STUDY & EVALUATION SCHEME
B. TECH. Biomedical Engineering
(with effect from 2020-2021)

3rdYear **5thSemester**

S. No.	Course Category	Subject code	Name of Subject	Periods and Credits				Evaluation Scheme				Sub. Total
								Sessional (CA)			ESE	
				L	T	P	C	CT	TA	Total		
1	DC*	EC346	Microprocessor System in Medicine	3	1	0	4	25	15	40	60	100
2	DC*	EC347	Bio-Control Systems	3	1	0	4	25	15	40	60	100
3	DC*	EC348	Biomedical Signal Processing	3	1	0	4	25	15	40	60	100
4	DC	BE361	Hospital Management	3	1	0	4	25	15	40	60	100
5	DE		Departmental Elective 1	3	1	0	4	25	15	40	60	100
6	DC	BE362	Therapeutic Equipments	3	1	0	4	25	15	40	60	100
Practicals												
7	DC*	EC349	Biomedical Signal Processing Lab	0	0	4	2	30	30	60	40	100
8	DC*	EC350	Microprocessor System Lab	0	0	4	2	30	30	60	40	100
9	DC	BE363	Therapeutic Equipments Lab	0	0	4	2	30	30	60	40	100
Total				18	6	12	30	240	180	420	480	900

* An inter-disciplinary program offered by the Department of Bioengineering in association with the Department of Electronics and Communication Engineering.

L: Lecture **T**: Tutorial **P**: Practical **C**: Credit

CA: Continuous Assessment **CT**: Class Test **TA**: Teacher's Assessment

ESE: End Semester Examination **DC**: Departmental Core

DE: Departmental Elective **ESA** – Engineering Sciences & Arts (Foundation Course & Engineering Courses)

Departmental Elective 1

1. Computational Methods for Signal and Image Processing (EC351)
2. Biomedical Nanotechnology (BE364)

MICROPROCESSOR SYSTEM IN MEDICINE

EC346

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Course Objective:

UNIT I	**INTRODUCTION TO INTEL 8085** Evolution of Microprocessor and its importance in biomedical domain, - Architecture of 8085 - Instruction format - Addressing modes - Basic timing diagram of opcode fetch, memory read, memory write, I/O read and I/O write - Interrupts of 8085 - Software interrupts, Hardware interrupts, Priorities of interrupts	**8**
UNIT II	**INTRODUCTION TO 8086** Architecture and signal description of 8086, Architecture of 8086 - Registers set of 8086 - Special function of general purpose register - Addressing modes of 8086 - Instruction set - pin diagram of 8086 - Timing diagram- memory read, memory write, I/O read and I/O write - Minimum and Maximum mode of operation Interrupts of 8086	**8**
UNIT III	**MICROCONTROLLER** Introduction to 8 - bit Microcontrollers - 8051 Microcontroller Architecture - Registers set of 8051 - modes of Timer operation - Serial Port operation - Interrupt Structure of 8051 - Memory and Input / Output Interfacing of 8051.	**8**
UNIT IV	**Interfacing devices**- 8255 Programmable Peripherals Interface- Architecture & various modes of operation – 8251, DMA Controller Architecture & Programming features. Interfacing with ADC and DAC, LCD, keyboard Interface.	**8**
UNIT V	**Application In Medicine** Mobile phone based bio signal recording, pulse oximeter circuit using ARM microcontroller, pulse oximeter circuit using ARM microcontroller	**8**

TEXT / REFERENCE BOOKS

1. Ramesh S Gaonkar, Microprocessor Architecture, Programming and application with 8085, 4 th Edition, Penram International Publishing, New Delhi, 2000
2. Kennith J Ayala, 8051 Microcontroller, Thomson, 2005.
3. Dougles V Hall, Microprocessor and Interfacing, Tata MC Graw Hill Publication, 2nd Edition, 1992.
4. Charless M Gilmore, “Microprocessor Principle and application, McGraw Hill publication, 1995.
5. A NagoorKani, Microprocessor & Microcontroller, Tata Mc Graw Hill, 3rd Edition, 2012
6. B Ram, Fundamentals of Microprocessors and Microcomputers, Dhanpat Rai Publications, 2001
7. A K Ray, K.M.Bhurchandi, “Advanced Microprocessor and Peripherals”, Tata McGraw Hill, 3rdedition, 2013.
8. Douglas V Hall, “Microprocessor and Interfacing:Programming and Hardware”,Glencoe, 2nd edition, 2006.

BIO-CONTROL SYSTEMS

EC347

Pre-requisite	Co-requisite	L	T	P	C
None	**None**	**3**	**1**	**0**	**4**

UNIT I	Types of systems - Open loop systems, closed systems, Effects of feedback, Block diagram algebra andSignal flow graphs, Mathematical Models of Physical systems: Differential equations, Transfer functions and block diagrams of simple electrical networks, Translational and Rotational mechanical systems.	**8**
UNIT II	Standard test signals, Time response of first order and second order systems with unit step as input, Time domain specification, steady state errors and static error constants, P, PI, PD and PID controllers, Concept of stability and Algebraic Criteria	**8**
UNIT III	Concept of stability, Routh stability criterion qualitative stability and conditional stability. the Root locus concept, construction of root loci	**8**
UNIT IV	Frequency response of the systems - Correlation between time and frequency responses - Gain and phase margins, Bode plots, Polar Plots, Nyquist stability Criteria	**8**
UNIT V	Examples of Biological control Systems: Cardiovascular Control System, Endocrine Control Systems, Pupil Control System, Skeletal Muscle Servomech	**8**

Books Recommended:

1. Hacısalihzade, Selim S. Biomedical applications of control engineering. Vol. 441. Springer, 2013.

Reference materials:

1. Ogata, Katsuhiko, and Yanjuan Yang. Modern control engineering. Vol. 4. India: Prentice hall, 2002.
2. Nise, Norman S. CONTROL SYSTEMS ENGINEERING. John Wiley & Sons, 2007.

BIOMEDICAL SIGNAL PROCESSING

EC348

Pre-requisite	Co-requisite	L	T	P	C
BE-275	**None**	**3**	**1**	**0**	**4**

UNIT I	**Fundamentals of Signal Processing** Sampling and aliasing, simple signal conversion systems, spectral analysis FFT -decimation in time algorithm Decimation in Frequency algorithm Different types of bioelectric signals and its basic characteristics	**8**
UNIT II	IIR Digital Filter Design and its Applications Impulse invariant method Bilinear transformation method Design of bilinear transformation method using Butterworth technique Design of impulse invariant method using Butterworth technique Design of bilinear transformation Method- using Chebyshev technique Design of impulse invariant method using Chebyshev technique	**8**
UNIT III	Characteristics of FIR filter FIR filter design using windowing techniques- rectangular window Hamming window Hanning window Blackmann window Time domain filters- synchronized averaging, moving average filters	**8**
UNIT IV	P-wave detection, QRS complex detection-derivative based method, Pan Tompkins algorithm Template matching method, Signal averaged ECG	**8**
UNIT V	ECG rhythm analysis, normal and ectopic ECG beats, analysis of exercise ECG Analysis of respiration, spectral analysis of EEG signals Case studies- in ECG and PCG PCG and carotid pulse ECG and atrial electrogramd Cardio respiratory interaction EMG and Vibromyogram (VMG)	**8**

Books Recommended:

2. Rangaraj.M.Rangayyan, “Biomedical signal processing”, Wiley-IEEE press, 2nd Edition, 2015.
3. S.Salivahnan, C.Gnanapriya, “Digital signal processing”, Tata McGraw-Hill, New Delhi, 2nd Edition 2011..

Reference material

1. John G. Proakis and DimitrisG.Manolakis, “Digital signal processing, algorithms and applications”, PHI of India Ltd., New Delhi, 4th edition, 2007.
2. Reddy D.C, “Biomedical signal processing: Principles and techniques”, Tata McGraw-Hill, New Delhi, 2nd edition, 2005.

HOSPITAL MANAGEMENT

BE361

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Course objectives:

- Identify various areas ofhospitals.
- Identify various activities of departments like out/in patient andnursing.
- Discuss about critical care departments of hospital like iccu, icu and activities of central sterile supplydepartment.
- Discuss about effective hospitalmanagement.
- Maintain various medical records and wastemanagement.
- To prepare a competent workforce of hospital managers who have basic knowledge and skills of efficiently planning, managing and maintaining the physicalenvironment,
- Develop knowledge of hospital building maintenance, equipment and systems for healthcare.
- Develop knowledge regarding plant operations, clinical engineering, biomedical engineering, safety technology and hospital informationsystem.
- Students shall be well trained to solve the rising challenges and specific necessities of modern dayhospitals.

Course outcome:

- Develop an understanding of criteria regarding assessment, management, administration and regulation of healthcare technology.
- Improve the clinical effectiveness, efficiency and safety of technology use, considering the importance and impact of technology on patientcare.
- Develop projects with a technological component within a hospital environment.
- Develop improvements and solutions to specific biomedical technologyissues.
- Promote better management of information regarding identification of biomedical and hospital technology planning, procurement and operationrequirements.
- Interact and network with other healthcare technology managers to know of best practices and solutions for common issues.
- An ability to understand environmental considerations and sustainable engineering solutions in hospital engineering andmanagement.
- Develop an ability to understand professional ethics and legal issues related to hospital engineering and healthcare system.
- Develop an ability to function effectively as an individual and a member in diverseteam.

UNIT I	**Healthcare System:** Health organization of the country, health technology and challenges in maintaining normal health, Indian hospitals- challenges and strategies, modern techniques of hospital management.	**8**
UNIT II	**Hospital Organization:** Classification of hospital, Hospital- social system, location of hospital, site selection of new hospital, Line services, Supportive services and Auxiliary services of hospital.	**8**
UNIT III	**Engineering Services of hospital:** Biomedical engineer's role in hospital, Maintenance department, MRO, Clinical engineering preventive maintenance of equipment, Electrical system, Power supply system, Electrical safety, Centralized gas supply system, Air conditioning system,	**8**

	Hospital waste management system, Fire safety and threat alarm system.	
UNIT IV	**Hospital Management and Information System:** Role of HMIS, Functional areas, Modules forming HMIS, HMIS and Internet, Centralized data record system, computerized patient record system, Health information system.	**8**
UNIT V	**Regulation and planning of new hospital:** FDA regulation, ISO certification, Fire protection standard, Planning and designing of new hospital.	**8**

Text/ Reference Books:

1. R.C. Goyal, Handbook of Hospital Personal Management, Prentice Hall of India,1993
2. Hans Pfeiff, Vera Dammann (Ed.), Hospital Engineering in Developing Countries,Zreport Eschbom, 1986
3. Cesar A. Caceres and Albert Zara, The practice of clinical engineering, Academic Press,1977.
4. Webster, J. G and Albert M. Cook, Clinical Engineering Principles and Practices, Prentice HallInc. Englewood Cliffs,1979
5. Jacob Kline, Handbook of Bio Medical Engineering, Academic Press, San Diego1988

THERAPEUTIC EQUIPMENTS

BE362

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Course Objectives:

1. This course will provide to students brief review of physiology and common pathology from an engineering point of view for understanding of therapeutic medicaldevices.
2. The lectures will focus on function of therapeutic medical devices so that the students will gain the ability to contribute in their design, development and effective usage in their futurecareers.
3. To study the concept of various assist devices so as to enable the students to develop new assistdevices.
4. To develop an understanding of the physiotherapy and diathermy equipment so that the student can learn tooperate.
4. To introduce the recent trends in field of diagnostic and therapeuticequipments.
5. This course is also focus on function of therapeutic medical devices so that the students will gain the ability to contribute in their design, development and effective usage in their futurecareers.

Course Outcome:

After successful completion of the course the students will be able to

1. Understand and explain the working principle of cardiac pacemakers &defibrillators
2. Understand and explain the working principle of ventilators &anaestheticsystem
3. Understand and explain the working principle of physiotherapy & electrotherapyequipments
4. Understand and explain the working principle of surgical diathermy &LASER
5. Understand and explain the working principle of neonatal care & drug deliverysystems

UNIT I	**Cardiac pacemakers and defibrillators:** Effects of electric field on cardiac muscles and laws of stimulation, need for pacemaker, external pacemakers, implantable pacemakers and types, codes for pacemakers, pulse generator and power sources, electrodes and leads system, pacing system analyzer, programmable pacemakers, rate responsive and ventricular synchronous pacemakers, microprocessor based modern pacemakers, need for defibrillators, DC defibrillator, synchronous operation, implantable defibrillator, defibrillator analyzer and safety.	**8**
UNIT II	**Ventilators and an aesthetic system:** Artificial ventilations, ventilators and types, terminology of ventilators, classification of ventilators and modern ventilators, need for anaesthesia, anaesthesia gases and vapours, anaesthesia delivery system, humidifiers, nebulizers and aspirators.	**8**
UNIT III	**Physiotherapy and Electrotherapy Equipments:** IR diathermy, UV diathermy, short wave diathermy, microwave diathermy, ultrasonic diathermy, electrotherapy and different waveforms, electrode system, electrical stimulator and types, nerve muscle stimulator, ultrasonic stimulators, pain relief through electrical stimulators.	**8**
UNIT IV	**Surgical diathermy and LASER:** Principles and applications of surgical diathermy, electrosurgery machine, electrosurgery circuits, different electrodes, electrosurgery techniques, solid state electrosurgery, generator	**8**

	circuits, testing of electrosurgery units, electrosurgery safety, basic principle of ultrasonic lithotripter and extracorporeal shock wave lithotripter, principle operation of LASER, various application of CO_2, Ar, He-Ne, Nd–YAG and pulsed ruby LASER, application of LASER in surgery.	
UNIT V	**Neonatal Care and Drug Delivery systems:** Baby incubator, radiant warmer and phototherapy unit, suction apparatus, infusion pumps, syringe pumps, peristaltic pumps, implantable infusion pumps, programmable volumetric pumps.	**8**

Text Books:

1. R. S. Khandpur "Handbook of Bio-Medical Instrumentation", 2nd Edition, Tata McGraw Hill
2. J.J. Carr& J.M. Brown, "Introduction to Biomedical Equipment Technology" Pearson Education, Asia.
3. J. Webster, "Bioinstrumentation", Wiley & Sons

References:

1. Joseph Bronzino, " Biomedical Engineering and Instrumentation", PWS Engg , Boston.
2. Willard Van Nostrand, "Instrumental Methods of Analysis"
3. Sharms, "Instrumental Methods", S Chand & Co.
4. Harry Bronzino E, "Handbook of Biomedical Engineering and Measurements", Reston, Virginia.
5. Jacobson &Websler, " Medicine & Clinical Engg"
6. Leslie Cromwell, " Biomedical Instrumentation and Measurements"

COMPUTATIONAL METHODS FOR SIGNAL AND IMAGE PROCESSING

EC351

Pre-requisite	Co-requisite	L	T	P	C
MT-101,BE-276	None	3	1	0	4

UNIT I	**Introduction to Metric and Normed Spaces :** Metric Space, Normed Space, Inner Product Space, Orthogonality, L2 ,l2 and Lp spaces and their properties, concept of convergence, point wise and uniform convergence, different inequalities in L2 ,l2 and Lp spaces. The Bases - Best approximation, Orthogonal complement and projection theorem, Orthonormal basis and some common example, Orthogonal direct sums, Dual Spaces, and Adjoints.	**8**
UNIT II	**The Fourier Series:** Historical perspective, Computation of fourier series - on interval [,] $-\pi\ \pi$, on general interval, Cosine and Sine Expansion. The complex form of Fourier series. **Convergence of Fourier series** – Riemann-Lebesgue Lemma, Convergence at a point of continuity, Convergence at a point of discontinuity, Uniform convergence, Convergence in the Mean.	**8**
UNIT III	**The Fourier Transform (L1 (R) L2 (R),):** Development of Fourier transform, Fourier inversion theorem, Properties of the Fourier Transform – Basic properties, Poisson summation formula, Fourier transform of a convolution, approximate identity, Adjoint of the Fourier transform. Linear filters, Sampling theorem, and Uncertainty Principle. Idea of discrete Fourier	**8**
UNIT IV	**Wavelet Analysis and Wavelet Transform:** Why wavelets, Haar wavelet – Scaling function and its different properties. Haar decomposition and reconstruction algorithm. Daubechies wavelets - Daubechies construction; classification, Moments, and Smoothness; Computational issues; The scaling function at dyadic points. Wavelet Transform - Definition of Wavelet transform, Relation with Fourier Transform, Inversion formula for the Wavelet Transform, Local properties.	**8**
UNIT V	**Other Wavelet Topics:** Idea of multiresolution analysis, Wavelets in higher dimensions, Wavelet packets, Orthogonality and Scaling equation via Fourier transform. **Application:** Signal enhancement, function approximation, deconvolution, image processing, speech processing etc.	**8**

Books Recommended:

1. Albert Boggess and Francis J.Narcowich, A First Course in Wavelets with Fourier Analysis, WILEY, 2009.

2. Stephen Mallat, A Wavelet tour of signal processing the sparse way, 3rd edition, Academic Press, 2009.

3. George Bachman, Lawrence Narici, Edward Beckenstein, Fourier and Wavelet Analysis, SPRINGER, 2000.

4. Ingrid Daubechies, Ten Lectures on Wavelets, SIAM, 1992.

BIOMEDICAL NANOTECHNOLOGY

BE364

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Objective: To impart knowledge of principles of nanoscience and nanotechnology, synthesis characterization of nano-structured materials and equipment, promote innovation and foster translational research for the basic and applied biomedical applications.

UNIT I	Introduction to nanotechnology, Physical and Chemical properties of materials at nanoscale, Classification based on dimensionality, Challenges and opportunities associated with biology on the Nanoscale, Types of Nanomaterials, Biological and medical applications of Bionanomaterials.	**8**
UNIT II	Physical, Chemical and Biological Methods of Nanomaterial Synthesis, Characterization of Nanomaterials – Surface Potential and DLVO theory, SEM, TEM, STM, AFM, Confocal and TIRF Imaging.	**8**
UNIT III	DNA nanotechnology, DNA nanowires, Protein &Glyco nanotechnology, Lipid nanotechnology, Bio-nanomachines, Carbon nanotube and its bio-applications.	**8**
UNIT IV	Introduction to Nanobiosensors, Types of Nanobiosensors: Magnetic biosensors, Electrochemical biosensors, Nanotube based sensors, Nanowire based sensors, Applications of Nanobiosensors: Biomedical, Diagnostic and Environmental Applications.	**8**
UNIT V	Nanocircuitry, Ultra sound triggered Nano/Microbubbles, Bioconjugation of Nanomaterials, Nano particle Based Drug delivery systems, Nanotoxicology: Toxicity and Environmental Risks of Nanomaterials	**8**

Books Recommended:

1. Malsch, N.H., "Biomedical Nanotechnology", CRC Press. (2005).
2. Niemeyer C. M., "Nanobiotechnology: Concepts, Applications and Perspectives", Wiley – VCH, 2006.
3. Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: More Concepts and Applications", Wiley-VCH. (2007).
4. Kumar, C. S. S. R., Hormes, J. and Leuschner C., "Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications, and Impact", WILEY -VCH Verlag GmbH & Co. (2005).
5. Lamprecht, A., "Nanotherapeutics: Drug Delivery Concepts in Nanoscience", Pan Stanford Publishing Pte. Ltd. (2009).
6. Jain, K.K., "The Handbook of Nanomedicine", Humana press. (2008).

7. K E Drexler, Nanosystems: Molecular Machinery, Manufacturing and Computation, Wiley,ISBN 0471575186.
8. David S Goodsell, “Bionanotechnology”, John Wiley & Sons, 2004.
9. DebasisBagchi, ManashiBagchi, Hiroyoshi Moriyama, FereidoonShahidi, “Bio-Nanotechnology: A Revolution in Food, Biomedical and Health Sciences” Wiley-Blackwell, 2013.
10.Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, “Biomaterials Science: An Introduction to Materials in Medicine”,Academic Press,2012.
11.BalajiSitharaman “Nanobiomaterials Handbook”, Taylor & Francis Group, 2011.

BIOMEDICAL SIGNAL PROCESSING LAB
EC349

Pre-requisite	Co-requisite	L	T	P	C
None	None	**0**	**0**	**4**	**2**

Course Objective:

Examining the full scope of digital signal processing in the biomedical field, this course provides the basics of digital signal processing as well as programming in MATLAB for designing and implementing digital filers for biomedical application. It provides a set of laboratory experiments that can be done using either an actual analog-to-digital converter, or taking the available data base to process the biomedical signals. The course emphasizes on feature extraction and classification of normal and abnormal features using different modeling techniques.

Course Outcome:

After completion of the course the students, using MATLAB software, will be able to

1. Perform DFT of a stepresponse
2. Estimate Power spectral density ofwaveform
3. Determine frequency response, phase response & magnitude response of FIR & IIRfilters
4. DCT, IDCT, FFT, IFFT, correlation, autocorrelation and cross-correlation of ECGsignals

List of experiments:

1. Find out DFT of a Step Sequence.
2. Power Spectral Density of any sequence.
3. Estimation of Power Spectral Density.
4. Frequency Response, Phase Response & Magnitude Response of all types of FIR filter.
5. Frequency Response, Phase Response & Magnitude Response of all types of IIR filter.
6. Auto-Correlation and Cross-Correlation of ECG signals.
7. Correlation of ECG Signal & Noise Signal.
8. Convolution of ECG Signal & Noise Signal.
9. DCT and IDCT of ECG signal.
10. FFT and IFFT of ECG signals
11. 60-Hz adaptive filter
12. Reduction of ECG signal

MICROPROCESSORS LAB
EC350

Pre-requisite	Co-requisite	L	T	P	C
None	None	**0**	**0**	**4**	**2**

Course Objectives:

To provide practice of programming in assembly language in 8085 microprocessor, 8086 microprocessor. Objective of this course to be familiar with the trainer kit of microprocessor as well as the interfacing with the external peripherals & sensors

Course Outcome

Upon successful completion of this course, the student will be able to:

1. Write the program in assembly language.
2. Familiar with the trainer kit of 8085, 8086 microprocessor kit.
3. Familiar with the simulator of 8085, 8086 microprocessor kit.

4. Interface peripherals and sensors with microprocessor.

List of experiments:

1. Writeaprogramin8085microprocessortoswapthecontentoftworegisterBandCcontainingthevalues08Han d 06Hrespectively.
2. Write a program in 8085 microprocessor to add two number 09H and 08H and store the result in 9085H location and draw the flowchart.
3. Write a program in 8085 microprocessor to subtract 05H from 09H and store the result in 8072H and drawthe flow chart.
4. Writeaprogramin8085microprocessortoaddfive(5)numbersandstoretheresultinmemorylocation9071H. The numbers are stored from 9061H to 9065H location. The numbers are stored in 5 consecutive memory locations given below and draw the flowchart.
5. Write a program in 8085 microprocessor to multiply 08H with 03H and store the result in 9065H location.and draw the flowchart.
6. Write a program in 8085 microprocessor to multiply FEH with 0FH and store the result in 9074H &9075Hmemory location and draw the flowchart.
7. Write a program in 8085 microprocessor to divide 07H by 03H and store the quotient in 9075Hand reminder in 9076H memory location and draw the flowchart.
8. Writeaprogramin8085microprocessortoaddsix(6)numbersandstoretheresultin memory location9071Hand 9061H.The numbers are stored from 9050H to 9055H location. The numbers are stored in 6 consecutive memory locations given below and draw the flowchart.
9. Writeaprogramin8085microprocessorofshiftingblockoffive(5)datafrom9055Hlocationto9080Hlocation and draw the flowchart.
10. Writeaprogramin8085microprocessorto countones(1)in8 bitdata.The8 bitno.isstorein memorylocation 9070H.Store the counting result in memory location 9080H and draw the flowchart.

THERAPEUTIC LAB

BE363

Pre-requisite	Co-requisite	L	T	P	C
None	None	**0**	**0**	**4**	**2**

Course Objectives:

1. To familiarize students with different types of medicalequipments
2. To make them understand about the working principle of versatile medicalequipments
3. To familiarize students with the application of suchequipments

Course Outcome

After completion of the course the students will be to

1. Describe different types of medicalequipments
2. Explain the working principle of versatile medicalequipments
3. Describe the application of suchequipments

List of experiments:

1. Study on simulated DCdefibrillator
2. Study on musclestimulator
3. Study on ECG heart rate monitor with alarmsystem
4. Study on peripheral pulse rate monitor with alarmsystem
5. Study on digital body/skin temperature monitoringsystem
6. Study on US Doppler / Foetalmonitor
7. Study on hearing aid and audiometer: air and boneconduction
8. Study on EMG bio-feedbacksystem
9. Study on ECG simulator and servicing of ECGmachine
10. Study on Baby incubator / Infusionpump

STUDY & EVALUATION SCHEME
B. TECH. Biomedical Engineering
(with effect from 2020-2021)

3rd Year **6th Semester**

S. No.	Course Category	Subject code	Name of Subject	Periods and Credits				Evaluation Scheme				Sub. Total
								Sessional (CA)			ESE	
				L	T	P	C	CT	TA	Total		
1	DC	BE365	Tissue Engineering	3	1	0	4	25	15	40	60	100
2	DC	BE366	Biomedical Hazards & Safety	3	1	0	4	25	15	40	60	100
3	DC*	EC355	Biomedical Laser Instruments	3	1	0	4	25	15	40	60	100
4	DC*	EC356	Diagnostic Imaging Systems	3	1	0	4	25	15	40	60	100
5	DE		Departmental Elective 2	3	1	0	4	25	15	40	60	100
6	OE		Open Elective I	3	1	0	4	25	15	40	60	100
Practicals												
7	DC*	EC357	Electro Diagnosis Lab	0	0	4	2	30	30	60	40	100
8	DC*	EC358	Biosensors & Transducers Laboratory	0	0	4	2	30	30	60	40	100
9	DC	BE367	Tissue Engineering Laboratory	0	0	4	2	30	30	60	40	100
Total				18	6	8	30	240	180	420	480	900

* An inter-disciplinary program offered by the Department of Bioengineering in association with the Department of Electronics and Communication Engineering.

L: Lecture **T**: Tutorial **P**: Practical **C**: Credit

CA: Continuous Assessment **CT**: Class Test **TA**: Teacher's Assessment

ESE: End Semester Examination **DC**: Departmental Core

DE: Departmental Elective

ESA – Engineering Sciences & Arts (Foundation Course & Engineering Courses)

Departmental Elective 2

1. X-Ray Imaging and Computed Tomography (EC359)
2. Biophysics & Biochemistry (BE368)

TISSUE ENGINEERING

BE365

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Course Objective:

This course will provide an overview of cell biology fundamentals, an extensive review on extracellular matrix and basics of receptors, followed by topics on cell-cell and cell-matrix interactions at both the theoretical and experimental levels. Subsequent lectures will cover the effects of physical (shear, stress, strain), chemical (cytokines, growth factors), and electrical stimuli on cell function, emphasizing topics on gene regulation and signal transduction processes. Tissue engineering will be introduced by reviewing tissue structure and function and the clinical need for tissue repair. An overview of scaffold design and processing for tissue engineering will be reviewed and the application of tissue engineering to specialized tissues and organs will then be addressed in depth. Specific organ systems include skin, muscular skeletal system (vascular grafts, blood substitutions, cardiac patch, and heart valve), nervous system (peripheral and central nervous systems), liver, pancreas, and kidney.

Course Outcome:

After completion of this course the students will be able to

1. Demonstrate knowledge of the difference between cells and tissues and understand how complex structures can arise from simpler components.
2. Demonstrate the ability to predict single component fluid properties and changes in thermodynamic variables associated with intercellular processes associated withtissues.
3. Demonstrate understanding of common tissue engineering strategies and known solutions for organreplication.
4. Apply the combined knowledge of tissue organization and common tissue engineering strategies to design a unique, plausible tissue engineeringsolution.

UNIT I	**INTRODUCTION TO TISSUE ENGINEERING** Introduction – definitions - basic principles - structure-function relationships –Biomaterials: metals, ceramics, polymers (synthetic and natural) – Biodegradable materials - native matrix - Tissue Engineering and Cell-Based Therapies –Tissue Morphogenesis and Dynamics- Stem Cells and Lineages- Cell-Cell Communication	**8**
UNIT II	**TISSUE CULTURE BASICS** Primary cells vs. cell lines - sterile techniques – plastics – enzymes - reactors and cryopreservation - Synthetic Biomaterial Scaffolds-Graft Rejection – Immune Responses-Cell Migration-Controlled DrugDelivery- Micro technology Tools	**8**
UNIT III	**SCAFFOLD FORMATION** Oxygen transport - Diffusion - Michalies-Menten kinetics - oxygen uptake rates -limits of diffusion - Principals of self assembly - Cell migration - 3D organization and angiogenesis - Skin tissue engineering –Introduction - scar vs. regeneration - split skin graft -	**8**

	apligraft. EngineeredDiseaseModels- Tissue Organization- Cell Isolation and Culture - ECM and Natural Scaffold Materials- Scaffold Fabrication and Tailoring	
UNIT IV	**CARDIOVASCULAR TISSUE ENGINEERING** Blood vessels structure - vascular grafts - Liver tissue engineering – Bioartificial liver assist device - shear forces - oxygen transport - plasma effects – Liver tissue engineering - Self-assembled organoids - decelluarized whole livers – Stem cells - basic principle - embryonic stem cells - Induced pluripotentstem cells -Material Biocompatibility - Cell Mechanics - Vascularization- Stem Cell Therapies	**8**
UNIT V	**PATTERNING OF BIOMIMETIC SUBSTRATES** Patterning of biomimetic substrates with AFM lithography primarily focusing on DPN-Nanotemplating polymer melts - Nanotechnology-based approaches in the treatment of injuries to tendons and ligaments- Progress in the use of electrospinning processing techniques for fabricating nanofiber scaffolds for neural applications -Nanotopography techniques for tissue-engineered scaffolds	**8**

TEXT BOOKS

1. KetulPopat"Nanotechnology in Tissue Engineering and Regenerative Medicine" CRC Press Taylor and Francis2011.
2. Cato T. Laurencin, Lakshmi S "Nanotechnology and Tissue Engineering: The Scaffold "CRC Press Taylor and Francis 2008.

REFERENCES

1. Kun Zhou, David Nisbet, George Thouas, Claude Bernard and John Forsythe "Bio-nanotechnology Approaches to Neural Tissue Engineering", NC-SA 2010.
2. Nair "Biologically Responsive Biomaterials for Tissue Engineering", Springer Series in Biomaterials Science and Engineering, Vol. 1 Antoniac, Iulian (Ed.) 2012.

BIOMEDICAL HAZARDS &SAFETY

BE366

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Course objectives:

To impart sufficient information on the various hazards and relevant precautionary and safety measures in healthcare system

Course outcome:

After completion of the course the students will be able to

1. Understand and explain types of hazards in healthcaresystem
2. Understand the guidelines of precautionary and safety measures inmedicine.

UNIT I	**STANDARDIZATION OF QUALITY MEDICAL CARE IN HOSPITALS** Define Quality- Need for Standardization & Quality Management, TQM in Health care organization-Quality assurance methods ,QA in (Medical Imaging & Nuclear medicine) Diagnostic services – Classification of equipments **REGULATORY REQUIREMENT FOR HEALTH CARE** FDA regulations, Accreditation for hospitals - JCI, NABH and NABL, Other regulatory Codes	**8**
UNIT II	**ELECTRICAL & FIRE SAFETY** Sources of shocks, macro & micro shocks -Hazards, monitoring and interrupting the Operation from leakage current- Elements of fire, causes of fire , Action to be taken in case of fire in aHospital.	**8**
UNIT III	**RADIATION SAFETY IN NUCLEAR MEDICINE AND RADIOTHERAPY** Design and description of NM department- Radiation protection in nuclear industry- Guidelines for radiation protection- Molecular medicine and radiation safety program-procedures for safe operation of radiation equipment- Radiation protection in external beam radiotherapy- Radiation protection in brachytherapy-Radioactive wastes.	**8**
UNIT IV	**LASER AND ULTRAVIOLET RADIATION SAFETY** Classification of UV radiation -Sources of UV- Biological effects of UV- Hazards associated with UV radiation- UV control measures - Safety management of UV Classifications of LASER and its radiation hazards- control measures-Emergencies and incident procedures.	**8**
UNIT V	**ASSESSING QUALITY HEALTH CARE** Patient Safety Organization- Governmental & Independent, Measuring Quality care –Evaluation of hospital services – six sigma	**8**

	way, Quality Assurance in Hospitals Sop's – Patient Orientation for Total Patient Satisfaction. 5S techniques	

Books:

1. Khandpur R.S., Hand book of Biomedical instrumentation,TMH
2. Carr& Brown , Introduction to BiomedicalEquipment,PHI
3. Webster J.G and Albert M.Cook, Clinical Engg, Principles & Practices, Prentice Hall Inc., Engle wood Cliffs, New Jersy,1979.
4. Cesar A. Cacere& Albert Zana, The Practice of Clinical Engg. Academic press, New York,1977.
5. B.M.Sakharkar, Principles of Hospital administration and Planning, JAYPEE Brothers, MedicalPublishers(P) Ltd.
6. K.Shridhara Bhat, Quality Management, Himalaya PublishingHouse.
7. Karen Parsley, Karen Parsley Philomena Corrigan‖ Quality improvement in Healthcare, 2nd edition,Nelson Thrones Pub, 2002.
8. Sharon Myers ―Patient Safety & Hospital Accreditation - A Model for Ensuring Success‖ Springer Publishers 2012
9. Joseph F Dyro ―Clinical Engineering Handbook― Elsevier Publishers,2004

BIOMEDICAL LASER INSTRUMENTS

EC355

Pre-requisite	Co-requisite	L	T	P	C
PY-101	None	3	1	0	4

UNIT I	**Laser Tissue Interaction** Principle and fundamentals of laser, Laser radiation and its characteristics, Biological tissue composition, Light penetration and reflectance, Laser medicine domains, Alterations of bio tissue properties during hyperthermal and ablation reactions, photodynamic therapy	**8**
UNIT II	**Types of Laser Used In Medicine** Classification of laser, laser construction and working principle of solid state laser, Atomic laser, Molecular laser, Liquid dye laser, Semiconductor laser, Solid state dye laser	**8**
UNIT III	**Laser Applications-I** Applications of laser radiation in ophthalmology, Laser treatment for eye tissues and diseases, Lasers in dermatology- handling of pain, Dermatological disorders, Lasers in cardiovascular diagnostics, Lasers in cardiovascular therapy	**8**
UNIT IV	**Laser Applications- II** Lasers in urology, Lasers in gynecology, Lasers in laparoscopy, Lasers in laryngeal surgery, Lasers in otology, Lasers in neurology	**8**
UNIT V	**Laser In Orthopaedic Surgery, Dentistry and Laser Safety** Mechanism of bone and cartilage reparation, Lasers in orthopaedic surgery, Laser techniques used in spinal surgery, Lasers in dentistry- lasers in endodontic procedures, Caries detection and treatment by laser radiation, Types of laser hazards, laser safety, laser use risk management.	**8**

Books Recommended:

1. Helena Jelinkova, “Lasers for medical applications: Diagnostics, Therapy and Surgery”, Woodhead Publishing, 1st edition, 2013.

2. MarkolfH.Neimz, “Laser tissue interactions-Fundamentals and applications”, Springer, 3rd edition, 2014.

3. OrazioSvelto and David C. Hanna, “Principles of lasers”, Springer, 5th edition, 2010.

4. William T. Silfvast, “Laser fundamentals”, Cambridge University Press, 2nd edition, 2009.

DIAGNOSTIC IMAGING SYSTEMS

EC356

Pre-requisite	Co-requisite	L	T	P	C
PY-101	None	3	1	0	4

UNIT I	**X-Ray and CT** Production of X-rays, X-ray tubes and generators, Screen film and digital radiography, mammography, CT system design, Hounsfield unit, modes of acquisition	**8**
UNIT II	**Nuclear Medicine** Radioisotopes, radionuclide production, types of detectors, scintillators, gamma camera, Emission tomography –positron emission tomography (PET) and Single photon emission computer tomography	**8**
UNIT III	**Ultrasound** Characteristics of sound, interactions of ultrasound with matter, Ultrasound transducers, ultrasound beam properties, image data acquisition, Modes of image display and storage, Doppler ultrasound, intravascular ultrasound	**8**
UNIT IV	**MRI** Basic concepts of MR physics, spin polarization, Resonance, relaxation, spin echoes, gradient echoes, Spatial encoding using magnetic field gradients, k-space and image reconstruction, MRI scanner hardware, functional MRI, MR spectroscopy	**8**
UNIT V	**Other Imaging Techniques** Spectroscopy techniques: light source, optical fibers, monochromator,filters and polarizers, Real time spectroscopy techniques, fractional flow reserve measurement techniques, Magnetoencephalography, optical coherence tomography	**8**

Books Recommended:

1. Jerrold T. Bushberg, John M. Boone, “The essential physics of medical imaging”, Lippincott Williams & Wilkins, 3rd edition, 2011.

2. Rongguang Liang, “Biomedical optical imaging technologies: Design and applications”, Springer Science & Business Media, 1st edition, 2012

3. M. A. Flower (Editor), “Webb's Physics of medical imaging, Second Edition”, CRC Press, Taylor & Francis Group, ISBN: 978-0-7503-0573-0, 2nd edition, 2016.

X-RAY IMAGING AND COMPUTED TOMOGRAPHY

EC358

Pre-requisite	Co-requisite	L	T	P	C
PY-101	None	3	1	0	4

UNIT I	**X-Ray** Projection radiography, Screen film radiography, Computed radiography, digital radiography,Dual energy radiography, X-ray contrast agents	**8**
UNIT II	**Mammography** Mammography: X-ray tube, beam filtration, X-ray generator and photo timer system, compression, scattered radiation and magnification, Digital mammography, colour X-ray imaging	**8**
UNIT III	**Specialized X-Ray Techniques** Fluoroscopy: Imaging chain components, detector systems, Modes of operation and automatic exposure control, Digital subtraction angiography, Single photon counting x-ray detectors in medical imaging, Image quality and artifacts	**8**
UNIT IV	**Advanced CT** Slip ring technology, Helical CT-instrumentation, Multislice CT, detector configuration, multislice helical configuration, Cone beam CT, isotropic imaging, Dual source and dual energy	**8**
UNIT V	**Special Applications** Quantitative CT, phase selective imaging of heart, 3D reconstruction: technical aspects, rendering techniques, Features of dedicated breast CT scanner, Quality control of CT scanners, future of CT	**8**

Books Recommended:

1. Jerrold T. Bushberg, John M. Boone, Lippincott Williams & Wilkins, “The Essential Physics of Medical Imaging”, Lippincott Williams and Wilkins, 3rdedition, 2011.

2. Willi A. Kalender, ‘Computed Tomography: Fundamentals, System Technology, Image Quality, Applications’, John Wiley & Sons, 3rdedition, 2011.

3. Euclid Seeram, “Computed Tomography: Physical Principles, Clinical Applications, and Quality Control”,Elsevier Health Sciences, 4thedition,2015.

BIOPHYSICS & BIOCHEMISTRY
BE368

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Course Objective:

- The course aims to provide an advanced understanding of the core principles and topics of Biophysics & Biochemistry and their experimental basis, and to enable students to acquire a specialized knowledge and understanding of selected aspects by means of a branch lectureseries.
- Students will be able to learn the vocabulary and conceptually understand the biochemical & biophysicalprocesses.
- Students will be able to learn the theoretical and technical basis for biophysical & biochemical definition and determination of macromolecular structure.
- This course focuses on the phenomena related to the interaction and communication between living cells and their molecular constituents, drawing on research methods used within the fields of molecular and cellular biochemistry and biophysics.

Course Outcome:

- The students will get broad and deep understanding of the ways that life functions are explained in terms of the principles of chemistry andphysics.
- The ability to utilize computational tools as appropriate to the biochemistry, biophysics, and molecular biology disciplines, including research, data analysis, andcommunication.
- The students will get knowledge necessary for students, according to their career goals, to attain acceptance into advanced degree programs.
- The students will be exposed to familiarity with the complexity of issues facing professionals in the biochemistry, biophysics, and molecular biology disciplines, including scientific and moral ethics, cultural diversity, and environmentalconcerns.
- The students will be exposed to familiarity with the types of contributions that this course can provide to society, including improvements in the human condition, and economic stimulation at the local, national, and international levels.
- Learn how to design and interpret experiments, thereby contributing to the creation of new knowledge in the fields of biochemistry andbiophysics.
- Develop an awareness of ethical responsibilities when conducting and reporting research in the biochemistry, biophysics, and molecular biologydisciplines.

UNIT I	**Biological Principles:** Composition and properties of cell membrane, membrane transport, body fluid, electrolytes, filtration, diffusion, osmosis, electrophoresis, plasmapheresis, radioimmunoassay, Photochemical reaction, laws of photochemistry, fluorescence, phosphorescence. **Bioelectricity:** Membrane potential, Action potential, Electrical properties ofmembrane, capacitance, resistance, conductance, dielectric properties of membrane.	**8**

UNIT II	**Electrical stimulus and biophysical activity:** Patient safety, electrical shock and hazards, leakage current, Electrical activity of heart (ECG), Electrical activity of brain(EEG), Electroretinogram (ERG), Electro-occologram (EOG), Electromyogram(EMG).	**8**
UNIT III	**Radioactivity:** Ionizing radiation, U-V & IR radiations, Production of radioisotopes, Radioactive decay, Half-life period.	**8**
UNIT IV	**Macromolecules:** Classification & functions of carbohydrates, glycolysis, TCA cycle, ATP synthesis. Classification & functions of proteins, architecture of protein, Classification of amino acid, oxidative and non oxidative deamination, transamination. Classification & functions of lipids, biosynthesis of long chain fatty acid, oxidation and degradation of fattyacid.	**8**
UNIT V	**Enzymes and Nucleic acid:** Chemical nature &broad classification of enzymes, M-M kinetics, Isozymes and Allosteric enzymes. Structure of DNA, DNA Replication, Transcription, Translation.	**8**

Reference Books:

1. Radiation Biophysics, Second Edition - by Edward L. Alpen - Academic Press; 2 edition
2. Bio-Physics – Roland Glaser- Springer; 2nd printing edition (November 23, 2004)
3. Text book of Medical Physiology- Guyton
4. The Biomedical Engineering Hand Book- 3rd Ed- (Biomedical Engineering Fundamentals) - Joseph D. Bronzino – CRC –Tylor-Francis – 2006 (Section- III – Bio-Electrical Phenomena)
5. Lehninger Principles of Biochemistry, Fourth Edition - by David L. Nelson & Michael M.Cox , - W. H. Freeman; 4 edition (April 23, 2004)
6. Fundamentals of Biochemistry: Life at the Molecular Level - by Donald J. Voet , Judith G. Voet & Charlotte W. Pratt. - Wiley; 2 edition (March 31, 2005)

ELECTRODIAGNOSIS LAB

EC357

Pre-requisite	Co-requisite	L	T	P	C
None	None	**0**	**0**	**4**	**2**

Course Objectives:

To provide practice on recording and analysis of different bio potentials, study the function of different therapeutic equipments.

Course Outcomes:

After successful completion of this course the students will be able to

1. Perform and study experiments on Lead selection circuits & pulse ratemeter
2. Perform and study experiments on colorimeter/spectrophotometer & flame photometer
3. Perform and study experiments on electronic BP and calibration procedure
4. Perform and study experiments on ultrasonic transmitter and detector
5. Perform and study experiments on pulmonary function analyzer, respiratory rate meter &apnea detection
6. Perform and study experiments on blood flow velocity measurement
7. Perform and study experiments on diathermy unit (ultrasound &short-wave)
8. Perform and study experiments on Pacemaker Circuits / Pacemaker simulator, nerve conduction velocity measuring system

List of experiments:

1. Lead selection circuits
2. Study on pulse rate meter
3. Study on colorimeter/spectrophotometer
4. Study on flame photometer
5. Study on electronic BP and calibration procedure
6. Study of ultrasonic devices - transmitter and detector
7. Study on pulmonary function analyzer -spirometer
8. Study on respiratory rate meter &apnea detection
9. Study on blood flow velocity measurement – ultrasonic method
10. Study on diathermy unit (ultrasound &short-wave)
11. Pacemaker Circuits / Pacemaker simulator
12. Study on nerve conduction velocity measuring system

BIOSENSORS & TRANSDUCERS LAB

EC358

Pre-requisite	Co-requisite	L	T	P	C
None	None	**0**	**0**	**4**	**2**

Course Objectives:

1. To study and analyze the theory and practical characteristics of the various transducers for the measurement of the vital physiologicalsignals
2. To get familiar with the various types of transducers and to study the compatibility for any clinicalmeasurements

Course Outcomes:

After completion of this course the students will be able to

1. Perform temperature, pressure & displacement measurement using relevantsensors/transducers
2. Study the characteristics of an LDR, load cell &pH electrodes
3. Perform torque measurement with strain gauge
4. Study the characteristics of biotransducers andbioelectrodes

List of Experiments:

1. Temperature measurement using AD590 ICsensor
2. Displacement measurement by using a capacitivetransducer
3. Study of the characteristics of aLDR
4. Pressure and displacement measurement by usingLVDT
5. Study of a load cell with tensile and compressiveload
6. Torque measurement Strain gaugetransducer
7. Study & characterization of Biotransducers – Pressure, Temperature,Humidity
8. Study & characterization of Bioelectrodes – ECG, EMG,EEG
9. Study & Characterization of pHelectrodes.

TISSUE ENGINEERING LAB
BE367

Pre-requisite	Co-requisite	L	T	P	C
None	None	**0**	**0**	**4**	**2**

Course Objective:

This course will train students in advanced cellular and tissue engineering methods that apply physical, mechanical and chemical manipulation of materials in order to direct cell and tissue function. Students will learn the techniques and equipment of bench research including cell culture, immunofluorescent imaging, soft lithography, variable stiffness substrates, application/measurement of forces and other methods. Students will integrate classroom lectures and lab skills by applying the scientific method to develop a unique project while working in a team environment, keeping a detailed lab notebook and meeting mandated milestones.

Course Outcome:

After completion of this course the students will be able to

1. Use of conventional microscopy for the understanding of tissuestructure
2. Understand microscopic organization of Tissues into Organs andsystem
3. Tissue observation and imagecapture
4. Histology as a diagnostictool
5. Use of Immuno-histochemicaltechniques

List of Experiments:

Module 1 –

Scaffold Formation and Characterization; Preparation of 2D Collagen Films; Preparation of 3D Scaffolds; Preparation of Silk Fibroin scaffold by Salt Leaching Method; Preparation of Silk Fibroin scaffold by Phase Separation Method;

Preparation of Silk Fibroin scaffold by Electrospinning; Design of 3D scaffold by rapid proto typing technique.; Characterization of biopolymers and scaffold; Mechanical Strength;

Contact angle measurement;

Pore size & Porosity;

Module 2 –

Cells and Cell Culture; Introduction to Cell Culture lab and aseptic skill; Use of Biosafety cabinet, CO2 incubators, Microscopes, Sterile Conditions; Preparation of Cell Culture Media and other supplements & Additives; Isolation and Culturing of MNCs from Peripheral blood;

Cell counting & cell morphology

Module 3 –

Bioreactors and Integration;

Introduction to type of bioreactors & their operation; (Spinner Flask, Rotating vessel, Perfused Column and Perfused Chamber);

MNC seeding on 2D films and 3D scaffolds;

MNC seeding on 2D & 3D polymer scaffolds by static method; MNC seeding on 2D & 3D polymer scaffolds by dynamic method; Culture and cell growth study inbioreactor;

Module-4 –

Cell Survival & Function; Live/Dead Fluorescence Assay; MTT Viability Test;
Cell Viability Test by Trypan Blue staining method