measurement, excitation light sources – high pressure arc lamp, solid state LEDs, LASERs, optical filters, polarizer's, solid state detectors, time resolved and phase resolved detectors

Unit – IV Biophotonic Diagnostics
Near IR spectroscopy for biological glucose analysis, flow cytometry – basic operation, optical response – applications – optical biosensors – principles, bio-recognition, optical transduction – Bio-imaging – cellular, tissue imaging and in vivo imaging. Introduction to Optical Coherence Tomography

Unit – V Biophotonic Therapy
Photodynamic therapy – basic principle, photo sensitizers, mechanism of photodynamic action, applications – Laser tissue welding, lasers in dermatology, neurosurgery, ophthalmology, urology.

Suggested Reading:

1	Keiser, Optical *Fiber Communication Systems*, Mc Graw Hill Ltd., 1983
2	Ed., Tuan Volume Dinh, "Biomedical Photonics Handbook", CRC Press, 2003.
3	Leon Goldman, "The Biomedical Laser Technology and Clinical Applications", Springer Verlag, 1981.
4	Leon Goldman and R. James Rockwell, "Lasers in Medicine", Gordan& Breach, Science Publishers Inc, 1971
5	Koebmer K R, "Lasers in Medicine", John Wiley & Sons, 1980
6	Paras N Prasad, "Introduction to Biomedical Photonics", John Wiley. 2003

BM 127	**LASERS IN MEDICINE**					
	(PROGRAM ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make students know the basic optical laws and fiber optic fundamentals.
2	To expose students to laser fundamentals and fiber optic applications in medicine
3	To make students clearly understand laser applications in medicine and laser safety fundamentals

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the basicoptical laws and properties of fiber optics
CO-2	Implement working principle of lasers for medical applications
CO-3	Analyze the tissue characteristics when light interacts with tissues
CO-4	Provide adequate knowledge about various lasers used in medical applications
CO-5	Appraise the laser safety standards, hazardsand precautions

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Basic optical laws and definitions, optical fiber modes and configuration, single mode fibers, graded index fiber structure, fiber materials, attenuation, signal distortion in optical waveguides, pulse broadening in graded index waveguides.

Unit - II
Medical Lasers: Introduction, Laser physics- fundamentals, principles, advances. Medical

Laser system-fundamentals, principles. Reflection and Refraction, Absorption, Scattering, turbid media, Photon Transport Therapy, Measurement of optical Tissue Properties.

Unit – III
Photochemical interaction-Photo Dynamic Therapy, Biostimulation. Thermal interaction-Heat Generation, Heat Transport, Heat Effects, laser-induced interstitial thermotherapy. Photo-ablation – Model of photo-ablation, cytotoxicity of UV Radiation. Plasma induced ablation-Model of Plasma induced ablation, Analysis of Plasma parameters, Photo-disruption- Plasma formation, Shockwave Generation, Cavitation, Jet formation

Unit – IV
Lasers In Opthalmology, Dentistry, Gynecology, Urology, Neurosurgery, Angioplasty and Cardiology, Dermatology, Orthopedics, Gastroenterology, orthinolaryngology and Pulmonology.

Unit – V
Laser safety-fundamentals. Laser hazards, skin hazards, eye hazards, Associated hazards from high power lasers, laser safety standards and hazard classification, viewing laser radiation, eye protection, laser calculations and measurements

Suggested Reading:

1	Markolf H. Niemz, laser-tissue interactions fundamentals and applications, Springer
2	Laser and optical fibers in Medicine by Abraham Katzir, Academics Press,1998.
3	Keiser, Optical Fiber Communication Systems, Mc Graw Hill Ltd., 1983
4	Medical Lasers and their safe use DAVID H Shiney .Stephen and L Trokel, Springer, Springer. verlag publications.

LABORATORIES

BM 151	**MEDICAL SENSORS & SIGNAL CONDITIONING LAB**					
	(LABORATORY)					
Pre-requisites			**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make the students conduct experiments using various sensors.
2	To make the students design signal conditioning circuits for different sensors and implement them for medical applications.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	conduct experiments on self-generating sensors, and use them for medical applications
CO-2	Able to measure conductivity, flow rate, acceleration using various sensors
CO-3	Design the data acquisition system with ADC and filters for different sensors.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

LIST OF EXPERIMENTS
1. Experiments on Electrodes- ECG, EEG, EMG
2. Signal conditioners for the following transducers: i) Piezoelectric transducers ii) Thermocouple ii) Phonocardiography transducer iv) Strain gauge v) LVDT vi) Plethysmographic transducer vii) Capacitive transducer viii) Electromagnetic flow transducer ix) Optical transducer x) Carrier Amplifier xi) Chopper Amplifier xii) Isolation Amplifier xiii) MEMS Sensors

BM 152	**EMBEDDED MEDICAL PRODUCT DESIGN LAB**					
	(LABORATORY)					
Pre-requisites			**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make the students know the basic concepts of embedded systems, device drivers and memory management.
2	To make the students write programs to interface various peripheral devices with 8051 and PIC microcontrollers

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the functionality of 8051 and PIC microcontroller
CO-2	Interface various peripheral devices with 8051 and PIC microcontrollers
CO-3	Interface matrix sensors to PIC microcontroller

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

LIST OF EXPERIMENTS

Study of different microcontroller development systems

Interface 8051 microcontroller with :

1. ADC
2. DAC
3. Keyboard interface & Touch screen
4. LCD Display: Alphanumeric mode & Graphic mode
5. Seven segment display
6. PC interface: RS 232
7. PC interface: Ethernet
8. Stepper motor
9. I2C based EEPROM interfacing
10. SPI based EEPROM interfacing
11. Interfacing of matrix sensors to PIC microcontroller
    a) Pin to pin study of MCU
    b) To study of initialization of internal fix PWM
    c) To study of Initialization of internal PWM with variable duty cycle using Internal ADC
    d) ECG sensor
    e) Oxygen sensor
    f) Heart rate monitor

Note:

The experiments to be conducted under this lab should include design/fabrication/ evaluation/technical reporting/case-studies/mini projects. The students should be encouraged to take up different challenging mini projects in this lab.

BM 153	**BIOMEDICAL SIGNAL & IMAGE PROCESSING LAB**					
	(LABORATORY)					
Pre-requisites			**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make the students develop programs on process of medical signals.
2	To make the students develop programs on process of medical images.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Design and apply the filters for the pre-processing of Bio signals and medical images.
CO-2	Develop programs for the processing and compression of medical signals.
CO-3	Develop programs for basic operations on medical images.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

LIST OF EXPERIMENTS

Experiments on Signal Processing

1. Use of DSP processors-6X and 2X series for
   (i) Generation of basic signals.
   (ii) Linear and circular convolution
   (iii)Realization of FIR and IIR filters
   (iv)Finding DFT and IDFT of given sequence
   (v) Plotting the power spectral density.
2. Computation of convolution and correlation sequences.
3. Signal averaging improvement in the SNR Using coherent and incoherent averaging.
4. Exponential averaging.
5. Data polishing: mean and trend removal
6. Design of IIR and FIR Filter
7. PSD Estimation
8. AR Modeling for Predictive Filters

9. LMS Based Algorithm for Adaptive Noise Canceling
10. Data Compression Techniques: AZTEC, TP, CORTES, KL Transform
11. Template matching algorithm for QRS detection
12. Classification of EEG waves.

Experiments on Image Processing

1. Reading and displaying JPEG and BMP images.
2. Negative of an image.
3. Contrast Stretching
4. Logarithmic Transform.
5. Power-law Transform.
6. Transpose of an image.
7. Filtering in spatial domain
   a. High pass filter.
   b. Low pass filter
   c. Laplacian filter.
8. Filtering in frequency domain
   a. Low pass filter
   b. High pass filter
   c. Butterworth low-pass & high-pass filters.
   d. Gaussian low pass& high pass filter
9. determine the image after applying the threshold
10. Highlight a specific range of gray levels in a given image.
11. Enhance the given image by Histogram processing & Histogram Equalization.
12. Edge detection operators

BM 154	**MEDICAL EQUIPMENT LAB**					
	(LABORATORY)					
Pre-requisites			**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To make the students design and test systems for medical applications
2	To make the students develop programs for filtering noisy medical signals

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Design and test systems for biopotential signals
CO-2	Design and test a3 op-amp instrumentation amplifier
CO-3	Design filters for biopotential signals

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

LIST OF EXPERIMENTS

Design/Fabrication and testing of following list using Lab view:

1) ECG system
2) EEG system
3) EMG system
4) GSR system
5) 3 OP-Amp Instrumentation Amplifier
6) Filters:
   i. Notch Filter
   ii. Low pass Filter
   iii. High Pass Filter
   iv. Filters in feedback loop

BM 162	**MINI PROJECT**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	4	2
Evaluation	**SEE**	-	**CIE**	50 Marks		

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To review available literature and formulate structural engineering problems
2	To learn the technique of writing reports and prepare presentation

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Identify engineering problems reviewing available literature
CO-2	Understand of contemporary / emerging technology for various processes and systems.
CO-3	Share knowledge effectively in oral and written form and formulate documents
CO-4	Present solution by using his/her technique applying engineering principles.
CO-5	Prepare technical report and presentation

Guidelines:

The students are required to search / gather the material / information on a specific topic comprehend it and present / discuss in the class. Students can take up small problems in the field of design engineering as mini project. It can be related to solution to an engineering problem, verification and analysis of experimental data available, conducting experiments on various engineering subjects, material characterization, studying a software tool for the solution of an engineering problem etc.

Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available. End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution. Continuous assessment of Mini Project at Mid Semester and End Semester will be monitored by the departmental committee.

OPEN ELECTIVES

OE 941 BM	**MEDICAL ASSISTIVE DEVICES**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To extend knowledge of the amputee, of lost and remaining functions affecting locomotion, and to collect information on the best possible medical treatment.
2	To improve fitting techniques and practices, including training, so that existing devices might be used with greater comfort and function.
3	To develop improved lower-extremity devices

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Apply fundamental knowledge of engineering in rehabilitation
CO-2	Apply analytical skills to assess and evaluate the need of the end-user
CO-3	Develop self-learning initiatives and integrate learned knowledge for problem solving
CO-4	Understand the basics of robotics and apply their principles in developing prosthetics
CO-5	Apply the knowledge of computers in solving rehabilitation problems

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Introduction to Rehabilitation Engineering, Measurement and analysis of human movement, Disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering.

Unit – II
Assistive Technology, Seating Biomechanics and systems. Wheeled Mobility: Categories of Wheelchairs. Wheelchair Structure and Component Design. Ergonomics of Wheel chair propulsion. Power Wheelchair Electrical Systems. Control. Personal Transportation. Auxiliary

devices and systems.

Unit – III
Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution. Measurement tools and processes: fundamental principles, structure, function; performance and behavior. Subjective and objective measurement methods.

Unit – IV
Rehabilitation Robotics, Major Limb Prosthetic Devices, Orthotic Devices, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Controlled orthotics and prosthetics FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand.

Unit – V
Augmentative and Alternative communication technology, Computer applications in Rehabilitation Engineering, telecommunications, and Web Accessibility.

Suggested Reading:

1	Robinson C.J., *Rehabilitation Engineering*, CRC Press, 1995.
2	Ballabio E., et al., *Rehabilitation Technology*, IOS Press, 1993.
3	Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, *Series in medical physis and biomedical engineering: An introduction to rehabilitation engineering*, Taylor and Francis Group, London, 2007.
4	Joseph D. Bronzino *The biomedical engineering handbook -biomedical engineering fundamentals*, 3rdEd., CRC Press, Taylor & Francis Group, London, 2006.

OE 942 BM	**MEDICAL IMAGING TECHNIQUES**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the students with various medical imaging modalities.
2	To make learners understand the principles, detectors and operating procedures of X-ray, CT, MRI, ultrasound, PET and SPECT.
3	To make the students learn the advantages, disadvantages and hazards of various medical imaging equipment.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Interpret the working principle and operating procedure and applications of X-ray equipment.
CO-2	Understand the image reconstruction techniques and applications of CT.
CO-3	Summarize the image acquisition and reconstruction techniques in MRI.
CO-4	Comprehend the working principle, modes and medical applications of ultrasound imaging.
CO-5	Examine the operation and applications of PET, SPECT and radio nuclide instrumentation.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

X ray Imaging: Electromagnetic spectrum, Production of X-rays, X-ray tubes- Stationary and Rotating Anode types, Block diagram of an X-Ray Machine, Collimators and Grids, Timing and Exposure controls. X-Ray Image visualization-Films, Fluorescent screens, Image Intensifiers.

Dental X-Ray machines, Portable and mobile X-Ray units, Mammographic X-Ray equipment, Digital Radiography and flat panel detectors.

Radiation safety, ALARA principle, Dose units and dose limits, Radiation dosimeters and detectors.

Unit – II
Computed Tomography: Basic principles, CT number scale, CT Generations. Major sub systems- Scanning system, processing unit, viewing unit, storage unit. Need and Principle of sectional imaging, 2D image reconstruction techniques - Iteration and Fourier methods. Applications of CT - Angio, Osteo, Dental, Perfusion (Body & Neuro), Virtual Endoscopy, Coronary Angiography.

Unit – III
Magnetic Resonance Imaging: Principles of NMR imaging systems, Image reconstruction techniques-Relaxation processes, imaging/ pulse sequences. Sub systems of an NMR imaging system, NMR detection system, types of coils, biological effects and advantages of NMR imaging. Functional MRI - The BOLD effect, intra and extra vascular field offsets, source of T2* effects, Creating BOLD contrast sequence optimization sources and dependences of physiological noise in fMRI.

Unit – IV
Ultrasound Imaging: - Principles of image formation -Imaging principles and instrumentation of A-mode, B-Mode, Gating Mode, Transmission mode and M-mode. Basics of multi-element linear array scanners, Digital scan conversion. Doppler Ultrasound and Colour Doppler imaging, Image artifacts, Biological effects, Ultrasound applications in diagnosis, therapy and surgery.

Unit – V
Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation detectors, Pulse height analyzer, Rectilinear scanner, Gamma camera. Emission Computed Tomography (ECT), Principle and instrumentation of Single Photon Emission Computed Tomography(SPECT) and Positron Emission Tomography (PET). Comparison of SPECT, PET and combined PET/ X-ray CT.

Suggested Reading:

1	Khandpur R.S., *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 2016.
2	S Webb, "*The Physics of Medical Imaging*", Adam Highler, Bristol Published by CRC Press, 1988.
3	A C Kak, "*Principle of Computed Tomography*", IEEE Press New York, 1988.
4	Hykes, Heorick, Starchman, *Ultrasound physics and Instrumentation* MOSBY year book, 2nd Ed. 1992.
5	Stewart C. Bushong, *Magnetic Resonance Imaging- physical and biological principles*, MOSBY, 2nd Ed., 1995.

OE 941 CE	**GREEN BUILDING TECHNOLOGY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Exposure to the green building technologies and their significance.
2	Understand the judicial use of energy and its management.
3	Educate about the Sun-earth relationship and its effect on climate.
4	Enhance awareness of end-use energy requirements in the society.
5	Develop suitable technologies for energy management

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of energy use and energy processes in building.
CO-2	Identify the energy requirement and its management.
CO-3	Know the Sun-earth relationship vis-a-vis its effect on climate.
CO-4	Be acquainted with the end-use energy requirements.
CO-5	Be familiar with the audit procedures of energy

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	3	3	2	1	2
CO-2	3	2	3	2	1	1
CO-3	3	2	3	2	1	2
CO-4	3	2	3	2	1	2
CO-5	3	2	3	2	1	1

Unit – I
Overview of the significance of energy use and energy processes in building - Indoor activities and environmental control - Internal and external factors on energy use and the attributes of the factors - Characteristics of energy use and its management - Macro aspect of energy use in dwellings and its implications.

Unit – II
Indoor environmental requirement and management - Thermal comfort - Ventilation and air quality – Air-conditioning requirement - Visual perception - Illumination requirement - Auditory requirement.

Unit – III
Climate, solar radiation and their influences - Sun-earth relationship and the energy balance on the earth's surface - Climate, wind, solar radiation, and temperature - Sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings.

Unit – IV
End-use, energy utilization and requirements - Lighting and day lighting - End-use energy requirements - Status of energy use in buildings Estimation of energy use in a building. Heat gain and thermal performance of building envelope - Steady and non-steady heat transfer through the glazed window and the wall - Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer.

Unit – V
Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation Energy management options - Energy audit and energy targeting - Technological options for energy management.

Suggested Reading:

1	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
2	Carter, W. Nick, (1991): Disaster Management, Asian Development Bank, Manila.
3	Sahni, Pardeep et.al. (eds.) (2002), Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.
4	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.

OE 942 CE	**COST MANAGEMENT OF ENGINEERING PROJECTS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of cost management
2	Fundamentals of cost overruns
3	Introduce the concepts of Quantitative techniques for cost management Linear Programming, PERT/CPM.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understanding of strategic cost management process, control of cost and decision making based on the cost of the project.
CO-2	Ability to appreciative detailed engineering activities of the project and execution of projects
CO-3	Preparation of project report and network diagram
CO-4	Able to plan Cost Behavior , Profit Planning , Enterprise Resource Planning, Total Quality Management.
CO-5	Applications of various quantitative techniques for cost management

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Introduction and Overview of the Strategic Cost Management Process-Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System- Inventory valuation- Creation of a Database for operational control; Provision of data for Decision-Making.

Unit – II
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning- Project execution as conglomeration of technical and non- technical activities- Detailed Engineering activities.

Unit – III
Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

Unit – IV
Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems- Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector- Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints- Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets- Performance budgets- Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit – V
Quantitative techniques for cost management, Linear Programming, PERT/CPM,- Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Suggested Reading:

1	Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2	Charles T. Horngren and George Foster, Advanced Management Accounting
3	Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4	Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5	N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

OE 941 CS	**BUSINESS ANALYTICS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding the basic concepts of business analytics and applications
2	Study various business analytics methods including predictive, prescriptive and prescriptive analytics
3	Prepare the students to model business data using various data mining, decision making methods

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the basic concepts of business analytics
CO-2	Identify the application of business analytics and use tools to analyze business data
CO-3	Become familiar with various metrics, measures used in business analytics
CO-4	Illustrate various descriptive, predictive and prescriptive methods and techniques
CO-5	Model the business data using various business analytical methods and techniques

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Introduction to Business Analytics: Introduction to Business Analytics, need and science of data driven (DD) decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, framework for decision making, challenges in DD decision making and future.

Unit – II

Descriptive Analytics: Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

Unit – III
Forecasting Techniques: Introduction, time-series data and components, forecasting accuracy, moving average method, single exponential smoothing, Holt's method, Holt-Winter model, Croston's forecasting method, regression model for forecasting, Auto regression models, auto-regressive moving process, ARIMA, Theil's coefficient

Unit – IV
Decision Trees: CHAID, Classification and Regression tree, splitting criteria, Ensemble and method and random forest. **Clustering**: Distance and similarity measures used in clustering, Clustering algorithms, K-Means and Hierarchical algorithms, **Prescriptive Analytics**- Linear Programming(LP) and LP model building.

Unit – V
Six Sigma: Introduction, introduction, origin, 3-Sigma Vs Six-Sigma process, cost of poor quality, sigma score, industry applications, six sigma measures, DPMO, yield, sigma score, DMAIC methodology, Six Sigma toolbox.

Suggested Reading:

1	U Dinesh Kumar, "Data Analytics", Wiley Publications, 1st Edition, 2017
2	Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles, Concepts, and Applications with SAS", Associate Publishers, 2015
3	S. Christian Albright, Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making", 5th Edition, Cengage, 2015

Web Resources:

1	https://onlinecourses.nptel.ac.in/noc18-mg11/preview
2	https://nptel.ac.in/courses/110105089/

OE 941 EC	**ELEMENTS OF EMBEDDED SYSTEMS**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding various Embedded Design strategies
2	Designing Micro controller based Embedded Systems
3	Designing FPGA Based Embedded Systems

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand Embedded Design Strategies and architecture of Arduino Board
CO-2	Program using various onboard components of Arduino
CO-3	Design real time interfacing with Arduino
CO-4	Understand Design Flow of FPGA, programming FPGA using Verilog HDL
CO-5	Implement combinational and sequential circuits using verilog HDL

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Embedded Systems Design Strategies: Micro Controller, DSP, FPGA, Introduction to Arduino (Micro controller Board), Components of Arduino, Architecture and Pin Configuration of ATMega328, Ports of ATMega328.

Unit – II

Interfacing: Interfacing Switches, LEDs, Analog to Digital Converter, Digital to Analog Converter, Interfacing and Programming I2C, SPI

Unit – III

Real Time Programming: Interfacing Key Pad, 7-segment display, LCD, Interfacing Sensors, Interfacing Stepper Motor**,** USB programming

Unit – IV

FPGA Based Embedded Design: FPGA Design flow, Introduction to Verilog HDL**,** Basic building blocks, Data types of Verolog HDL, Behavioral Modelling, Data Flow Modelling, Structural Modelling, Hierarchal Structural Modelling, Case Studies on Verilog HDL descriptions of Basic Circuits

Unit – V
Modelling of Circuits: Verilog HDL Implementation of Combinational MSI Circuits, Verilog HDL Implementation of Sequential MSI Circuits, Finite Sate Machine Design, Tasks and Functions, Introduction to Test Benches

Suggested Reading:

1	Ming-Bo Lin, Digital System Designs and Practices Using Verilog HDL and FPGAs, Wiley India, 2008
2	Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson Education, 2005
3	Simon Monk, Programming Arduino: Getting Started with sketches, Mc.Hill, 2016

Web Resources:

1	www.arduino.cc
2	www.learn.sparkfun.com/tutorials/arduino

OE 941 EE	**WASTE TO ENERGY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To know the various forms of waste
2	To understand the processes of Biomass Pyrolysis.
3	To learn the technique of Biomass Combustion.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of conservation of waste
CO-2	Identify the different forms of wastage.
CO-3	Chose the best way for conservation to produce energy from waste.
CO-4	Explore the ways and means of combustion of biomass.
CO-5	Develop a healthy environment for the mankind.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	-	3	2	3	1
CO-2	3	-	3	2	3	1
CO-3	3	-	3	2	3	1
CO-4	3	-	3	2	3	1
CO-5	3	-	3	2	3	1

Unit – I
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit – II
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit – III
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for

thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit – IV
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit – V
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Reading:

1	Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2	Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3	Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4	Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

OE 942 EE	**POWER PLANT CONTROL AND INSTRUMENTATION**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	The operation of different types of power plants.
2	The basic working principle of instruments for measurement of electrical and non-electrical quantities like Temperature Pressure flow level measurements.
3	The instrumentation and protection systems applied in thermal power plant.
4	The control techniques employed for the operation of modern power generation plant

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain the different methods of power generation. Along with Piping and Instrumentation diagram of boiler.
CO-2	Select various measurements involved in power generation for measuring electrical and non-electrical parameters.
CO-3	Identify the different types of analyzers used for scrutinizing boiler steam and water.
CO-4	Model different types of controls and control loops in boilers.
CO-5	Illustrate the methods of monitoring and control of different parameters like speed, vibration of turbines

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	1	-	-	-	2
CO-2	3	1	-	-	-	2
CO-3	3	1	-	-	-	2
CO-4	3	1	-	-	-	2
CO-5	3	1	-	-	-	2

Unit – I
Brief survey of methods of power generation, hydro, thermal, nuclear, solar and wind power, importance of instrumentation in power generation, thermal power plants, block diagram, details of boiler processes, Piping and Instrumentation diagram of boiler, cogeneration.

Unit – II
Electrical measurements, current, voltage, power, frequency, power factor etc, non-electrical parameters, flow of feed water, fuel, air and steam with correction factor for temperature, steam pressure and steam temperature, drum level measurement, radiation detector, smoke density measurement, dust monitor.

Unit – III
Flue gas oxygen analyzer: Analysis of impurities in feed water and steam, dissolved oxygen analyzer. Chromatography, pH meter, fuel analyzer, pollution monitoring instruments.

Unit – IV
Combustion control, air / fuel ratio control, furnace draft control, drum level control, main steam and reheat steam temperature control, super heater control, air temperature, distributed control system in power plants, interlocks in boiler operation.

Unit – V
Speed, vibration, shell temperature monitoring and control, steam pressure control, lubricant oil temperature control, cooling system.

Suggested Reading:

1	Sam G. Dukelow, The Control of Boilers, Instrument Society of America, 2nd Edition, 2010.
2	P.K. Nag, „Power Plant Engineering", Tata McGraw-Hill, 1st Edition, 2001.
3	S.M. Elonka and A.L. Kohal, "Standard Boiler Operations", Tata McGraw-Hill, 1st Edition, 1994.
4	R K Jain, "Mechanical and Industrial Measurements", Khanna Publishers, 1st Edition, 1995.
5	E Al Wakil, "Power Plant Engineering", Tata McGraw-Hill, 1st Edition, 1984.

OE 941 ME	**OPERATION RESEARCH**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of optimization techniques
2	Formulation of LPP models
3	Basic concepts of Non-linear programming, Dynamic programming, Game theory are introduced.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
CO-2	Students should able to apply the concept of non-linear programming
CO-3	Students should able to carry out sensitivity analysis
CO-4	Student should able to model the real world problem and simulate it.
CO-5	Student should able to apply graph theory, competitive models, and game theory simulations.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

Unit – II
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

Unit – III
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

Unit – IV
Scheduling and sequencing - single server and multiple server models deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit – V
Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Suggested Reading:

1	H.A. Taha, Operations Research, An Introduction, PHI, 2008
2	H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3	J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.
4	Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5	Pannerselvam, Operations Research: Prentice Hall of India 2010.
6	Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

OE 942 ME	**COMPOSITE MATERIALS**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Study the concepts of composite construction.*
2	*Learn analysis and designs of composite beams, floors, columns and trusses as per the recommendations of IS codes of practice.*
3	*Apply the concepts for design of multi-storey composite buildings.*
4	*Scope of analysis is restricted to skeletal structures subjected to prescribed dynamic loads.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understand the fundamentals of composite construction, and analysis and designs of composite beams.*
CO-2	*Analyse and design the composite floors*
CO-3	*Select suitable materials for composite columns,*
CO-4	*Analyse composite trusses and understand connection details.*
CO-5	*Analyse and design the multi-storey composite buildings*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Introduction of composite constructions: Benefits of composite construction - Introduction to IS - BS and Euro codal provisions.

Composite beams: Elastic behaviour of composite beams - No and full interaction cases - Shear connectors - Ultimate load behaviour - Serviceability limits - Effective breadth of flange - Interaction between shear and moment - Basic design consideration and design of composite beams.

Unit – II

Composite floors: Structural elements - Profiled sheet decking - Bending resistance - Shear resistance - Serviceability criterion - Analysis for internal forces and moments - Design of composite floors.

Unit – III
Composite columns: Materials - Concrete filled circular tubular sections - Non-dimensional slenderness - Local buckling of steel sections - Effective elastic flexural stiffness - Resistance of members to axial compressions - Composite column design - Fire resistance.

Unit – IV
Composite trusses: Design of truss - Configuration - Truss members - Analysis and design of composite trusses and connection details.

Unit – V
Design of multi-storey composite buildings: Design basis - Load calculations - Design of composite slabs with profile decks - Composite beam design - Design for compression members - Vertical cross bracings - Design of foundation.

Suggested Reading:

1	R.P. Johnson, "Composite Structures of Steel and Concrete - Beams, Slabs, Columns and Frames in Buildings", Blackwell Publishing, Malden, USA, 2004.
2	"INSDAG Teaching Resources for Structural Steel Design", Vol-2, Institute for Steel Development and Growth Publishers, Calcutta, India.
3	"INSDAG Handbook on Composite Construction – Multi-Storey Buildings", Institute for Steel Development and Growth Publishers, Calcutta, India.
4	"INSDAG Design of Composite Truss for Building", Institute for Steel Development and Growth Publishers, Calcutta, India.
5	"INSDAG Handbook on Composite Construction – Bridges and Flyovers", Institute for Steel Development and Growth Publishers, Calcutta, India.
6	IS: 11384-1985, "Code of Practice for Composite Construction in Structural Steel and Concrete", Bureau of Indian Standards, New Delhi, 1985.

OE 943 ME	**INDUSTRIAL SAFETY**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Causes for industrial accidents and preventive steps to be taken.
2	Fundamental concepts of Maintenance Engineering.
3	About wear and corrosion along with preventive steps to be taken
4	The basic concepts and importance of fault tracing.
5	The steps involved in carrying out periodic and preventive maintenance of various equipments used in industry

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Identify the causes for industrial accidents and suggest preventive measures.
CO-2	Identify the basic tools and requirements of different maintenance procedures.
CO-3	Apply different techniques to reduce and prevent Wear and corrosion in Industry.
CO-4	Identify different types of faults present in various equipments like machine tools, IC Engines, boilers etc.
CO-5	Apply periodic and preventive maintenance techniques as required for industrial equipments like motors, pumps and air compressors and machine tools etc

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes, Fire prevention and firefighting, equipment and methods.

Unit – II
Fundamentals of Maintenance Engineering: Definition and aim of maintenance engineering,

Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit – III
Wear and Corrosion and their Prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications of Screw down grease cup, Pressure grease gun, Splash lubrication, Gravity lubrication, Wick feed lubrication, Side feed lubrication, Ring lubrication, Definition of corrosion, principle and factors affecting the corrosion, Types of corrosion, corrosion prevention methods.

Unit – IV
Fault Tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, any one machine tool, Pump, Air compressor, Internal combustion engine, Boiler, Electrical motors, Types of faults in machine tools and their general causes.

Unit – V
Periodic and Preventive Maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of Machine tools, Pumps, Air compressors, Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Suggested Reading:

1	H. P. Garg, "Maintenance Engineering", S. Chand and Company
2	Audels, "Pump-hydraulic Compressors", Mcgraw Hill Publication
3	Higgins & Morrow, "Maintenance Engineering Handbook", Da Information Services.
4	Winterkorn, Hans, "Foundation Engineering Handbook", Chapman & Hall London

OE 941 LA	**INTELLECTUAL PROPERTY RIGHTS**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Acquaint the students with basics of intellectual property rights with special reference to Indian Laws and its practices.
2	Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.
3	Provide an overview of the statutory, procedural, and case law underlining these processes and their interplay with litigation.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of intellectual property rights.
CO-2	Develop proficiency in trademarks and acquisition of trade mark rights.
CO-3	Understand the skill of acquiring the copy rights, ownership rights and transfer.
CO-4	Able to protect trade secrets, liability for misappropriations of trade secrets.
CO-5	Apply the patents and demonstration of case studies.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit – II
Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

Unit – III
Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer**.**

Unit – IV
Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation. Unfair competition: Misappropriation right of publicity, false advertising.

Unit – V
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Suggested Reading:

1	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
2	“Mayall, “Industrial Design”, McGraw Hill,1992
3	“Niebel, “Product Design”, McGraw Hill,1974.
4	“Asimov, “Introduction to Design”, Prentice Hall,1962.
5	“Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”,2016.
6	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand,2008

AUDIT COURSES

SEMESTER –III

AC 030 BM	**MEDICAL RESEARCH & ETHICS**					
	(AUDIT COURSE I)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To learn the clinical research types, methodology and formulation.
2	To know the sources of literature, survey, review and quality journals.
3	To understand the research design for collection of research data, and standard databases.
4	To understand the research data analysis, writing of research report and grant proposal.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the significance of pursuing research and defining research problem.
CO-2	Appreciate the importance and methodology of literature survey, and research design.
CO-3	Identify proper data and collect using appropriate tool.
CO-4	Compare and select the correct technique for the analysis of collected data.
CO-5	Summarize the data analysis in the form of technical report and understand relevant standards and regulations.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I

Research Methodology: Introduction to Clinical Research, Objectives and Motivation of Research, Types of Clinical Research, Research Approaches, Significance of Research, Research Methods verses Methodology, Principle of GCP, Problems Encountered by Researchers in India, Benefits to the society in general.

Defining the Research Problem: Definition of Research Problem, Problem Formulation, Necessity of Defining the Problem, Technique involved in Defining a Problem.

Unit – II
Literature Survey*:* Importance of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. ***Literature Review****:* Need of Review, Guidelines for Review, Record of Research Review. ***Research Design:*** Need of Research Design, Feature of a Good Design Important Concepts Related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standards and Codes.

Unit – III
Data Collection*:* Collection of primary data, Secondary data, Protocol Development ,Patient Information Sheet & Informed Consent Form, Source Data & Case Reports Forms, Standard Operating Procedures, Subject Selection, Recruitment & Retention, Clinical Trial Designs ,Randomization & blinding in Clinical Trials ,Roles & Responsibilities of IEC ,Monitoring & Auditing of Clinical Trials, standard databases for medical data, ***Medical ethics:*** Moral Problems in Medical Ethics / Bioethics, Principles & Challenges in Medical Ethics, Ethical Guidelines for conducting clinical trials in Humans, Essential documents for conducting clinical research

Unit – IV
Data Analysis: Role of Statistics for Data Analysis, Parametric V/s Non Parametric methods, Descriptive Statistics, Measures of central tendency and Dispersion, Hypothesis testing, Use of Statistical software. Deterministic and random data, Uncertainty analysis, Tests for significance: Chi-square, student's t-test, Regression modeling, Direct and Interaction effects, ANOVA, F-test, Time Series analysis, Autocorrelation and Autoregressive modeling.

Unit – V
Research Report Writing*:* Format of the medical Research report, Synopsis, Dissertation, writing a Research Proposal and Research Report, funding agencies for medical research. ***Medical device regulations and standards:***. Food and Drug Administration, Medical device directives, ISO 9001 series of standards, Domestic standards, International standards.

Suggested Reading:

1	Peter Agger, Robert S. Stephenson, J. Michael Hasenkam, A Practical Guide to Biomedical Research: for the Aspiring Scientist, Springer international publishers, 2017.
2	Biomedical Research Methodology :Including Biostatistical Applications Paperback – 2011by Ranjan Das
3	C.R Kothari, Research Methodology, Methods & Technique; New Age International Publishers, 2004
4	Y.P. Agarwal, Statistical Methods: Concepts, Application and Computation, Sterling Publs., Pvt., Ltd., New Delhi, 2004
5	Richard C.Fries, *Handbook of medical device design*, Marcel Dekker Inc., 2001.

AC 031	**ENGLISH FOR RESEARCH PAPER WRITING**					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Understand that how to improve your writing skills and level of readability*
2	*Understand the nuances of language and vocabulary in writing a Research Paper.*
3	*Develop the content, structure, format of writing a research paper and produce original research papers without plagiarism*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Interpret the nuances of research paper writing.*
CO-2	*Differentiate the research paper format and citation of sources.*
CO-3	*To review the research papers and articles in a scientific manner.*
CO-4	*Avoid plagiarism and be able to develop their writing skills in presenting the research work.*
CO-5	*Create a research paper and acquire the knowledge of how and where to publish their original research papers*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Academic Writing: Meaning & Definition of a research paper– Purpose of a research paper – Scope – Benefits, Limitations – outcomes.

Unit – II
Research Paper Format: Title – Abstract – Introduction – Discussion – Findings, Conclusion – Style of Indentation – Font size/Font types – Indexing – Citation of sources.

Unit – III
Research Methodology: Methods (Qualitative – Quantitative) Review of Literature. Criticizing, Paraphrasing & Plagiarism.

Unit – IV
Process of Writing a research paper: Choosing a topic - Thesis Statement – Outline – Organizing notes - Language of Research – Word order, Paragraphs – Writing first draft – Revising/Editing - The final draft and proof reading.

Unit – V
Research Paper Publication: Reputed Journals – National/International – ISSN No, No. of volumes, Scopus Index/UGC Journals – Free publications - Paid Journal publications – Advantages/Benefits *Presentation Skills:* Developing Persuasive Presentations, Structure of Presentation, Presentation Slides, Presentation Delivery, role of the audience, what to search and cite, how to establish credibility.

Suggested Reading:

1	C. R Kothari, Gaurav, Garg, "*Research Methodology Methods and Techniques*", 4/e, New Age International Publishers.
2	Day R, "*How to Write and Publish a Scientific Paper",* Cambridge University Press, 2006
3	"*MLA Hand book for writers of Research Papers*", 7/e, East West Press Pvt. Ltd, New Delhi
4	Lauri Rozakis, Schaum's, "*Quick Guide to Writing Great Research Papers"*, Tata McGraw Hills Pvt. Ltd, New Delhi.

AC 032	**DISASTER MITIGATION AND MANAGEMENT**					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Introduction of various types of disasters and its effect on structures.*
2	*Learning of quality assurance and damage assessment of structures*
3	*Educate different types of repair, strengthening, rehabilitation and retrofitting techniques.*
4	*Awareness about flood characteristics and flood forecasting systems*
5	*Description of Flood mitigation, adjustment, and regulation*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understand the fundamentals of disaster and seismic performance of buildings*
CO-2	*Able to assess various damages in structures and give assurance of quality of concrete*
CO-3	*Decide the appropriate repair, strengthening, rehabilitation and technique required for a case study of building.*
CO-4	*Applications of flood routing, flood forecasting and space time characteristics of rainfall.*
CO-5	*Advanced understanding of flood plain adjustments and employment of appropriate technologies for flood mitigation.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
Disaster: Classifications - Causes - Impacts including social, economical, political, environmental, health, psychosocial, etc.
Seismic performance of buildings: case studies of major earthquakes in the country, damage to buildings, damage patterns, performance of non-engineered buildings-Introduction to repair and rehabilitation of structures.

Unit – II
Quality assurance for concrete – Strength, Durability and Thermal properties of concrete.

Damage Assessment**:** - Condition assessment and distress, Purpose of assessment, Rapid assessment - diagnostic techniques, Investigation of damage, , Evaluation of surface and structural cracks, Damage assessment procedure, destructive, non-destructive and semi destructive testing systems, Procedure for evaluating damaged of structure.

Unit – III
Repair, Rehabilitation And Retrofitting Techniques : Repair materials, Common types of repairs – Repair in concrete structures – Repairs in under water structures – Guniting – Shot create –Underpinning, Strengthening of Structural elements, Repair of structures distressed due to corrosion, fire, Leakage, earthquake, Retrofitting techniques

Unit – IV
Introduction to Disasters: Hazard, Vulnerability, Resilience, Risks.-Disaster- Different types of cold wave-heat wave- droughts- floods-Effect of climate change on Processes.
Flood characteristics and forecasting: Measureable features of a flood (Elevation, discharge, volume, and duration), flood forecasting (unit hydrograph method, meteorological and snow data, and snow field air temperatures), operation of flood forecasting systems.
Space-time characteristics of rainfall: Policy criteria for design flood of a major and minor reservoir, spillways, diversion dams and barrages, design flood criteria for dams and other hydraulic structures (CWC recommendations).

Unit – V
Flood Routing: Mathematics of flood routing, various methods of flood routing, Hydrologic and Hydraulic routing.
Flood mitigation: flood ways, channel improvement, evacuation and flood proofing, land management, flood plain management, estimating benefits of flood mitigation.
Flood plain adjustments and regulations: Results of controlling floods, alternatives to controlling floods, range of possible adjustments, practical range of choice, critical characteristics of flood hazards.

Suggested Reading:

1	Barry A. Richardson, “Defects and Deterioration in Buildings”, E &FN Spon Press, London, 1991.
2	J. H. Bungey, “Testing of Concrete in Structures”, Chapman and Hall,New York, 1989.
3	“A.R. Santakumar, “Concrete Technology”, Oxford University Press,New Delhi, 2006.
4	“Pankaj Agarwal and Manish Shrihkande (2006). “Earthquake Resistance Design of Structures.” Prentice Hall of India.
5	“Ravishankar.K., Krishnamoorthy.T.S, "Structural Health Monitoring, Repair and Rehabilitation of Concrete Structures", Allied Publishers, 2004. New Technological Age”,2016.
6	CPWD and Indian Buildings Congress, Hand book on Seismic Retrofit of Buildings, Narosa Publishers, 2008.

AC 033	**SANSKRIT FOR TECHNICAL KNOWLEDGE**					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To get a working knowledge in illustrious Sanskrit, the scientific language in the world*
2	*To make the novice Learn the Sanskrit to develop the logic in mathematics, science & other subjects*
3	*To explore the huge knowledge from ancient Indian literature*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Develop passion towards Sanskrit language*
CO-2	*Decipher the latent engineering principles from Sanskrit literature*
CO-3	*Correlates the technological concepts with the ancient Sanskrit history.*
CO-4	*Develop knowledge for the technological progress*
CO-5	*Explore the avenue for research in engineering with aid of Sanskrit*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Introduction to Sanskrit Language: Sanskrit Alphabets-vowels-consonants- significance of Amarakosa-parts of Speech-Morphology-creation of new words-significance of synonyms-sandhi-samasa-sutras-active and passive Voice-Past/Present/Future Tense-Syntax-Simple Sentences (elementary treatment only)

Unit – II

Role of Sanskrit in Basic Sciences: Brahmagupthas lemmas (second degree indeterminate equations), sum of squares of n-terms of AP- sulba, sutram or baudhayana theorem (origination of Pythagoras theorem)-value of pie-Madhava's sine and cosine theory (origination of Taylor's series). The measurement system-time-mass-length-temp, Matter elasticity-optics-speed of light (origination of Michaelson and Morley theory).

Unit – III
Role of Sanskrit in Engineering-I (Civil, Mechanical, Electrical and Electronics Engineering): Building construction-soil testing-mortar-town planning-Machine definition-crucible-furnace-air blower- Generation of electricity in a cell-magnetism-Solar system-Sun: The source of energy, the earth-Pingala chandasutram (origination of digital logic system)

Unit – IV
*Role of Sanskrit in Engineering-II (Computer Science Engineering & Information Technology):*Computer languages and the Sanskrit languages-computer command words and the vediccommand words-analogy of pramana in memamsa with operators in computer language-sanskrit analogy of physical sequence and logical sequence, programming.

Unit – V
*Role of Sanskrit in Engineering-III (Bio-technology and Chemical Engineering):*Classification of plants- plants, the living-plants have senses-classification of living creatures, Chemical laboratory location and layout- equipment-distillation vessel-kosthiyanthram

Suggested Reading:

1	M Krishnamachariar, "*History of Classical Sanskrit Literature",* TTD Press, 1937.
2	M.R. Kale, "*A Higher Sanskrit Grammar: For the Use of School and College Students*", Motilal Banarsidass Publishers, 2015.
3	Kapail Kapoor, "*Language, Linguistics and Literature: The Indian Perspective",* ISBN- 10: 8171880649, 1994.
4	"*Pride of India*", Samskrita Bharati Publisher, ISBN: 81-87276 27-4, 2007.
5	Shri Rama Verma, "*Vedas the source of ultimate science",* Nag publishers, 2005.

AC 034	**VALUE EDUCATION**					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Understand the need and importance of Values for self-development and for National development.*
2	*Imbibe good human values and Morals*
3	*Cultivate individual and National character.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Gain necessary Knowledge for self-development*
CO-2	*Learn the importance of Human values and their application in day to day professional life.*
CO-3	*Appreciate the need and importance of interpersonal skills for successful career and social life*
CO-4	*Emphasize the role of personal and social responsibility of an individual for all-round growth.*
CO-5	*Develop a perspective based on spiritual outlook and respect women, other religious practices, equality, non-violence and universal brotherhood.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
Human Values, Ethics and Morals: Concept of Values, Indian concept of humanism, human values; Values for self-development, Social values, individual attitudes; Work ethics, moral and non- moral behaviour, standards and principles based on religion, culture and tradition.

Unit – II
Value Cultivation, and Self-management: Need and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.

Unit – III
Spiritual outlook and social values: Personality and Behavior, Scientific attitude and Spiritual (soul) outlook; Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, avoiding fault finding in others, Reduction of anger, forgiveness, Dignity of labour, True friendship, Universal brotherhood and religious tolerance.

Unit – IV
Values in Holy Books: Self-management and Good health; internal & external cleanliness, Holy books versus Blind faith, Character and Competence, Equality, Nonviolence, Humility, Role of Women.

Unit – V
Dharma, Karma and Guna: Concept of soul; Science of Reincarnation, Character and Conduct, Concept of Dharma; Cause and Effect based Karma Theory; The qualities of Devine and Devilish; Satwic, Rajasic and Tamasic gunas.

Suggested Reading:

1	Chakroborty, S.K., *"Values & Ethics for organizations Theory and practice*", Oxford University Press, New Delhi, 1998.
2	Jaya DayalGoyandaka, "*Srimad Bhagavad Gita with Sanskrit Text*", Word Meaning and Prose Meaning‖, Gita Press, Gorakhpur, 2017.

AC 035	**STRESS MANAGEMENT BY YOGA**					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Creating awareness about different types of stress and the role of yoga in the management of stress.*
2	*Promotion of positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).*
3	*Prevention of stress related health problems by yoga practice.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*To understand yoga and its benefits.*
CO-2	*Enhance Physical strength and flexibility.*
CO-3	*Learn to relax and focus.*
CO-4	*Relieve physical and mental tension through Asanas*
CO-5	*Improve work performance and efficiency.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Meaning and definition of Yoga - Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali.

Unit – II
Meaning and definition of Stress - Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

Unit – III
Concept of Stress according to Yoga - Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress.

Unit – IV
Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar.

Unit – V
Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama – Kapalabhati-Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.
Meditation techniques: Om Meditation - Cyclic meditation : Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT).

Suggested Reading:

1	"Yogic Asanas for Group Training - Part-I": Janardhan Swami Yogabhyasi Mandal, Nagpur
2	"Rajayoga or Conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata
3	Nagendra H.R nad Nagaratna R, "Yoga Perspective in Stress Management", Bangalore, Swami Vivekananda Yoga Prakashan

Web resource:

1	https://onlinecourses.nptel.ac.in/noc16_ge04/preview
2	https://freevideolectures.com/course/3539/indian-philosophy/11

AC 036	**PERSONALITY DEVELOPMENT THROUGH LIFE ENHANCEMENT SKILLS**					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To learn to achieve the highest goal happily*
2	*To become a person with stable mind, pleasing personality and determination*
3	*To awaken wisdom in students*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Develop their personality and achieve their highest goal of life.*
CO-2	*Lead the nation and mankind to peace and prosperity.*
CO-3	*To practice emotional self regulation.*
CO-4	*Develop a positive approach to work and duties.*
CO-5	*Develop a versatile personality.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
Neetisatakam – Holistic development of personality - Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)

Unit – II
Neetisatakam – Holistic development of personality (cont'd) - Verses 52, 53, 59 (dont's) - Verses 71,73,75 & 78 (do's) - Approach to day to day works and duties.

Unit – III
Introduction to Bhagavad Geetha for Personality Development - Shrimad Bhagawad Geeta: Unit 2 – Verses 41, 47, 48 - Unit 3 – Verses 13,21,27,35 - Unit 6 – Verses 5,13,17,23,35 - Unit

18 – Verses 45, 46, 48 Unit – 6: Verses 5, 13, 17, 23, 35; Unit – 18: Verses 45, 46, 48.

Unit – IV
Statements of basic knowledge - Shrimad Bhagawad Geeta: Unit 2- Verses 56, 62,68 - Unit 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.

Unit – V
Role of Bahgavadgeeta in the present scenario - Unit 2 – Verses 17 – Unit 3 – Verses 36, 37, 42 - Unit 4 – Verses 18, 38, 39 - Unit 18 – Verses 37, 38, 63.

Suggested Reading:

1	"Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata.
2	Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit, Sansthanam, New Delhi.

Web resource:

1	NTPEL:http://nptel.ac.in/downloads/109104115

AC 037	**CONSTITUTION OF INDIA**					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*The history of Indian Constitution and its role in the Indian democracy.*
2	*Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.*
3	*Have knowledge of the various Organs of Governance and Local Administration.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understand the making of the Indian Constitution and its features.*
CO-2	*Understand the Rights of equality, the Right of freedom and the Right to constitutional remedies.*
CO-3	*Have an insight into various Organs of Governance - composition and functions*
CO-4	*Understand powers and functions of Municipalities, Panchayats and Co-operative Societies.*
CO-5	*Understand Electoral Process, special provisions.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
History of making of the Indian constitutions: History, Drafting Committee (Composition & Working). **Philosophy of the Indian Constitution**: Preamble, Salient Features.

Unit – II
Contours of Constitutional Rights and Duties Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties

Unit – III
Organs of Governance": Parliament: Composition, Qualifications, Powers and Functions, Union executives : President, Governor, Council of Ministers, Judiciary, appointment and transfer of judges, qualifications, powers and functions.

Unit – IV
Local Administration - District's Administration head: Role and importance. Municipalities: Introduction, ayor and role of Elected Representative, CEO of Municipal Corporation. Panchayati Raj: Introduction, PRI: Zilla Panchayat, Elected Officials and their roles, CEO Zilla Panchayat: positions and role. Block level: Organizational Hierarchy (Different departments) Village level: role of elected and appointed officials. Importance of grass root democracy.

Unit – V
Election commission: Election Commission: Role and functioning, Chief Election Commissioner and Election Commissioners, State Election Commission :Role and functioning. Institute and Bodies for the welfare of SC/ST/OBC and women**.**

Suggested Reading:

1	The Constitution of India", 1950 (Bare Act), Government Publication
2	Dr. S. N. Busi, Dr. B. R. Ambedkar, "Framing of Indian Constitution", 1st Edition, 2015.
3	M. P. Jain, "Indian Constitution Law", 7th Edn., Lexis Nexis, 2014
4	D.D. Basu, "Introduction to the Constitution of India", Lexis Nexis, 2015.

Web resource:

1	http://www.nptel.ac.in/courses/103107084/Script.pdf

AC 038	**PEDAGOGY STUDIES**					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To present the basic concepts of design and policies of pedagogy studies.*
2	*To provide understanding of the abilities and dispositions with regard to teaching techniques, curriculum design and assessment practices and familiarize various theories of learning and their connection to teaching practice.*
3	*To create awareness about the practices followed by DFID, other agencies and other researchers and provide understanding of critical evidence gaps that guides the professional development*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.*
CO-2	*Examine the effectiveness of pedagogical practices.*
CO-3	*Understand the concept, characteristics and types of educational research and perspectives of research.*
CO-4	*Describe the role of classroom practices, curriculum and barriers to learning.*
CO-5	*Understand Research gaps and learn the future directions.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions, Overview of methodology and Searching.

Unit – II
Thematic Overview: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

Unit – III
*Evidence on the Effectiveness of Pedagogical Practices***:** Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and Practicum) and the school curriculum and guidance material best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches – Teachers attitudes and beliefs and pedagogic strategies.

Unit – IV
Professional Development: alignment with classroom practices and follow up support - Support from the head teacher and the community – Curriculum and assessment - Barriers to learning: Limited resources and large class sizes.

Unit – V
Research Gaps and Future Directions: Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

Suggested Reading:

1	Ackers J, Hardman F, *"Classroom Interaction in Kenyan Primary Schools, Compare*", 31 (2): 245 – 261, 2001.
2	Agarwal M, *"Curricular Reform in Schools: The importance of evaluation*", Journal of Curriculum Studies, 36 (3): 361 – 379, 2004.
3	Akyeampong K, "*Teacher Training in Ghana – does it count? Multisite teacher education research project (MUSTER)",* Country Report 1. London: DFID, 2003.
4	Akyeampong K, Lussier K, Pryor J, Westbrook J, *"Improving teaching and learning of Basic Maths and Reading in Africa: Does teacher Preparation count?"*International Journal Educational Development, 33 (3): 272- 282, 2013.
5	Alexander R J, *"Culture and Pedagogy: International Comparisons in Primary Education",* Oxford and Boston: Blackwell, 2001.
6	Chavan M, Read India: *"A mass scale, rapid, learning to read campaign",* 2003

AC 039	**E-WASTE MANAGEMENT**					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduction to E-Waste management
2	Understanding on resource efficiency and circular economy
3	E-waste Management rules 2016
4	RoHS compliances/directives to EEE

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Complete understanding on E-Waste management
CO-2	Understanding on effective recycling methodologies for e-waste management
CO-3	Overall understanding about E-waste Management rules 2016 and strategies for e-waste management
CO-4	Understanding on RoHS compliances for EEE products

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Waste Electrical and Electronic Equipment (WEEE): Flows, Quantities and Management, a Global Scenario; The Importance of Waste Management; Types of Waste- Solid and Liquid; Criteria for EEE/E-Waste Classification; Multivariate Model for E-Waste Estimation; Environmental and Health Effects of Waste Management, Inventorisation of E-Waste and Emerging trends in E-waste disposal with bench marks for depollution - global scenario; Dumping, Burning and Landfill: Impact on the Environment

Unit – II
Effective Waste Management and Disposal Strategies; Legislative Influence on Electronics Recycling; Waste Management Rules and Their Amendments; Extended Producer Responsibility (EPR) in E-Waste Management; The Role of Collective versus Individual Producer Responsibility in E-Waste Management

Unit – III
Electronic Waste: Public Health Implications; Restriction of Hazardous Substances (RoHS) Directives in Electrical and Electronic Equipment; Materials Used in Manufacturing Electrical and Electronic Products

Unit – IV
Recycling and Resource Management: Ecological and Economical Valuation; Life Cycle Assessment (LCA) Approach to Waste Management System; Environmental Incentives for Recycling and Life Cycle Analysis of Materials Recycling Electronic Waste: Challenges and Opportunities for Sustainable Management; Resource Recovery from E-waste: Efficiency and Circular Economy; Integrated Approach to E-Waste Recycling: Recycling and Recovery Technologies, Recycling and Recovery Technologies.

Unit – V
Cases studies: E-waste Generation, collection and recycling

Suggested Reading:

1	Electronic Waste Management and Treatment Technology, Editors: MajetiNarasimhaVara Prasad MeththikaVithanage
2	Electronic Waste Management, Edited by R. E. Hester, R. M. Harrison, RSC Publishing 2009
3	Solid Waste Technology & Management, Christensen, T., Ed., Wiley and Sons., 2011
4	Electronics Waste Management: An India Perspective. Front Cover. Sandip Chatterjee. Lap Lambert Academic Publishing GmbH KG, 2010 - Electronic
5	Handbook of Electronic Waste Management, International Best Practices and Case studies, Elsevier, 2019
6	E-waste: Implications, regulations, and management in India and current global best practices. Author(s): RakeshJohri, TERI Press

BM 181	**DISSERTATION PHASE-I**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	20	10
Evaluation	**SEE**	-	**CIE**	100 Marks		

Course Objectives :	
1	Identification of the research problem
2	Discussion of literature survey.

Course Outcomes :	
CO-1	Synthesize knowledge and skills previously gained and apply them to new technical problem.
CO-2	Select from different methodologies, methods and analyses to produce a suitable research design, and justify their design.
CO-3	Present the findings of their technical solution in a written report.
CO-4	Presenting the work in International/ National conference or reputed journals.
CO-5	Develop oral and written communication skills to present and defend their work in front of technically qualified audience

Course Outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Guidelines:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study.

After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Biomedical Instrumentation, Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Robotics and Control Systems, Signal and Image Processing and Analysis and any other related domain. In case of industry sponsored projects, the relevant application notes, product catalogues should be referred and reported. The student is expected

to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.

Evaluation for stage-I is based on mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available. End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions and must bring out individuals contribution. Continuous assessment of Project stage – I at Mid Semester and End Semester will be monitored by the departmental committee.

A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, record of continuous progress. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.

SEMESTER - IV

BM 182	**DISSERTATION PHASE-II**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	32	16
Evaluation	**SEE**	100	**CIE**	100 Marks		

Course Objectives :	
1	Identification of the research problem
2	Use different software/ computational/analytical tools.
3	Discussion of literature survey.

Course Outcomes :	
CO-1	Expand the defined Research Problem for the dissertation work.
CO-2	Conduct of Laboratory/analytical/ software studies and Use different software/ computational/analytical tools.
CO-3	Analysis of Data, development of models, offer solutions to the research problem and provide conclusions of the work.
CO-4	Conduct tests on existing set ups/equipments and draw logical conclusions from the results after analyzing them.
CO-5	Either work in a research environment or in an industrial environment.
CO-6	Present and convince their topic of study to the engineering community.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Guidelines:
Dissertation – II will be extension of the work on the topic identified in Dissertation – I. Student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents. The candidate has to prepare a detailed project report consisting of introduction of the problem,

problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study.

A dissertation should be presented in standard format as provided by the department. The candidate has to be in regular contact with his guide. Continuous assessment should be done of the work done by adopting the methodology decided involving numerical analysis/ conduct experiments, collection and analysis of data, etc. There will be pre-submission seminar at the end of academic term. After the approval the student has to submit the detail report and external examiner is called for the viva-voce to assess along with guide.