

ANNA UNIVERSITY, CHENNAI
NON- AUTONOMOUS COLLEGES
AFFILIATED TO ANNA UNIVERSITY
M.E. BIOMEDICAL ENGINEERING
REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES(PSOs):

PSO	Programme Specific Outcomes
PSO1	Ability to design and implement innovative solutions to solve complex problems in Biomedical Engineering.
PSO2	Competence to independently undertake research projects involving simulation, measurement, and product development in Biomedical Engineering -related fields.



ANNA UNIVERSITY, CHENNAI

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E., Biomedical Engineering

Regulations: 2025

Abbreviations:

BS – Basic Science (Mathematics, Physics, Chemistry)

ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**))

SD – Skill Development

SL – Self Learning

TCP – Total Contact Period(s)

L – Laboratory Course

T – Theory

LIT – Laboratory Integrated Theory

PW – Project Work

Semester I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	BM25101	Diagnostic and Therapeutic Equipment	T	3	0	0	3	3	ES (PC)
2.	BM25102	Biomedical Sensors and Instrumentation	T	3	0	0	3	3	ES (PC)
3.	BM25103	Bio Signal Processing	LIT	3	0	2	5	4	ES (PC)
4.	BM25104	Human Anatomy and Physiology	T	3	0	0	3	3	ES (PC)
5.	BM25105	Medical Imaging Systems	T	3	0	0	3	3	ES (PC)
6.	BM25106	Clinical Instrumentation and Design Laboratory	L	0	0	4	4	2	ES (PC)
7.	BM25107	Technical Seminar	-	0	0	2	2	1	SD
Total							23	19	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	BM25201	Medical Device Design	T	3	0	0	3	3	ES (PC)
2.	BM25202	Biomaterials and Biomechanics	T	3	0	0	3	3	ES (PC)
3.	BM25203	Applied Medical Image Processing	LIT	3	0	2	5	4	ES (PC)
4.	BM25204	Soft Computing	T	3	0	0	3	3	ES (PC)
5.		Programme Elective I	T	3	0	0	3	3	ES(PE)
6.	BM25205	Biomedical Design and Modeling Laboratory	L	0	0	4	2	2	ES (PC)
7.	-	Industry Oriented Course I	--	1	0	0	1	1	SD
8.	BM25206	Industrial Training	-	-	--	-	---	1	SD
9.	-	Self-Learning Course	-	-	--	-	---	1	--
Total							20	21	

Semester III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Programme Elective II	T	3	0	0	3	3	ES (PE)
2.		Programme Elective III	T	3	0	0	3	3	ES (PE)
3.		Programme Elective IV	T	3	0	0	3	3	ES (PE)
4.		Programme Elective V	T	3	0	0	3	3	ES (PE)
5.	-	Industry-Oriented Course II	--	1	0	0	1	1	SD
6.	BM25301	Hospital Training	--	0	0	4	2	2	SD
7.	BM25302	Project Work I	--	0	0	12	12	6	SD
Total							27	21	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	BM25401	Project Work II	--	0	0	24	24	12	SD
Total Credits							24	12	

Programme Electives Courses (PE)

S. No.	Course Code	Course Title	Periods Per Week			Total Contact Periods	Credits
			L	T	P		
1.	BM25001	Rehabilitation Engineering	3	0	0	3	3
2.	BM25002	Medical Optics	3	0	0	3	3
3.	BM25003	Human Assist Devices	3	0	0	3	3
4.	BM25004	Micro and Nano Fluids	3	0	0	3	3
5.	BM25005	Medical Device Standards and Regulation	3	0	0	3	3
6.	BM25006	Tele Health Technology	3	0	0	3	3
7.	BM25007	Medical Robotics	3	0	0	3	3
8.	BM25008	Wearable Technologies	3	0	0	3	3
9.	BM25009	Medical Ethics and Standards	3	0	0	3	3
10.	BM25010	Brain Computer Interface	3	0	0	3	3
11.	BM25011	Wavelet Transforms and Its Applications	3	0	0	3	3
12.	BM25012	Hospital Planning, Organization and Management	3	0	0	3	3
13.	BM25013	Human Resource Management in Hospitals	3	0	0	3	3
14.	BM25014	Health Policy and Equipment Management	3	0	0	3	3
15.	BM25015	Hospital Waste management	3	0	0	3	3
16.	BM25016	Quality Assurance and Patient Safety standards in Hospitals	3	0	0	3	3
17.	BM25017	Genetic Algorithms and Fuzzy Logics	3	0	0	3	3
18.	BM25018	Tissue Engineering	3	0	0	3	3
19.	BM25019	Embedded System and Internet of Things for Biomedical Applications	3	0	2	5	4
20.	BM25020	Medical Informatics	3	0	2	5	4
21.	BM25021	Pattern Recognition Techniques and Applications	3	0	2	5	4
22.	BM25022	Data Analytics for Health Care Technologies	3	0	2	5	4
23.	BM25023	Mixed Reality	3	0	2	5	4

Semester I

BM25101	Diagnostic and Therapeutic Equipments	L	T	P	C
		3	0	0	3
Course Objectives: To study biomedical measurements, assist devices, and hospital electrical safety.					
Cardiac Care Units: Pacemakers, DC defibrillators (asynchronous & synchronous), patient monitoring systems, principles of bio-telemetry, echocardiography. Activities: <ol style="list-style-type: none"> 1. Virtual demonstration on pacemaker design and battery longevity. 2. Simulation of patient monitoring and telemetry systems. 					
Neurological Equipment: Multi-channel EEG recording, clinical EEG (sleep patterns, epilepsy), evoked potentials (visual, auditory, somatosensory), EEG biofeedback, psychophysiological measurements, MEG principles. Activities: <ol style="list-style-type: none"> 1. EEG waveform analysis for epilepsy and sleep stages. 2. Virtual demonstration on MEG applications in neurology. 					
Muscular Equipment: EMG (recording, waveform analysis, fatigue characteristics), muscle and nerve stimulators, nerve conduction velocity, EMG biofeedback, EGG (Electro-gastrograph), MMG (Magneto-myograph). Activities: <ol style="list-style-type: none"> 1. Lab experiment: EMG recording during muscle activity. 2. Case discussion on clinical use of nerve conduction studies. 					
Respiratory Measurement and Assist Systems: Lung Volume and vital capacity, Spirometer, measurements of residual volume. pneumotachometer – Airway resistance measurement, Whole body plethysmography. Intra- Alveolar and Thoracic pressure measurements, Apnea Monitor. Types of Ventilators – Pressure, Volume, and Time controlled. Flow, Patient Cycle Ventilators, Humidifiers, Nebulizers, Inhalators. Activities: <ol style="list-style-type: none"> 1. Spirometry practical: measurement of lung capacity. 2. Design-based assignment on ventilator control systems. 					
Diathermy, Stimulator and Patient Safety: Diathermy-Physiological effects of high frequency radiation, Depth of Penetration, short wave, Ultrasonic and microwave diathermy, Surgical diathermy, Hazards and safety procedures. Activities: <ol style="list-style-type: none"> 1. Demonstration of diathermy equipment with safety considerations. 2. Simulation/Case study on electrical safety hazards in hospitals. 					
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%					
Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).					
References: <ol style="list-style-type: none"> 1. Geddes, L. A., & Baker, L. E. (2008). Principles of applied biomedical instrumentation (3rd ed.). John Wiley & Sons. 2. Webster, J. G. (2009). Medical instrumentation: Application and design (4th ed.). John Wiley & Sons. 					

3. Khandpur, R. S. (2014). Handbook of biomedical instrumentation (3rd ed.). Tata McGraw-Hill.
4. Carr, J. J., & Brown, J. M. (2014). Introduction to biomedical equipment technology. Pearson Education.
5. Cobbold, R. S. C. (1992). Transducers for biomedical measurements: Principles and applications. John Wiley & Sons.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the principles, working, and clinical significance of biomedical equipment.	-	-	-
CO2	Apply appropriate methods to measure bio potentials, physiological parameters, and therapeutic responses	PO1(3) PO3(3)	2	2
CO3	Analyze biomedical signals and equipment performance for diagnosis, safety, and effective patient monitoring.	PO3(3)	3	3
CO4	Design and evaluate biomedical instruments with safety protocols	PO1(3)	3	3

BM25102	Biomedical Sensors and Instrumentation	L	T	P	C
		3	0	0	3
<p>Course Objectives: To study measurement principles, errors, and biosensors in medicine, and to understand biopotentials and bioamplifiers</p>					
<p>Biomedical Sensors & Transducers: Resistive transducers (strain gauge – gauge factor, configuration, displacement & pressure sensing, biomedical applications), RTDs, thermistors, temperature sensors, capacitive and inductive transducers, LVDT, thermocouples.</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. Case study on strain gauge applications in biomedical measurement. 2. Demonstration/assignment on temperature sensors in medical devices. 					
<p>Biopotential and Its Measurements: Origin and propagation of biopotentials, electrode–electrolyte and electrode–skin interface, half-cell potential, polarization, surface/needle/micro electrodes & equivalent circuits, non-polarizable electrodes.</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. Simulation/lab: Measuring skin–electrode impedance. 2. Comparative study of electrode types and their biomedical uses. 					
<p>Measurement of Non-Electrical Parameter: Measurements of Respiration Rate, Temperature, Pulse rate, Blood pressure Measurements- Direct, Indirect. Blood flow Measurements – In vitro, In vivo, Gas flow measurements. Blood cell counter.</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. Practical measurement of pulse rate and respiration using available sensors. 2. Assignment on methods of blood pressure measurement and comparison. 					
<p>Biosignals & Measurement Systems: Characteristics of biosignals (frequency, amplitude), ECG (Einthoven’s triangle, 12-lead system), EEG (10–20 system, recording modes), EMG (recording modes), PCG, ERG, EOG, EGG – recording methods, waveform analysis, abnormal signals, evoked responses.</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. Lab experiment: ECG or EEG signal recording and waveform analysis. 2. Case study on clinical use of EMG or PCG signals. 					
<p>Bioamplifiers & Signal Conditioning: Need for bioamplifiers, single-ended & differential bioamplifiers, impedance matching, isolation amplifiers (transformer & optical isolation), isolated DC & AC carrier amplifiers, power-line interference removal, right-leg driven ECG amplifier, band-pass filtering, recording systems.</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. Design exercise: Differential bioamplifier for ECG. 2. Simulation of noise removal techniques (band-pass filtering, right-leg drive). 					
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>					
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>					
<p>References:</p> <ol style="list-style-type: none"> 1. Aston, R. (2002). Principles of biomedical instrumentation and measurement. Merrill Publishing Company. 2. Carr, J. J., & Brown, J. M. (2000). Introduction to biomedical equipment technology. Pearson. 3. Cromwell, L. (2015). Biomedical instrumentation and measurement. Prentice Hall of India. 4. Geddes, L. A., & Baker, L. E. (1989). Principles of applied biomedical instrumentation. John Wiley & Sons. 					

5. Khandpur, R. S. (2014). Handbook of biomedical instrumentation. McGraw Hill Education India.
6. Webster, J. G. (2009). Medical instrumentation: Application and design. John Wiley & Sons.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the working principles of biomedical sensors, electrodes, bio potentials, and signal acquisition systems.	-	-	-
CO2	Apply appropriate methods to measure bio potentials, physiological parameters, and therapeutic responses	PO1(3) PO3(3)	2	2
CO3	Analyze biomedical signals and equipment performance for diagnosis, safety, and effective patient monitoring.	PO3(3)	3	3
CO4	Design and evaluate biomedical instruments with safety protocols	PO1(3)	3	3

BM25103	Bio Signal Processing	L	T	P	C
		3	0	2	4
<p>Course Objectives: To study biosignal characteristics, apply filtering techniques, and demonstrate wavelet-based feature extraction in biosignal processing.</p>					
<p>Signal, System and Spectrum: Characteristics of biomedical signals, types of noise (random, structured, physiological), IIR and FIR filters, spectrum analysis (PSD, cross-spectral density, coherence function, cepstrum, homomorphic filtering), estimation of mean in finite time signals.</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. Lab experiment: FIR filter design for ECG noise removal. 2. Assignment on power spectral density estimation of EEG signals. <p>Practicals:</p> <ol style="list-style-type: none"> 1. Design and implementation of FIR & IIR filters for ECG noise removal. 2. Power Spectral Density (PSD) estimation of EEG signals using Welch's method. 					
<p>Time Series Analysis and Spectral Estimation: Time series models, linear prediction, process order estimation, non-stationary processes, fixed/adaptive segmentation, applications in EEG, PCG, HRV, model-based ECG simulator. Spectral estimation (Blackman–Tukey, periodogram, model-based).</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. MATLAB/Python implementation of periodogram method for HRV. 2. Case study on adaptive segmentation in EEG signals. <p>Practicals:</p> <ol style="list-style-type: none"> 1. Time series modeling of ECG signals using linear prediction (AR model). 2. Spectral estimation using Periodogram & Blackman-Tukey methods on HRV signals. 					
<p>Adaptive Filtering and Wavelet Detection Adaptive filtering, LMS adaptive filter, adaptive noise cancellation in ECG, FECG, EEG; wavelet detection in ECG, structural features, matched filtering, adaptive wavelet detection, overlapping wavelets.</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. Implementation of LMS adaptive filter for ECG denoising. 2. Mini-project: QRS detection using wavelet transform. <p>Practicals:</p> <ol style="list-style-type: none"> 1. Biosignal analysis in virtual instrumentation platform 					
<p>Analysis of Biosignal: Artifact removal, event detection in ECG, P wave, QRS complex, T wave detection, correlation analysis of ECG, averaging of PCG/ECG/EMG signals.</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. ECG signal event detection using correlation analysis. 2. Group project: Noise artifact removal from EMG recordings. 					
<p>Biosignal Classification: Statistical signal classification, linear discriminant function, feature selection, backpropagation neural network, biosignal classification using CNN & LSTM.</p> <p>Activities:</p> <ol style="list-style-type: none"> 1. Simulation of statistical classification for EMG/EEG signals. 2. Deep learning project: ECG classification using CNN/LSTM. 					

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References:

1. Babu, P. R. (2014). Digital signal processing. SciTech Publications.
2. Ifeachor, E. C., & Jervis, B. W. (2002). Digital signal processing: A practical approach Pearson Education.
3. Rao, R. M., & Bopardikar, A. S.(2000). Wavelet transforms: Introduction to theory and its applications. Pearson Education.
4. Rangaraj, M. R. M. (2015). Biomedical signal analysis: A case-study approach. Wiley -IEEE Press.
5. Tompkins, W. J. (2006). Biomedical digital signal processing. Prentice Hall of India.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the characteristics of biomedical signals, noise sources, and spectrum analysis methods.	-	-	-
CO2	Apply time series and spectral estimation techniques to analyze biosignals.	PO1(3) PO3(3)	2	2
CO3	Analyze biosignals using adaptive filtering, wavelet-based detection, and artifact removal methods.	PO3(3)	3	3
CO4	Design and implement signal classification models	PO1(3)	3	3

BM25104	Human Anatomy and Physiology	L	T	P	C
		3	0	0	3
<p>Course Objectives: To study animal cell organelles, human body systems, sensory and accessory organs, and understand the anatomy, physiology, and regulatory mechanisms of the human body.</p>					
<p>Organization of the Human Body: Levels of organization, anatomical planes, cell structure & functions, plasma membrane, cell transport, cell signaling, cell cycle regulation, action potential, homeostasis, specialized tissues. Activities: 1. Microscopy lab – identification of cell structures and tissues. 2. Case study on disorders related to cell cycle regulation.</p>					
<p>Integumentary, Skeletal, Muscular and Respiratory Systems: Skin (structure & functions), bones (types, formation, joints, cartilage), muscular system (parts, movement), respiratory system (structure, types, breathing, regulation). Activities: 1. Skeleton model demonstration – identification of major bones & joints. 2. Spirometry experiment – measurement of lung volumes & capacities</p>					
<p>Cardiovascular, Lymphatic and Endocrine Systems: Heart structure & conduction system, cardiac cycle, cardiac muscle properties, heart rate regulation, blood vessels, blood composition, blood groups. Lymphatic organs, functions. Endocrine glands (pituitary, thyroid). Activities: 1. ECG recording and analysis of heart rate. 2. Blood group determination practical.</p>					
<p>Nervous, Sense Organs and Reproductive Systems: Neuron structure, properties, nerve impulse, CNS & PNS, brain parts, reflex mechanism. Sensory systems (eye, ear). Reproductive system (male & female anatomy). Activities: 1. Reflex activity demonstration (e.g., knee-jerk reflex). 2. Model/diagram study of brain, eye, and ear structures.</p>					
<p>Digestive and Urinary Systems : Digestive organs, digestion & absorption, kidney & nephron structure, urine formation, urinary reflex, blood pressure regulation by urinary system. Activities: 1. Urine analysis (physical and chemical tests). 2. Chart/animation-based activity on digestive processes.</p>					
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>					
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>					
<p>References: 1. Ganong, W. F. (2010). Review of medical physiology. McGraw Hill. 2. Guyton, A. C., & Hall, J. E. (2015). Medical physiology. Elsevier Saunders. 3. Martini, F. H., Nath, J. L., & Bartholomew, E. F. (2014). Fundamentals of anatomy and physiology). Pearson Publishers. 4. Marieb, E. N. (2015). Essentials of human anatomy and physiology. <i>Pearson Education</i>.</p>					

5. *Pocock, G., & Richards, C. D. (2017). The human body: An introduction for biomedical and health sciences. Oxford University Press.*
6. *Solomon, E. P. (2015). Introduction to human anatomy and physiology. W. B. Saunders Company.*

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the structural organization of the human body from cells to organ systems.	-	-	-
CO2	Apply anatomical and physiological knowledge to measure, record, and interpret basic body functions.	PO1(3) PO3(3)	2	2
CO3	Analyze the integration of various systems in maintaining homeostasis.	PO3(3)	3	3
CO4	Design activities to explore structure–function relationships of human organ systems	PO1(3)	3	3

BM25105	Medical Imaging Systems	L	T	P	C
		3	0	0	3
Course Objectives: To study the principles of Medical Imaging Systems					
X-ray Imaging Modalities: Principle and production of soft X – Rays, X- ray machine and digital radiography, principles of Angiography and Fluoroscopic Techniques, digital subtraction angiography, mammography. Activities: <ol style="list-style-type: none"> 1. Lab demo/visit: Digital radiography machine and image acquisition. 2. Case study on mammography in breast cancer screening. 					
CT and Computer Aided Tomography: Principle, multisection radiography, computerized axial tomography, detectors, image reconstruction, spiral CT, transverse tomography, 3D imaging, convolution and back-projection, multislice CT, artifacts. Activities: <ol style="list-style-type: none"> 1. MATLAB/Python simulation of back-projection for CT image reconstruction. 2. Assignment on types of CT artifacts with clinical examples. 					
MRI and Emission Computed Tomography: Principle of MRI, MRI instrumentation, tissue characterization, MR spectroscopy, functional MRI, radiation detectors, gamma camera, PET, SPECT, PET/CT, PET/MRI. Activities: <ol style="list-style-type: none"> 1. Mini-project: MRI pulse sequence simulation. 2. Case study on PET/CT in oncology imaging. 					
Ultrasound Imaging: Ultrasonic frequency for medical application, display modes (A, B, M), ultrasonic probes, real-time echo, 2D scanner. Activities: <ol style="list-style-type: none"> 1. Practical demo: Ultrasound scanning for abdominal imaging. 2. Assignment on probe design and applications of Doppler ultrasound. 					
Quality Metrics in Medical Imaging: Global parameter assessment, spatial and frequency assessment, image processing assessment, observer assessment, image discrimination models, figure of merit, AI in imaging systems. Activities: <ol style="list-style-type: none"> 1. Project: Comparative analysis of image quality across CT/MRI/Ultrasound. 2. Seminar: AI applications in medical imaging and diagnostics. Specific Activity: Case Study: Applications of Imaging Methods					
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%					
Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).					
References: <ol style="list-style-type: none"> 1. Richard L. Van Metter, Jacob Beutel, Harold L. Kundel, Handbook of Medical Imaging, 2. Volume 1. Physics and Psychophysics, SPIE, 2000 3. Chesney D. N., Chesney M. O. Radio graphic imaging, CBS Publications, New Delhi, 1989 4. Donald W. McRobbice, Elizabeth A. Moore, Martin J. Grave and Martin R. Prince MRI 					

5. from Picture to proton, Cambridge University press, second edition, New York 2007.
6. Frederick W Kremkau, Diagnostic Ultrasound Principles & Instruments, Saunders Elsevier,2005.
7. Jerry L. Prince, Jnathan M. Links, Medical Imaging Signals and Systems- Pearson Education Inc. 2014.
8. Peggy, W., Roger D. Ferimarch, MRI for Technologists, McGraw Hill, New York, second edition, 2000.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the principles of X-ray and ultrasound imaging systems and their clinical applications.	-	-	-
CO2	Apply reconstruction techniques in CT and MRI to generate sectional images.	PO1(3) PO3(3)	2	2
CO3	Analyze different medical imaging modalities (MRI, PET, SPECT) for tissue characterization and functional studies..	PO3(3)	3	3
CO4	Evaluate and design imaging quality metrics and AI-based methods for medical image assessment.	PO1(3)	3	3

BM25106	Clinical Instrumentation and Design Laboratory	L	T	P	C
		0	0	4	2
Course Objectives:					
To design the the design of bio medical instrumentation Circuits. And the critical care equipment in medical field.					
List of Experiments:					
<ol style="list-style-type: none"> 1. Design and analysis of bio amplifier using circuit simulation. 2. Design of instrumentation amplifier using Opamp and single IC 3. Design of bio amplifier for acquiring bio signals. 4. Recording and analysis of Electromyogram signals. 5. Recording of EEG signal. 6. Measurement of respiratory parameters using spirometer 7. Plotting of human auditory response using audiometer. 8. Performance and testing of surgical diathermy unit using diathermy Analyser. 9. Measurement of Vital parameters using patient monitoring system and biotelemetry. 10. Electrical safety testing of medical equipment. 11. Study of different types of muscle stimulator waveforms. 12. Study the working of Defibrillator and pacemakers 13. Study of ventilators 14. Develop prototype using 3D printing for Biomedical applications. 					
Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%					
Assessment Methodology: Project (30%), Assignment (10%), Practical (30%), Internal Examinations (30%)					

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the role of preamplifiers and isolation circuits in biomedical applications.	-	-	-
CO2	Apply amplifier design techniques for bio-signal acquisition..	PO1(3) PO3(3)	2	2
CO3	Analyze the operation of medical and critical care equipment..	PO3(3)	3	3
CO4	Design 3D printing models for biomedical applications.	PO1(3)	3	3

Semester II

BM25201	Medical Device Design	L T P C 3 0 0 3
<p>Course Objectives:</p> <ul style="list-style-type: none"> • To understand about basic design processes of medical device • To introduce with basics of design, construction and development devices • To follow a deterministic engineering design process to create new products. • To apply engineering theory to practice. • To perform design transfer and countermeasure development. 		
<p>Introduction - Needs finding, problem identification, prior art searches, strategy and concept generation, estimation, sketching, sketch modelling, machine elements, ergonomics and prototyping.</p>		
<p>Product Design - Definition, History and Modern Practice – Designs; Design and Product Life Cycle; Design Process; Medical device, Challenges in medical device, Understanding the innovation cycle, Good Design Practice. Understanding, analyzing and validating user needs, Screening Needs, Technical Requirements, Concept Generation – Innovation Survey Questionnaire, Morphological Matrix, QFD, Concept Analysis and validation, Concept Modelling, Concept Screening & Validation.</p>		
<p>Hardware and Software Design - Hardware design, Hardware risk analysis, Design and project merits, Design for six sigma, software design, software coding, software risk analysis, software metrics, licensing and alternate pathways.</p>		
<p>Design Transfer and IPR - Transfer to manufacturing, documents and deliverables. Standard-ISO, IES, Intellectual Property - Patents, Copy rights, Trademarks, Trade secrets.</p>		
<p>Manufacturing and Business Strategies -Lean Manufacturing – Toyota Production System, Good Manufacturing Practices, Framework for Product Strategy – Core Strategic Vision (CSV), Characteristics of good CSV, Opportunity Identification Process & Generating Opportunities, Quality of Opportunities – Real-Win-Worth It (3M RWW), Product Planning Process, Technology S- Curve, Evaluating and Prioritizing Projects, Product-Process Change Matrix, Resource Planning, Total Available Market (Segmentation, Targeting & Positioning), Served Available Market, Product Platform Strategy, Market Platform Plan (Product Platform Management, Product Line Strategy).</p>		
<p>Development Strategy and Planning - Intellectual property strategy – research and development strategy – clinical strategy – regulatory strategy – quality and process management – reimbursement strategy – marketing and stakeholder strategy – sales and distribution strategy – competitive advantage and business strategy.</p>		
<p>Specific Activity: Industrial Visit to any medical industry to understand the process of medical device design.</p>		

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References

1. Matthew Bret Weinger, Michael E. Wiklund, Daryle Jean Gardner-Bonneau'Handbook of Human Factors in Medical Device Design,' CRC press,2010
2. Peter J. Ogradnik, "Medical Device Design: Innovation from Concept to Market," Academic Press Inc; 1st Edition, 2012
3. Paul H. King, Richard C. Fries, Arthur T. Johnson, "Design of Biomedical Devices and Systems," Third Edition, 2014
4. StefanosZenios, Josh Makower, Paul Yock, Todd J. Brinton, Uday N. Kumar, Lyn Denend, Thomas M. Krummel, "Biodesign: The Process of Innovating MedicalTechnologies,"
5. Cambridge University Press; 1 edition, 2009.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Analyze and identify user needs, perform prior art searches, and generate innovative concepts for medical device design.	PO1(3), PO2(3), PO4(2)	3	2
CO2	Apply engineering principles to hardware and software design, risk analysis, and coding practices in medical devices.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO3	Implement design transfer, documentation, and intellectual property management including patents, trademarks, and regulatory compliance.	PO1(3), PO2(3), PO3(2), PO5(3)	3	3
CO4	Develop manufacturing, business, and development strategies for medical devices using lean manufacturing, product planning, market analysis, and strategic frameworks.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3

BM25202	Biomaterials and Biomechanics	L T P C 3 0 0 3
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Course Objectives:

To introduce concepts of materials, surface and tissue placement in biomaterial functions and to understand diverse elements controlling biological responses to materials. To get the clear understanding of application of mechanics in medicine. To study the properties of blood, bone and soft tissues like articular cartilage tendons and ligaments and gain necessary knowledge about accident and injuries.

Introduction to Biomaterials - Definition of biomaterials, Metals, Ceramics, Polymers and Biomimetic Materials, Composites. mechanical properties, surface chemistry of materials, surface modification, Tissue Reaction, Wound Kinetics, Bio Compatibility, Material preparation, Properties, uses in medicine and biosciences and failure mechanisms.

Sterilization and Testing of Biomaterials - Sterilization techniques. ETO, gamma radiation, autoclaving. Effects of sterilization on material properties. Testing with Tissue Culture – in vitro and in vivo assessment of biocompatibility, testing with Soft Tissues and testing at non Thrombogenic surface – blood compatibility and thrombogenicity, ISO 10993- standard for assessment of biocompatibility.

Tissue and Fluid Biomechanics - Mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voight models. Electrical properties of bone, type of fractures. Soft Tissues: Cartilage, Tendon, Ligament, and Muscle; Structure and functions - Material Properties, Modeling. Newton's law, stress, strain, elasticity, Hooke's law, viscosity, Newtonian fluid, non-Newtonian fluid, viscoelastic fluids, Velocity and pressure profile of blood flow, Resistance against flow

Movement Biomechanics and Implants - Gait analysis. Analysis of Joints forces in Elbow, knee and shoulder. General concepts of Implants, classification of implants, soft tissue and Hard tissue replacement, Design of orthopedic implant, specifications for a prosthetic joint, fixation of implants.

Cardiac & Respiratory Mechanics - Cardiovascular system, Mechanical properties of blood vessels: arteries, arterioles, capillaries, and veins. Function of native heart valves, artificial heart valves, biological and mechanical valves development, testing of valves. Alveoli mechanics, Interaction of blood and lung, P-V curve of lung, Breathing mechanism, Airway resistance, Physics of lung diseases.

Suggested Activities:

- 1: Stress-strain analysis of hip prosthesis
- 2: Estimation of hemocompatibility of biomaterials by hemolysis studies
- 3: Measurement of torque required to tap and screwing in jaw bone.
- 4: Determination of moment of inertia of human limb using dynamometer.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References

1. Jonathan Black, Biological Performance of Materials- Fundamentals of bio compatibility, 4th Edition, CRC Press 2005.
2. Larry L. Hench and Julian R. Jones, Biomaterials, Artificial organs, and Tissue Engineering, 2005.
3. Y. C. Fung, Biomechanics: Mechanical properties in living tissues, Springer Verlag, New York 1981.
4. Susan J. Hall, Basics Bio Mechanics 4th Edition, McGraw-Hill Publishing Co, 2002.
5. Subrata pal, Text book of Biomechanics, Viva education private limited, 2009.
6. C. R Ethier and C. A. Simmons, Biomechanics from cells to organisms, Cambridge University Press, 2007.
7. D. Dawson and Right, Introduction to Bio-mechanics of joints and joint replacement, Mechanical Engineering, publications Ltd. 1989.
8. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterial Science; An Introduction to Materials in Medicine, 2nd Edition, Elsevier Academic Press, San Diego, 2004.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the properties, surface chemistry, biocompatibility, and sterilization of biomaterials, including metals, ceramics, polymers, composites, and biomimetics.	-	-	-
CO2	Apply biomechanics principles to analyze mechanical properties of bones, soft tissues, and fluids, including stress, strain, viscoelasticity, and blood flow dynamics.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO3	Evaluate the design and functional requirements of orthopedic and cardiovascular implants, including joint prostheses, artificial valves, and fixation strategies.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3
CO4	Perform experimental and analytical studies, including stress-strain analysis, hemocompatibility testing, torque measurements, and limb inertia determination using biomechanical tools.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3

BM25203	Applied Medical Image Processing	L T P C 3 0 2 4
<p>Course Objectives: To understand the fundamentals of medical image processing techniques and understand the basic concepts of image enhancement, image restoration, morphological image processing, image segmentation, feature recognition in medical images. To provide information about various medical imaging modalities and provide information about classification and image visualization in medical image processing projects. To familiarize the student with the image processing facilities in MATLAB, Python and OpenCV.</p>		
<p>Fundamentals of Image Processing - Image perception, MTF of the visual system, Image fidelity criteria, Image model, Image sampling and quantization - Image transforms</p>		
<p>Medical Image Enhancement and Restoration - Image Enhancement operation, Noise distributions, Spatial averaging, Directional Smoothing, Median, Geometric mean, Harmonic mean, Contra harmonic mean filters, Homomorphic filtering, Color image enhancement. Image Restoration-degradation model, Unconstrained and constrained restoration, Inverse filtering-Wiener filtering.</p>		
<p>Medical Image Representation - Pixels and voxels - algebraic image operations - gray scale and color representation - depth - color and look up tables - image file formats - DICOM- other formats - Analyse 7.5, NifTI and Interfile, Image quality and the signal to noise ratio.</p>		
<p>Medical Image Analysis and Classification - Image segmentation- pixel based, edge based, region-based segmentation. Image representation and analysis, Feature extraction and representation, Statistical, Shape, Texture, feature, and image classification – Statistical, Rule based, Neural Network approaches.</p>		
<p>Image Registrations and Visualization - Image Registration: Rigid body transformation – Affine transformation, Principal axes registration, Iterative principal axes registration, Feature based registration, Elastic deformation based registration,</p>		
<p>Image visualization: 2-D display methods, 3-D display methods, surface and volume based 3-D display methods – Surface Visualization and Volume visualization, 3-D Echocardiography, 3D+time Echocardiography, virtual reality based interactive visualization.</p>		
<p>The following experiments should be performed in Open CV/ Python/ Scilab / Matlab /Octave/ othe Open-source software.</p>		
<p>List of Experiments</p> <ol style="list-style-type: none"> 1. Preprocessing of medical images 2. Filtering of medical images. 3. Edge detection using Python 4. Segmentation of ROI in medical images. 5. Feature extraction in medical images 6. Steganography using Open CV. 7. Medical image fusion. 8. Statistical analysis of features 9. Neural network-based classification. 		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		

References

1. Atam P. Dhawan, Medical Image Analysis, 2nd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2011.
2. Anil K Jain, Fundamentals of Digital Image Processing, 1st Edition, Pearson Education India, 2015.
3. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, 4th Edition, Pearson Education, 2018.
4. Wolfgang Birkfellner, "Applied Medical Image Processing – A Basic course," CRC Press, 2011
5. Geoff Dougherty, Digital Image Processing for Medical Applications, 1st Edition, Cambridge University Press, 2010.
6. John L. Semmlow, "Biosignal and Biomedical Image Processing Matlab Based applications" Marcel Dekker Inc., New York, 2004
7. Kavyan Najarian and Robert Splerstor, "Biomedical signals and Image processing", CRC – Taylor and Francis, New York, 2006
8. Milan Sonka et al, "Image Processing, Analysis and Machine Vision," Brookes/Cole, Vikas Publishing House, 2nd edition, 1999.
9. Ravikanth Malladi, Geometric Methods in Bio-Medical Image Processing (Mathematics and Visualization), 1st Edition, Springer-Verlag Berlin Heidelberg 2002.
10. Joseph V. Hajnal, Derek L.G. Hill and David J. Hawkes, Medical Image Registration, CRC Press, 2001.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Understand fundamentals of image processing, including image perception, sampling, quantization, transforms, and image fidelity metrics.	-	-	-
CO2	Apply medical image enhancement and restoration techniques, including spatial and frequency domain filtering, noise reduction, and color image enhancement.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO3	Represent and analyze medical images using pixels/voxels, algebraic operations, grayscale/color models, DICOM and other formats, and evaluate image quality metrics (SNR, MTF).	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO4	Perform medical image analysis, segmentation, feature extraction, classification (statistical, rule-based, neural networks), image registration, and visualization using 2D/3D and volume rendering techniques.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3

BM25204	Soft Computing	L T P C 3 0 0 3
<p>Course Objectives: To introduce the concept of machine learning and learn and apply neural networks for pattern classification and regression problems. To introduce the ideas of fuzzy sets, fuzzy logic.</p>		
<p>Introduction to Machine Learning - Machine Learning – Basic Concepts in Machine Learning – Types of Machine Learning – Examples of Machine Learning – Applications – Linear Models for Regression – Linear Basis Function Models – The Bias - Variance Decomposition – Bayesian Linear Regression – Dimensionality Reduction.</p> <p>Neural Networks - Biological Neurons and their Artificial models, Learning Rules, Single Layer Perceptron Classifiers., Back Propagation Network, generalized delta rule, Associative Memory, Adaptive Resonance Theory (ART) Network Descriptions.</p> <p>Fuzzy Logic Systems - Fuzzy Logic System: Basic of fuzzy logic theory, crisp and fuzzy sets, Basic set operation like union, intersection, complement, T-norm, T-conorm, fuzzy relations, fuzzy if-then rules, fuzzy reasoning, Neuro-Fuzzy Modeling: Adaptive Neuro-Fuzzy Inference System (ANFIS), ANFIS architecture, Hybrid Learning Algorithm.</p> <p>Evolutionary Computation & Genetic Algorithms - Evolutionary Computation (EC) – Features of EC – Classification of EC – Advantages – Applications. Genetic Algorithms: Introduction – Biological Background – Operators in GA - GA Algorithm – Classification of GA – Applications.</p> <p>Advances and Applications - Support Vector Machines, RBF Network. Introduction to Deep Learning– Convolutional Neural Network. Case Study– Neural Network based Classification of Biosignal and Medical Images.</p>		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		
<p>References</p> <ol style="list-style-type: none"> 1. Tom M. Mitchell, "Machine Learning," McGraw-Hill Education (INDIAN EDITION), 2013 2. Ethem Alpaydin, "Introduction to Machine Learning," 2nd Ed., PHI Learning Pvt. Ltd., 2013. 3. T. Hastie, R. Tibshirani, J. H. Friedman, The Elements of Statistical Learning, Springer; 1st edition, 2001. 4. Wolfgang Ertel, "Introduction to Artificial Intelligence", Springer, 2nd Edition, 2017 5. Nello Cristianini, John Shawe-Taylor, "An Introduction to Support Vector Machines and Other Kernel-based Learning Methods," Cambridge University Press. 2013 6. Timothy Ross, "Fuzzy Logic with Engineering Applications," Wiley, 2016 7. David E. Goldberg, "Genetic Algorithms in search, Optimization & Machine Learning," Pearson Education, 2006 		

8. Neural Networks and Deep Learning by Michael Nielsen., March 2017.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamentals of machine learning, including supervised and unsupervised learning, linear regression, dimensionality reduction, and Bayesian approaches.	-	-	-
CO2	Apply artificial neural network techniques, including perceptrons, backpropagation networks, associative memory, and ART networks for classification and regression problems.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO3	Understand and implement fuzzy logic systems, including fuzzy sets, rules, reasoning, and neuro-fuzzy models like ANFIS with hybrid learning algorithms.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO4	Implement evolutionary computation techniques, genetic algorithms, support vector machines, RBF networks, and introductory deep learning (CNNs) for practical applications in biomedical signal and image classification.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3

BM25205	Biomedical Design and Modelling Laboratory	L T P C 0 0 4 2
<p>Course objectives:</p> <ul style="list-style-type: none"> • To understand various voltage protection circuits • To understand data acquisition and displaying systems. • To gain knowledge about various noise cancellation systems. • To understand the interfacing mechanism of DSP. <p>List Of Experiments:</p> <ol style="list-style-type: none"> 1. Modelling of lung mechanics 2. Modelling of cardiovascular system 3. Simulation and kinematic analysis of musculoskeletal model 4. LabVIEW based biosignal analysis 5. Design of implants/ Joints using FEM 6. Finite element analysis of blood vessels. 7. Stress strain analysis using FEM software. 		
<p>Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%</p>		
<p>Assessment Methodology: Project (30%), Assignment (10%), Practical (30%), Internal Examinations (30%)</p>		

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Apply modeling techniques to physiological systems such as lung mechanics and cardiovascular system.	PO1(3), PO2(3), PO3(2)	3	2
CO2	Perform simulation and kinematic analysis of musculoskeletal systems and biomedical implants using computational tools.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO3	Conduct biosignal acquisition, analysis, and noise cancellation using LabVIEW and DSP interfacing.	PO1(3), PO2(3), PO5(2)	3	3
CO4	Use Finite Element Method (FEM) to analyze stress, strain, and mechanical properties of implants, joints, and blood vessels.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3

Programme Elective Courses

BM25001	Rehabilitation Engineering	L T P C 3 0 0 3
Course Objectives:		
To learn the basics of rehabilitation engineering and study about principle of rehabilitation engineering. Understand different types of Therapeutic Exercise Technique and tests to assess the hearing loss and development techniques of electronic devices for visually and auditory impaired. To study about various orthopedic devices and prosthetic devices		
Introduction to Rehabilitation Rehabilitation: Epidemiology of Rehabilitation, Health, Levels of Prevention, Preventive Rehabilitation, Diagnosis of Disability, Functional Diagnosis, Importance of Psychiatry in Functional diagnosis, Impairment disability handicap, Primary & secondary Disabilities, Rehabilitation team Classification of members, The Role of Psychiatrist, Occupational therapist, Physical therapist, Recreation therapist, Prosthetist - Orthotist, Speech pathologist, Rehabilitation nurse, Social worker, Corrective therapist, Psychologist, Music therapist, Dance therapist & Biomedical engineer		
Principle of Rehabilitation Introduction, The Human Component, Principles of Assistive Technology Assessment, Principles of Rehabilitation Engineering- Key Engineering Principles, Key Ergonomic Principles - Practice of Rehabilitation and Assistive Technology.		
Therapeutic Exercise Technique - Co-ordination exercises, Frenkels exercises, Gait Analyses-Pathological Gaits, Gait Training, Relaxation exercises-Methods for training Relaxation, Strengthening exercises-Strength training, Types of Contraction, Mobilization exercises, Endurance exercises.		
Management of Communication & Virtual Reality -Impairment-introduction to communication, Aphasia, Types of aphasia, Treatment of aphasic patient, Augmentative communication-general form of communication, types of visual aids, Hearing aids, Types of conventional hearing aid, Writing aids. Introduction to virtual reality, Virtual reality-based rehabilitation, Hand motor recovery systems with Phantom haptics, Robotics and Virtual Reality Applications in Mobility Rehabilitation.		
Orthotic, Prosthetic Devices & Restoration Techniques - General orthotics, Classification of orthotics-functional & regional, General principles of Orthosis, Calipers-FO, AFO, KAFO, HKAFO. Prosthetic devices: Hand and arm replacement, Body powered prosthetics, Myoelectric controlled prosthetics and externally powered limb prosthetics. Functional Electrical Stimulation Systems-Restoration of hand function, restoration of standing and walking, Hybrid Assistive Systems (HAS).		
Specific Activity:		
<ul style="list-style-type: none"> • Design of Prosthetic and orthotic devices using software. 		
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%		
Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).		

References

1. Rory A Cooper, An Introduction to Rehabilitation Engineering, Taylor & Francis, CRC press, 2006.
2. Susan B O'Sullivan, Thomas J Schmitz, Physical Rehabilitation. 5th Edition, Davis publications, 2007.
3. Joseph D. Bronzino, The Biomedical Engineering Handbook, Third Edition: Three Volume Set, CRC Press, 2006
4. MacLachlan M. and Gallagher P. Enabling Technologies – Body Image and Body Function, Churchill Livingstone, 2004.
5. Mann W.C. (ed). Smart Technology for Aging, Disability, and Independence – The State of The Science, Wiley, New Jersey, 2005.
6. Muzumdar A. Powered Upper Limb Prostheses – Control, Implementation and Clinical Application. Springer, 2004.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Understand the principles of rehabilitation engineering, assistive technology, and the role of biomedical engineers in rehabilitation teams.	-	-	-
CO2	Analyze and apply therapeutic exercise techniques including coordination, gait training, relaxation, strengthening, mobilization, and endurance exercises.	PO1(3), PO2(3), PO5(2)	3	3
CO3	Develop knowledge of communication management and virtual reality applications for rehabilitation, including aphasia treatment, hearing aids, and virtual reality-based rehabilitation systems.	PO1(3), PO2(3), PO3(2), PO5(2)	3	3
CO4	Design and evaluate orthotic and prosthetic devices, including functional electrical stimulation systems, hybrid assistive systems, and software-based modeling of prostheses and orthoses.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3

BM25002	Medical Optics	L T P C 3 0 0 3
Course Objectives:		
To understand various optical properties of tissue and gain the knowledge of photonics instruments, practical applications of optics related to diagnostics applications. To acquire knowledge about therapeutic and surgical applications of lasers in medical fields and gain the knowledge of fiber optic sensors used in medical application		
<p>Optical Properties of The Tissues -Optical properties of tissue- melanin, bilirubin, tissue and their spectrum, optical characteristics of constituents of blood – RBC, hemoglobin properties, plasma, oxygenated and deoxygenated hemoglobin, Laser tissue Interaction-Chemical, Thermal, Electromechanical. Photo ablative processes. Laser safety procedures.</p> <p>Instrumentation In Photonics - Review of basic properties of light – Reflection, Refraction, Scattering, fluorescence and phosphorescence. Instrumentation for absorption, scattering and emission measurements. Optical sources – high pressure arc lamps, LEDs, Medical Lasers. Optical filters. Optical detectors - Time resolved and phase resolved detectors, optical tweezers.</p> <p>Diagnostic Applications - Wood’s lamp, Imaging techniques - Optical coherence tomography, Elastography, Fluorescence Imaging, Raman Imaging, FLIM, FRAP, NIRS-Application, X-Ray Diagnostic Techniques, Speckle Correlometry, Near-Field Imaging in Biological and Biomedical Applications.</p> <p>Therapeutic And Surgical Applications of Light - Phototherapy, Photodynamic therapy (PDT) - Principle and mechanism - Oncological and non- oncological applications of PDT - Bio stimulation effect – applications. Laser in tissue welding, lasers in dermatology, lasers in ophthalmology, otolaryngology, urology, neurology, orthopedics, gastroenterology.</p> <p>Fiber Optic Sensors and Applications -Light transport in the optical fiber - Total internal reflection, Numerical aperture, Angle of acceptance. losses in fiber, Optical sensors based on polarization, magnetic sensors, medical applications of fiber optic sensors in measuring temperature, pressure, flow and chemical activities.</p> <p>Specific Activity:</p> <ul style="list-style-type: none"> • Case Study - Medical applications of fiber optic sensors 		
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%		
Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).		

References

1. Mark E. Brezinski, "Optical Coherence Tomography: Principles and Applications", Academic Press, 2006.
2. Markolf H. Niemz, "Laser-Tissue Interaction Fundamentals and Applications", Springer, 2007.
3. Paras N. Prasad, "Introduction to Bio photonics, A. John Wiley and sons, Inc Publications,2003.
4. R. Splinter and B.A. Hooper, "An Introduction to Biomedical Optics", Taylor and Francis,2007.
5. Tuan Vo Dinh, "Biomedical photonics – Handbook", CRC Press LLC, 2003. .

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Understand optical properties of tissues, including absorption, scattering, and laser-tissue interactions.	-	-	-
CO2	Analyze photonics instrumentation for diagnostics, including optical sources, detectors, and measurement techniques.	PO1(3), PO3(3)	3	3
CO3	Apply optical techniques for medical diagnostics using imaging methods like OCT, Raman imaging, FLIM, and NIRS.	PO1(3), PO3(3), PO4(2)	3	3
CO4	Evaluate therapeutic and surgical applications of light, including phototherapy, photodynamic therapy, and laser-based interventions.	PO1(3), PO3(2)	3	2
CO5	Understand and apply fiber optic sensor technology in medical applications for measuring temperature, pressure, flow, and chemical activity.	PO1(3), PO4(3)	3	3

BM25003	Human Assist Devices	L T P C 3 0 0 3
<p>Course objectives: To know the principle and design of Heart lung machine, artificial heart and various cardiac assist devices. To study implantation of artificial kidney, prosthetic and orthotic devices for the disability and Gain knowledge in respiratory devices and hearing aids</p>		
<p>Heart Lung Machine and Artificial Heart - Condition to be satisfied by the H/L System. Different types of Oxygenators, Pumps, Pulsatile and Continuous Types, Monitoring Process, Shunting, The Indication for Cardiac Transplant, Driving Mechanism, Blood Handling System, Functioning and different types of Artificial Heart, Mock test setup for assessing its Functions.</p> <p>Cardiac Assist Devices - Synchronous Counter pulsation, assisted through Respiration Right Ventricular Bypass Pump, Left Ventricular Bypass Pump, Open Chest and closed Chest type, Intra-Aortic Balloon Pumping Venous Arterial Pumping, Prosthetic Cardiac Valves, Principle and problem, Biomaterials for implantable purposes, its characteristics and testing.</p> <p>Artificial Kidney -Indication and Principle of Hemodialysis, Membrane, Dialysate, Different types of hemodialyzers, Monitoring Systems, Wearable Artificial Kidney, Implanting Type.</p> <p>Prosthetic AND Orthotic Devices - Spinal orthotics and Prosthesis, Splint – Static and Dynamic. Hand and Arm Replacement - Different Types of Models Externally Powered Limb Prosthesis, Intelligent prosthesis, Lower Limb and Upper limb orthotic devices, Functional Electrical Stimulation, Sensory Assist Devices, Materials for Prosthetic and orthotic devices, Haptic Devices, Transcutaneous electrical nerve stimulator.</p> <p>Respiratory and Hearing AIDS-Ventilator and its types-Intermittent positive pressure, Breathing Apparatus Operating Sequence, Electronic IPPB unit with monitoring for all respiratory parameters. Types of Deafness, Hearing Aids, Construction and Functional Characteristics.</p> <p>Specific Activity:</p> <ul style="list-style-type: none"> • Review and present the research papers related to recent assist devices 		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		
<p>References</p> <ol style="list-style-type: none"> 1. Andreas.F.Von racum, Handbook of biomaterial evaluation, Mc-Millan publishers, 1980 2. Albert M.Cook and Webster J.G., Therapeutic Medical Devices, Prentice Hall Inc.,New Jersey,1982 		

3. Gray E Wnek, Gray L Browlin – Encyclopedia of Biomaterials and Biomedical Engineering –Marcel Dekker Inc New York 2004
4. John. G . Webster – Bioinstrumentation - John Wiley & Sons (Asia) Pvt Ltd - 2008
5. Kolff W.J., Artificial Organs, John Wiley and Sons, New York, 1979.
6. Gerr . M. Craddock “Assistive Technology-Shaping the future”, IOS Press, 1st edition, 2003.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Understand the principles, design, and functioning of heart-lung machines and artificial hearts.	-	-	-
CO2	Analyze cardiac assist devices, prosthetic cardiac valves, and implantable biomaterials for cardiovascular support.	PO1(3), PO3(3)	3	3
CO3	Evaluate artificial kidney systems, prosthetic and orthotic devices, and functional electrical stimulation systems for rehabilitation.	PO1(3), PO3(2), PO4(2)	3	2
CO4	Understand respiratory and hearing assist devices, including ventilators, IPPB units, and hearing aids, and their applications in patient care.	PO1(3), PO4(3)	3	3

BM25004	Micro and Nano Fluids	L T P C 3 0 0 3
Course Objectives:		
<p>To develop a broad and deep understanding of transport phenomena at the micro/nanoscale, understand major applications of micro/nanofluidics and major methods to fabricate micro/nanofluidic devices. Design and test new micro/nanofluidic devices for certain applications and the process of nano fluid preparation</p>		
<p>Introduction to Microfluidics - Microfluidics Versus Traditional Fluidics, properties of fluids, classification of fluids, pressure driven flow, continuity equation, momentum equation, equation of motion, laminar flow in circular conduits, fluid flow in micro conduits, in sub micrometer and nanoscale. Microscale fluid, expression for liquid flow in a channel - surface tension, contact angle and Electro Wetting, Navier Stokes equation. Electrokinetic phenomena- Electro-Osmosis, Di electrophoresis, Electric double layer, Debye length, capillary flow, flow through porous media, Diffusion.</p>		
<p>Fabrication Techniques - Polymer-Based Micromachining Techniques- Polymeric Surface Micromachining, Soft Lithography, Micro stereo Lithography, Micro molding., Hot embossing, Fluid interconnections.</p>		
<p>Components - Design considerations and applications – Micromixers, Microvalves, Micropumps, Microchannels, Microflow sensors. Droplet generators - Microparticle separator - Principles of separation and sorting of microparticles. Practical aspects of testing flow through microfluidic channels, Digital Microfluidics. Immunosensors - Nucleic acid sensors, DNA amplification platforms.</p>		
<p>Diagnostic Applications - In vitro diagnostics, Point - of - care diagnostics, Controlled drug delivery using microfluidic devices, Microneedles for drug delivery and monitoring, Microfluidic devices for cell manipulation, single-cell trapping, automated micro-robotic injection, Microfluidic devices for stem cell analysis and genetic analysis, paper-based microfluidic biomedical devices.</p>		
<p>Specific Activity:</p> <ul style="list-style-type: none"> • Case study: Introduction to Simulation Tools to design Microfluidic device. • Case Study: Experimental measurement of fluid velocity profiles through particle velocimetry. 		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		
<p>References:</p> <ol style="list-style-type: none"> 1. Tabeling, P., "Introduction to microfluidics," Oxford University Press Inc., 2005. 2. Osterbrock and van den Berg, "Lab-on-a-chip: Miniaturized Systems for (Bio) Chemical Analysis and Synthesis." Elsevier, 2003. 3. Gescheke et al, "Microsystems Engineering of Lab-on-a-Chip Devices". Wiley, 2004. 4. Nguyen, N. T., Werely, S. T., "Fundamentals and Applications of Microfluidics," Artech house Inc., 2002. 5. Madou, M. J., "Manufacturing Techniques for Microfabrication and Nanotechnology," Vol. 2, CRC Press, Boca Raton, FL, 2011. 6. Kirby, B. J., "Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic 		

Devices,” Cambridge University Press, 2010.

7. Chakraborty, S., “Microfluidics and microfabrication,” Springer, New York, NY, 2010.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Fundamentals of micro/nano fluidics, flow in micro/nano channels, electrokinetic phenomena	-	-	-
CO2	Fabrication techniques and design considerations of micro/nanofluidic devices	PO1(3), PO2(3), PO5(2)	3	3
CO3	Design, analysis, and operation of microfluidic components and droplet/microparticle systems	PO1(3), PO3(3), PO4(2)	3	2
CO4	Biomedical applications of micro/nanofluidics, diagnostic and experimental case studies	PO1(3), PO4(3), PO6(2)	3	3

BM25005	Medical Device Standards And Regulation	L T P C 3 0 0 3
<p>Course objectives: Understand standards and safety aspects of medical devices, hospital safety standards and maintenance and medical device regulations. Describe medical device risk assessment and regulatory requirements.</p>		
<p>Standards and safety - quality management system for medical devices (iso 9001 and iso13485), safety and standardization for risk management (iso 14971), european standard conformity (ce marking), fda guidelines for medical devices approval and classification based on risk assessment.</p> <p>Hospital safety standards -life safety standards- protecting hospital and occupants from fire, smoke, and heat, providing and maintaining fire alarm systems, systems for extinguishing fires environment of care standards-minimizing ec risks, smoking prohibitions, managing hazardous material and waste, maintaining fire safety equipment, features, testing, maintaining, and inspecting medical equipment.</p> <p>Medical equipment essential requirements -general requirements for basic safety & essential performance of medical equipment, iec 60601 standards- base standard-general requirement of electrical medical devices, collateral standards- emc radiation protection &programmable medical device system, particular standards-type of medical device.</p> <p>Medical device regulation -medical device and in vitro diagnostics: introduction & types of devices including combination devices. Medical device rules, 2017: implications on medical devices. Classification of medical devices. Labelling of medical devices and in vitro diagnostics.</p> <p>Medical device risk assessment -inspection of medical device and ivd establishments. Iso 14971 (medical devices: application of risk management to medical devices). Regulatory requirements of biocompatibility of medical devices and iso 10993. Clinical investigation of medical devices, regulation of investigational medical devices. Medical device regulation: international practices.</p> <p>Specific activity:</p> <ul style="list-style-type: none"> • Case study related to standards 		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		

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3. Joseph D. Nally (ed.), Good Manufacturing Practices for Pharmaceuticals, CRC Press sixth edition, 2007
4. <https://nptel.ac.in/courses/127106136>
5. MDR17, Regulation of Medical Devices,

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Quality management systems and standards (ISO 9001, ISO 13485, ISO 14971)	PO1(3), PO2(2), PO3(2)	3	2
CO2	Hospital safety standards, life safety, and equipment maintenance	PO1(3), PO4(2), PO6(2)	3	2
CO3	Medical device regulations, classification, CE marking, FDA guidelines	PO1(3), PO5(3), PO6(2)	3	3
CO4	Risk assessment, biocompatibility testing, clinical investigation, international regulatory practices	PO2(3), PO4(2), PO5(3)	3	3

BM25006	Tele Health Technology	L T P C 3 0 0 3
<p>Course Objectives: To teach the key principles for telemedicine and telemedical technology, telemedical standards. design and develop m-Health platforms for telemedical applications. Diagnosis the applications of health care sectors</p>		
<p>Telemedicine and Health History and Evolution of telemedicine, Functional diagram of telemedicine system, Telemedicine, Tele health, Tele care, Organs of telemedicine, Global and Indian scenario, International regulations in e-health and telemedicine, Ethical and legal aspects of Telemedicine - Confidentiality, Social and legal issues, Safety and regulatory issues, Advances in Telemedicine.</p>		
<p>Telemedical Technology Principles of Multimedia - Text, Audio, Video, data, Data communications and networks, PSTN, POTS, ANT, ISDN, Internet, Air/ wireless communications: GSM satellite, and Micro wave, Modulation techniques, Types of Antenna, Integration and operational issues, Communication infrastructure for telemedicine – LAN and WAN technology. Satellite communication. Mobile hand held devices and mobile communication. Internet technology and telemedicine using world wide web (www). Video and audio conferencing. Clinical data –local and centralized</p>		
<p>Telemedical Standards Security and Legal Issues Data Security and Standards: Encryption, Cryptography, Mechanisms of encryption, phases of Encryption. Protocols: TCP/IP, ISO-OSI, Standards to followed DICOM, HL7, H. 320 series (Video phone based ISBN) T. 120, H.324 (Video phone based PSTN), Video Conferencing, Realtime Telemedicine integrating doctors / Hospitals, Clinical laboratory data, Radiological data, and other clinically significant biomedical data, Administration of centralized medical data, security and confidentially of medical records and access control, Cyber laws related to telemedicine.</p>		
<p>m-Health and Telemedicine Mobile Devices : Smart phones, Tablet PCs, iPads, PDAs, Wearable computers – m-Health technology and communication infrastructure - Healthcare Apps – m-Health applications: Education and awareness, Remote data collection, Remote monitoring, Communication and training for healthcare workers, Disease and epidemic outbreak tracking, Diagnostic and treatment support – m-Health and the Transformation of Clinical Trials - Harnessing data, advanced analytics, and the Internet of Things to optimize digitized clinical trials</p>		
<p>Telemedical Applications Telemedicine access to health care services – health education and self-care. · Introduction to robotics surgery, telesurgery. Telecardiology, Teleoncology, Telemedicine in neurosciences, Electronic Documentation, e-health services security and interoperability., Telemedicine access to health care services– health education and self-</p>		

care, Business aspects - Project planning and costing, Usage of telemedicine. Telemedicine and in loco assistance of patients, Interactive videoconferencing consults, Store and forward consults, Remote monitoring and home care

References

1. Wootton, R., Craig, J., Patterson, V. (Eds.), Introduction to Telemedicine. Royal Society of Medicine Press Ltd (ISBN 1853156779), 2006.
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3. David Dagan Feng, Biomedical Information Technology, Academic Press Series in Biomedical Engineering, Elsevier Inc, USA, 2008
4. Ilias G. Maglogiannis, Kostas Karpouzis and Manolis Wallace, Image and Signal Processing for Networked E-Health Applications, Morgan & Claypool Publishers' series, USA, 2006
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6. Bommel, J.H. van, Musen, M.A. (Eds.) (1997). Handbook of Medical Informatics. Heidelberg, Germany: Springer. (ISBN 3-540-63351-0).
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Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Principles, evolution, ethics, and regulations of telemedicine	PO1(3), PO2(2), PO4(2)	3	2
CO2	Telemedical technologies, multimedia communication, network and mobile infrastructure	PO1(3), PO3(3), PO5(2)	3	2
CO3	Telemedical standards, data security, encryption, interoperability protocols	PO2(3), PO4(3), PO5(3)	3	3
CO4	Design and implementation of m-Health platforms and telemedicine applications	PO3(3), PO6(3), PO7(2)	3	3

BM25007	Medical Robotics	L T P C 3 0 0 3
<p>Course objectives:</p>		
<p>To explain the basic concepts of robots and types of robots and design of manipulators, actuators and grippers. To impart knowledge on various types of sensors and power sources and explore various applications of Robots in Medicine and impart knowledge on wearable robots</p>		
<p>Introduction To Robotics - Introduction to Robotics, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Dynamic Stabilization.</p>		
<p>Sensors and Actuators Sensors and controllers, Internal and external sensors, position, velocity and acceleration sensors, Proximity sensors, force sensors Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, PD and PID feedback actuator models.</p>		
<p>Manipulators & Basic Kinematics Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and pneumatic manipulator, Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems. Navigation and Treatment Planning -Variable speed arrangements, Path determination – Machinery vision, Ranging – Laser – Acoustic, Magnetic, fiber optic and Tactile sensor.</p>		
<p>Surgical Robots -Da Vinci Surgical System, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump, CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric and General Surgery, Gynecologic Surgery, General Surgery and Nanorobotics. Case Study.</p>		
<p>Rehabilitation and Assistive Robots - Pediatric Rehabilitation, Robotic Therapy for the Upper Extremity and Walking, Clinical-Based Gait Rehabilitation Robots, Motion Correlation and Tracking, Motion Prediction, Motion Replication. Portable Robot for Tele rehabilitation, Robotic Exoskeletons – Design considerations, Hybrid assistive limb. Case Study.</p>		
<p>Wearable Robots - Augmented Reality, Kinematics and Dynamics for Wearable Robots, Wearable Robot technology, Sensors, Actuators, Portable Energy Storage, Human–robot cognitive interaction (cHRI), Human–robot physical interaction (pHRI), Wearable Robotic Communication.</p>		
<p>Specific Activity:</p>		
<p>Case study, recent trends in robotics-soft robots.</p>		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		

References

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2. Spong and Vidyasagar, "Robot Dynamics and Control," John Wiley and Sons, First edition, 2008
3. Fu.K.S, Gonzalez. R.C., Lee, C.S.G, "Robotics, control," sensing, Vision and Intelligence, Tata McGraw Hill International, First edition, 2008.
4. Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics, 1st Edition, Springer,2008
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CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Basics of robots, configurations, DOF, workspace, robot subsystems	PO1(3), PO2(2), PO3(2)	3	2
CO2	Design of manipulators, actuators, grippers, sensors, and kinematics	PO2(3), PO3(3), PO5(2)	3	3
CO3	Applications of medical robots: surgical, rehabilitation, assistive systems	PO3(3), PO6(3), PO7(2)	3	3
CO4	Wearable robotics, human–robot interaction, AR integration, soft robots	PO4(3), PO6(3), PO7(3)	3	3

BM25008	Wearable Technologies	L T P C 3 0 0 3
<p>Course objectives: Identify the motivation, guiding principles, and challenges of Wearable Computing and develop skills pertaining to the design of a holistic interactive wearable system comprising of the physical, digital, and the human aspects.</p>		
<p>Introduction - Attributes of wearables, Meta-wearable, Challenges and opportunities, Future of wearables - Social aspects of wearability and interaction: Social interpretation of Aesthetics - Case study: Google glass - Wearable haptics: Need for wearable haptic devices - Categories of wearable haptic and tactile display – Wearable sensorimotor enhancer.</p>		
<p>Wearable Sensors - Application areas - Inertia sensors, Parameters from inertia sensors - Applications for wearable motion sensors, Biochemical sensors –</p>		
<p>Flexible Electronics - Introduction, Thin-film transistors: Materials and Technologies, Review of Semi-conductors in flexible electronics - Low-power Integrated Circuit Design for Bio-potential sensing: Analog circuit design techniques - Low- power design for ADCs - Digital circuit design techniques - Architectural design for low-power bio-potential acquisition, Practical considerations.</p>		
<p>Energy Harvesting Systems - Energy harvesting from human body: Temperature gradient, Foot motion - Wireless energy transmission - Energy harvesting from light and RF energy - Energy and power consumption issues, Future considerations.</p>		
<p>Monitoring Physical and Physiological Parameters Physical measurement: Cardiovascular diseases, Neurological diseases, Gastrointestinal diseases - Wearable and non-invasive assistive technologies: Assistive devices for individuals with severe paralysis, Wearable tongue drive system, Sensor signal-processing algorithm, Dual-mode tongue drive system.</p>		
<p>Specific Activity:</p> <ul style="list-style-type: none"> • Design of Wearable sensors for physiological signal measurement 		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		
<p>References</p> <ol style="list-style-type: none"> 1. Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications", Academic Press, USA, 2014. 2. Tom Bruno , "Wearable Technology: Smart Watches to Google Glass for Libraries", Rowman & Littlefield Publishers, Lanham, Maryland, 2015. 3. Raymond Tong , "Wearable Technology in Medicine and Health Care", Academic Press, USA, 2018. 4. Haider Raad , "The Wearable Technology Handbook", United Scholars Publication, USA, 2017. 		

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CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Fundamentals of wearable computing: attributes, challenges, social aspects, wearable haptics, and case studies	-	-	-
CO2	Wearable sensors, flexible electronics, and low-power bio-potential acquisition circuit design	PO1(3), PO2(3), PO5(2)	3	2
CO3	Energy harvesting techniques and power management strategies for wearable systems	PO1(3), PO3(2), PO7(3)	2	2
CO4	Monitoring physical and physiological parameters and design of wearable sensors for biomedical applications	PO2(3), PO3(3), PO4(2), PO5(2)	3	3

BM25009	Medical Ethics and Standards	L T P C 3 0 0 3
<p>Course objectives: Achieve familiarity with some basic ethical frameworks & understand how these ethical frameworks can help us to think through contemporary questions in medical ethics. Students will be able to know about the legal and ethical principles and apply these principles in health care settings & gain knowledge about the medical standards that are to be followed in hospitals.</p>		
<p>Introduction to Medical Ethics - Definition of Medical ethics, Scope of ethics in medicine, American Medical Association code of ethics, CMA code of ethics-Fundamental Responsibilities, The Doctor and The Patient, The Doctor and The Profession, Professional Independence, The Doctor and Society.</p> <p>Ethical Theories & Moral Principles - Theories-Deontology & Utilitarianism, Casuist theory, Virtue theory, The Right Theory. Principles- Non- Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, Bioethical issues in Human Genetics & Reproductive Medicine.</p> <p>Hospital Accreditation Standards - Accreditation- JCI Accreditation & its Policies. Patient Organization management standards.</p> <p>Hospital Safety Standards - Life Safety Standards- Protecting Occupants and Hospital from Fire, Smoke, and Heat, Providing and Maintaining Fire Alarm Systems, Systems for Extinguishing Fires Environment of Care Standards-Minimizing EC Risks, Smoking Prohibitions, Managing Hazardous Material and Waste, Maintaining Fire Safety Equipment, Features, Testing, Maintaining, and Inspecting Medical Equipment.</p> <p>Medical Equipment Safety Standards - General requirements for basic safety & essential performance of medical equipment. IEC 60601 standards, Indian and International standards, ISO standards - Base Standard-general requirement of electrical medical devices, Collateral Standards- EMC radiation protection & programmable medical device system, Particular Standards-type of medical device.</p> <p>Specific Activity:</p> <ul style="list-style-type: none"> • Case study on general requirements for basic safety of medical equipment 		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		
<p>References</p> <ol style="list-style-type: none"> 1. Domiel A Vallero, Biomedical Ethics for Engineers, Elsevier Pub.1st edition, 2007 2. Johnna Fisher, Biomedical Ethics: A Canadian Focus., Oxford University Press Canada, 2009. 3. Robert M Veatch, The Basics of Bio Ethics, 3rd Edition. Routledge, 2011. 		

4. Physical Environment Online: A Guide to The Joint Commission's Safety Standards is published by HCPro, Inc. 2010
5. Joint Commission Accreditation Standards for Hospitals, 6th Edition 2018.
6. Ben Mepham, Bioethics-An Introduction for the biosciences, 2nd Edition, Oxford University Press, 2008.
7. Nils Hoppe and Jose Miola - Medical law and Medical Ethics - Cambridge University Press-2014

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain fundamental concepts of medical ethics, ethical theories, moral principles, and professional responsibilities in healthcare practice	-	-	-
CO2	Analyze ethical issues in medical practice, biomedical research, human genetics, and confidentiality in healthcare settings	PO2(3), PO6(3), PO8(3)	2	2
CO3	Describe hospital accreditation and safety standards including JCI policies, life safety, and environment of care standards	PO1(3), PO6(2), PO7(2)	2	2
CO4	Interpret and apply medical equipment safety standards (IEC 60601, ISO, Indian & International standards) through case studies	PO2(3), PO3(2), PO5(2), PO8(2)	3	3

BM25010	Brain Computer Interface	L T P C 3 0 0 3
Course objectives:		
<p>The objective of this course is to enable the student to understand the basic concepts of brain computer interface and explore the various signal acquisition methods, signal processing methods used in BCI. Understand the various machine learning methods of BCI and Learn the various applications of BCI.</p>		
<p>Introduction to BCI - Introduction - Brain structure and function, Brain Computer Interface Types - Synchronous and Asynchronous -Invasive BCI -Partially Invasive BCI - Non Invasive BCI, Structure of BCI System, BCI Monitoring Hardware, EEG, MEG, fMRI.</p>		
<p>Brain Activation - Brain activation patterns - Oscillatory potential and ERD, Slow cortical potentials, Movement related potentials-Mu rhythms, motor imagery, Stimulus related potentials – Visual Evoked Potentials – P300 and Auditory Evoked Potentials.</p>		
<p>Feature Extraction Methods - Data Processing – Spike sorting, Frequency domain analysis, Wavelet analysis, Time domain analysis, Spatial filtering -Principal Component Analysis (PCA), Independent Component Analysis (ICA), Artefacts reduction, Feature Extraction - Phase synchronization.</p>		
<p>Machine Learning Methods for BCI - Classification techniques –Binary classification, Multiclass Classification, Evaluation of classification performance, Regression - Linear, Polynomial, RBF's, Support vector machine, Graph theoretical functional connectivity analysis.</p>		
<p>Applications of BCI -Case Studies - Invasive BCIs: decoding and tracking arm (hand) position, controlling prosthetic devices such as orthotic hands, Cursor and robotic control using multi electrode array implant, Cortical control of muscles via functional electrical stimulation. Ethics of Brain Computer Interfacing.</p>		
<p>Specific Activity:</p>		
<p>Case Studies - Invasive BCIs: decoding and tracking arm (hand) position</p>		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		

References

1. Rajesh P.N. Rao, Brain-Computer Interfacing: An Introduction, Cambridge University Press, 1st Edition, 2013.
2. Ella Hassianien A and Azar A.T Ed, Brain-Computer Interfaces Current Trends and Applications, Springer, 2015.
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4. Bernhard Graimann, Brendan Allison and Gert Pfurtscheller, Brain-Computer Interfaces: Revolutionizing Human-Computer Interaction, Springer, 2010
5. Ali Bashashati, Mehrdad Fatourehchi, Rabab K Ward and Gary E Birch, A survey of signal Processing algorithms in brain-computer interfaces based on electrical brain signals, Journal of Neural Engineering, Vol.4, 2007, pp.32-57.
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7. Bishop C.M., Neural networks for Pattern Recognition, Oxford, Clarendon Press, 1995.
8. Andrew Webb, Statistical Pattern Recognition, Wiley International, 2nd Edition, 2002

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamentals of Brain Computer Interface systems including brain physiology, BCI types, and signal acquisition methods (EEG, MEG, fMRI)	-	-	-
CO2	Analyze brain activation patterns and apply signal processing and feature extraction techniques for BCI applications	PO2(3), PO4(2), PO5(3)	3	2
CO3	Apply machine learning and classification methods for BCI signal interpretation and performance evaluation	PO2(3), PO3(3), PO5(3)	3	3

BM25011

Wavelet Transforms and Applications

L T P C

3 0 0 3

Course objectives:

To study the basics of signal representation and Fourier theory, Multi Resolution Analysis and Wavelet concepts in both continuous and discrete domain. To understand the design of wavelets using Lifting scheme and applications of Wavelet transform

Fundamentals -Vector Spaces – Properties– Dot Product – Basis – Dimension, Orthogonality and Orthonormality – Relationship Between Vectors and Signals – Signal Spaces –Concept of Convergence – Hilbert Spaces for Energy Signals- Fourier Theory: Fourier series expansion, Fourier transform, Short time Fourier transform, Time-frequency analysis.

Multi Resolution Analysis -Definition of Multi Resolution Analysis (MRA) – Haar Basis – Construction of General Orthonormal MRA – Wavelet Basis for MRA – Continuous Time MRA Interpretation for the DTWT – Discrete Time MRA – Basis Functions for the DTWT – PRQMF Filter Banks.

Continuous Wavelet Transforms- Wavelet Transform – Definition and Properties – Concept of Scale and its Relation with Frequency – Continuous Wavelet Transform (CWT) – Scaling Function and Wavelet Functions(Daubechies Coiflet, Mexican Hat, Sinc, Gaussian, Bi Orthogonal)– Tiling of Time – Scale Plane for CWT.

Discrete Wavelet Transform - Filter Bank and Sub Band Coding Principles – Wavelet Filters – Inverse DWT Computation by Filter Banks – Basic Properties of Filter Coefficients – Choice of Wavelet Function Coefficients – Derivations of Daubechies Wavelets – Mallat's Algorithm for DWT –Multi Band Wavelet Transforms Lifting Scheme-Wavelet Transform Using Polyphase Matrix Factorization – Geometrical Foundations of Lifting Scheme – Lifting Scheme in Z –Domain.

Applications - Wavelet methods for signal processing- Adaptive wavelet techniques in signal acquisition, Detection of signal changes, analysis and classification of audio signals using CWT, Signal and Image compression Techniques: EZW–SPIHT Coding– Image Denoising Techniques: Noise Estimation – Shrinkage Rules – Shrinkage Functions –Edge Detection and Object Isolation, Image Fusion, and Object Detection. Wavelet based signal de-noising and energy compaction, Wavelets in adaptive filtering, Digital Communication and Multicarrier Modulation, Trans multiplexers.

Specific Activity:

- Wavelet based signal de-noising using software

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References:

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6. Soman K P and Ramachandran K I, Insight into Wavelets From Theory to practice, Prentice Hall, 2010.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain fundamentals of signal spaces, Fourier theory, and time–frequency analysis concepts	-	-	-
CO2	Analyze Multi Resolution Analysis (MRA), Continuous and Discrete Wavelet Transforms, and lifting schemes	PO1(3), PO2(3), PO4(2)	3	2
CO3	Design and implement wavelet transforms using filter banks and lifting schemes for signal processing applications	PO3(3), PO4(2), PO5(3)	3	2
CO4	Apply wavelet techniques for signal and image processing applications such as denoising, compression, detection, and adaptive filtering using software tools	PO3(3), PO5(3), PO12(2)	3	3

BM25012	Hospital Planning Organization and Management	L T P C 3 0 0 3
<p>Course Objectives: With an objective of imbibing a professional approach amongst students towards hospital management and encompasses management principles, staffing and marketing processes, discussing their significance and role in the effective and efficient management of health care organizations.</p>		
<p>Forms of Organisation - Sole proprietorship, Partnership, Company-public and private sector enterprises, Principles of management, Evolution of management.</p>		
<p>Hospital Administration and Management - Healthcare and Management, Functions of management, Healthcare delivery systems in India and globally, public vs private healthcare, Levels of care (primary, secondary, tertiary) Challenges in Hospital Administration, Hospital Planning, Design, and layout of hospitals. Equipment Planning, Facility and biomedical equipment planning, Legal Aspects of Hospital Administration, Strategic planning.</p>		
<p>Staffing - Staffing pattern in hospitals, Selection, Recruiting process, Training of staff, Organizational structures, Career development.</p>		
<p>Marketing and Management - Basic concepts marketing, Principles of social marketing, Social marketing in the health sector, Consumer behavior and research health, Advertising in Health Sector, Relevance of e-marketing of Health care services.</p>		
<p>Hospital Technical Support Services - HIS Technical Support, Management Decisions and Related Information Requirement, Administrative Information Systems, Support Service Technical Information Systems, Medical Transcription, Medical Records Department, Network Support, IT Infrastructure Support Medical Device Support, the Importance of Technical Support.</p>		
<p>Specific Activity:</p> <ul style="list-style-type: none"> • Assignment – Submission of Plan of Hospital 		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		
<p>References</p> <ol style="list-style-type: none"> 1. Goyal R.C., Human Resource Management in Hospital, Prentice Hall of India Pvt. Ltd.,New Delhi, 2000. 2. Nauhria R.N. and Rajnish Prakash, Management & systems, New Delhi Wheeler publishing, 1995. 3. Koontz, Essentials of Management, McGraw Hill, 1995. 4. G. D. Kunders Hospitals: Facilities Planning and Management, Tata McGrawHill Education, New Delhi, 2004 5. Syed Amin Tabish, Hospitals & Nursing Homes: Planning, Organisations & Management, Jaypee Brothers Medical Publishers (P) Limited, 2003 		

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain principles of management, forms of organization, and healthcare delivery systems in India and globally	-	-	-
CO2	Analyze hospital planning, administration, equipment planning, legal aspects, and strategic management in healthcare organizations	PO2(3), PO3(2), PO6(3), PO11(3)	2	2
CO3	Apply staffing, marketing, and organizational management concepts in hospital settings	PO3(3), PO9(2), PO10(2), PO11(3)	1	2
CO4	Develop a comprehensive hospital plan incorporating infrastructure, biomedical equipment planning, and technical support services	PO3(3), PO5(2), PO11(3), PO12(2)	2	3

BM25013	Human Resource Management in Hospitals	L T P C
		3 0 0 3

Course Objectives:

This subject acquaints the students with major functions of HRM aligned with the business strategy. The subject encompasses the concept of best fit employee, training & executive development, sustaining employee interest and performance appraisal

Perspectives of Human Resource Management - Evolution of Human Resource Management - Importance of Human factor, Objectives of Human Resource Management - Human Resource Policies - Need for HRD/HRM in Healthcare Organization - Computer Applications in Human Resource Management.

The Concept of Best Fit Employee - Organizational Job Design - job description - job analysis - job rotation-job evaluation- Man- power planning- Importance of Human Resource Planning, Forecasting of Human Resource Requirements - Selection procedures - test, Validation, Interviews, Recruitment, Medical Examination.

Training & Executive Development -Types of Training methods and their benefits - Executive development Programme - common practices - Benefits, self-development - knowledge Management.

Sustaining Employee Interest- Wage and Salary Administration – the concept of incentives and its operational implications – Participative decision making – Concept of Collective Bargaining – Compensation plans – Rewards – Motivation – Theories of motivation - Grievances and redressal methods.

Performance Appraisal - Importance of Performance Appraisal - Methods of Performance Evaluation, - Traditional methods – Modern methods – Feedback – Promotion – Demotion – transfer. Implications of jobs change. The control process, Methods and Requirements of an Effective control system.

Specific Activity:

- Case study - Computer Applications in Human Resource Management

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References

1. R.C.Goyal, Human Resource Management in Hospitals, Prentice Hall of India, 2000.
2. Mamoria C.B. and Mamoria S. Personnel Management, Himalaya Publishing Company, 1997.
3. Decenzo and Robbins, Human Resource Management, Wiley & Sons, Singapore, 1999.
4. D. K. Sharma, R. C. Goyal, Hospital administration and human resource management, PHI Learning Pvt. Ltd., 2013
5. Walter J. Flynn (Author), Robert L. Mathis (Author), John H. Jackson, Healthcare Human Resource Management, 2006.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain principles, evolution, and importance of Human Resource Management (HRM) in healthcare organizations including HR policies and computer applications	-	-	-
CO2	Apply job design, manpower planning, recruitment, and selection procedures for achieving best fit employees in hospitals	PO2(3), PO3(2), PO11(3)	1	2
CO3	Analyze training, executive development programs, motivation theories, compensation plans, and participative management practices	PO2(2), PO9(2), PO11(3), PO12(2)	1	2
CO4	Evaluate performance appraisal methods and control systems for effective human resource management in hospitals	PO2(3), PO3(2), PO10(2), PO11(3)	1	2

BM25014	Health Policy and Equipment Management	L T P C 3 0 0 3
<p>Course objectives: To expose the students for planning and operation of hospitals in a detailed manner which will include all facts of hospital planning activities covering every department that is involved both in clinical care as well as supportive services and introduce the equipment maintenance.</p>		
<p>Health System Health organization of the country, the state and cities, health financial system, teaching cum research hospitals, General Hospital, PHC reference system, Ambulatory Care.</p> <p>National Health Policy - Need for evaluating a health policy, need for providing primary health care, health education, health insurance, health legislation, inter-sectoral cooperation.</p> <p>Equipment Maintenance Management - Organizing the maintenance operation, biomedical equipment procurement procedure, proper selection, compatibility, testing and installation, purchase and contract procedure, trained medical staff, on the proper use of the equipment and operating instructions. Maintenance job planning, preventive maintenance, maintenance budgeting, contract maintenance.</p> <p>Logistic Support & Reliability - Maintenance equipment and Tools, failure analysis, spare parts, and maintenance materials. Reliability fundamentals.</p> <p>EMI In Hospital Equipment -Principles of EMI, computation of EMI, Method of suppressing and isolating the unit from interference.</p>		
<p>Specific Activity:</p> <ul style="list-style-type: none"> • Seminar – Maintenance of equipment 		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		
<p>References</p> <ol style="list-style-type: none"> 1. Antony Kelly, 'Maintenance Planning & control' Butterworth, London 1984. 2. Binseng Wang, Medical Equipment Maintenance: Management and Oversight, Morgan & Claypool Publishers, 2012 3. Hans Pleiff veradamann (ed) 'Hospital Engineering in developing countries, GTZ report Eschborn, 1986. 4. Medical Equipment Management, Keith Willson, Keith Ison, Slavik Tabakov CRC Press, 2013 5. R.C.Goyal 'Human Resource Management in Hospitals' Prentice Hall of India, New Delhi, 2000. 		

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the structure of health systems, national health policy, health financing, and primary healthcare delivery mechanisms	-	-	-
CO2	Analyze health policies, healthcare legislation, insurance systems, and inter-sectoral cooperation in hospital administration	PO2(3), PO6(3), PO8(2), PO11(2)	1	2
CO3	Apply principles of biomedical equipment procurement, maintenance management, preventive maintenance, budgeting, and contract management	PO3(3), PO5(2), PO11(3)	3	3
CO4	Evaluate reliability, logistics support systems, EMI issues, and failure analysis in hospital equipment management	PO2(3), PO4(2), PO5(2), PO7(2)	3	3

BM25015	Hospital Waste Management	L T P C 3 0 0 3
<p>Course Objectives: To understand the significance of infections, biomedical waste and its proper disposal and learn about the controls applied to waste management.</p>		
<p>Introduction - Medical waste stream, different types of medical waste, its source of origin. Waste management elements – categories of bio-medical waste, different colour codes and symbols –rules and regulation includes state and national level bodies.</p>		
<p>Principles of Sterilization - Disease and its mode of transmission - Disinfection methods- concept and mechanism – physical sterilization and chemical sterilization – Large scale autoclave - Microwave (Non-burn treatment technology).</p>		
<p>Disposal of Waste - Disposal methods – Incinerator and its types-hazardous waste, radioactive waste, liquid waste destruction – landfill and rules governing landfill.</p>		
<p>Controls Applied to Waste Management - Air pollution and emission control, rules governing pollution, instrumentation and monitoring, emission filters and its types, crematories- gas emission control device.</p>		
<p>Environmental Safety, Risks & Public Issues - Risk management in hospitals - Environment issues in hospitals - Risk analysis.</p>		
<p>Specific Activity:</p> <ul style="list-style-type: none"> • Case studies related to air pollution. 		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		
<p>References</p> <ol style="list-style-type: none"> 1. C.R. BRUNNER, Medical Waste 2. C.R. BRUNNER, Incentrated Consultant in Corporated Incentration System Hand Book, Virginia. 		

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain biomedical waste categories, regulations, color coding, and legal frameworks governing hospital waste management	-	-	-
CO2	Analyze principles of sterilization, disinfection methods, and disease transmission control in healthcare settings	PO2(3), PO6(2), PO7(2)	2	2
CO3	Evaluate waste disposal techniques including incineration, landfill management, hazardous and radioactive waste treatment	PO2(3), PO3(2), PO7(3)	2	2
CO4	Assess environmental safety, air pollution control measures, emission monitoring systems, and risk management strategies in hospitals	PO2(3), PO4(2), PO7(3), PO6(2)	2	2

BM25016	Quality assurance and Patients Safety Standards in hospitals	L T P C 3 0 0 3
<p>Course Objectives: To provide basic knowledge on the concept of Healthcare Quality management towards continuous improvement of patient care and aware of the role of the biomedical engineer in hospitals, especially in the management of electrical supply, maintenance of electrical safety.</p>		
<p>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 equipment.</p>		
<p>Regulatory Requirement for Health Care- FDA regulations, Accreditation for hospitals - JCI, NABH and NABL, Other regulatory Codes.</p>		
<p>Hospital Safety - Security & Safety of Hospital -Property, Staff & Patients, Radiation safety, Safety precautions, hazardous effects of radiation, allowed levels of radiation, ICRP regulations for radiation safety, Disposal of Biological waste.</p>		
<p>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 a Hospital.</p>		
<p>Assessing Quality Health Care -Patient Safety Organization- Governmental & Independent, Measuring Quality care – Evaluation of hospital services – six sigma way, Quality Assurance in Hospitals Sop's – Patient Orientation for Total Patient Satisfaction. 5S technique</p>		
<p>Specific Activity:</p>		
<p>Case Study - causes of fire and fire safety.</p>		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the principles of quality management, standardization, and total quality management (TQM) in healthcare	-	-	-
CO2	Analyze regulatory requirements, hospital accreditation (JCI, NABH, NABL), and compliance standards in healthcare	PO2(3), PO6(3), PO8(2)	2	2
CO3	Evaluate hospital safety, radiation safety, electrical and fire hazards, and implement safety precautions	PO2(3), PO3(2), PO6(3), PO7(3)	2	2
CO4	Apply patient safety and quality assessment tools (SOPs, 5S, Six Sigma) to improve hospital services and ensure patient satisfaction	PO3(3), PO4(2), PO5(2), PO12(2)	2	2

BM25017	Genetic Algorithms and Fuzzy Logics	L T P C 3 0 0 3
<p>Course objectives: To provide basic knowledge about the fundamentals of genetic algorithm familiarizewiththeantcolonyandparticleswamoptimizationtechniques, basics of fuzzy logic and its applications and neuro fuzzy system and fuzzy logic controller</p>		
<p>Genetic Algorithms Introduction, Building block hypothesis, working principle, Basic operators and Terminologies like individual, gene, encoding, fitness function and reproduction, Genetic modeling: Significance of Genetic operators, Inheritance operator, crossover, inversion & deletion, mutation operator, Bitwise operator, GA optimization problems, Applications of GA.</p> <p>Other Optimization Techniques - Ant Colony Optimization: Introduction – From real to artificial ants- Theoretical considerations – Particle Swarm Optimization: Introduction– Principles of bird flocking and fish schooling–Evolution of PSO – Operating principles – PSO Algorithm.</p> <p>Fuzzy Logic - Introduction to Fuzzy Logic, Classical and Fuzzy Sets, Membership Function, Operations on Fuzzy Sets, Fuzzy Arithmetic, Compliment, Intersections, Unions, Fuzzy Relation.</p> <p>Fuzzy Rule Based System - Linguistic Hedges. Rule based system, Fuzzification and Defuzzification, Fuzzy inference systems - Mamdani and Sugeno model, Fuzzy clustering - fuzzy C-means algorithm - fuzzy control method- fuzzy decision making.</p> <p>Advances and Applications -Case studies: Fuzzy logic control of Blood pressure during Anaesthesia, Fuzzy logic application to Biosignals and medical Image processing, Adaptive fuzzy system. Introduction to Neuro-fuzzy logic.</p> <p>Specific Activity:</p> <ul style="list-style-type: none"> • Algorithm development - Fuzzy logic application to Biosignals and medical Image processing 		
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		
<p>References</p> <ol style="list-style-type: none"> 1. Marco Dorigo and Thomas Stutzle, “Ant Colony optimization”, Prentice Hall of India, New Delhi, 2004. 2. David E. Goldberg, “Genetic Algorithms in search, Optimization & Machine Learning”, Pearson Education, 2006 3. Kenneth A DeJong, “Evolutionary Computation A Unified Approach”, Prentice Hall of India, New Delhi, 2006 4. H.-J. Zimmermann, “Fuzzy Set Theory and its Applications”, Springer Science+Business Media New York, 4th edition, 2001 5. Timothy Ross, “Fuzzy Logic with Engineering Applications”, Wiley, 2016 		

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamentals of Genetic Algorithms, optimization techniques, and terminology including operators, fitness function, and modeling	-	-	-
CO2	Analyze Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO) principles and their applications	PO2(3), PO3(2), PO5(2)	3	2
CO3	Apply fuzzy logic concepts, classical vs fuzzy sets, membership functions, and fuzzy arithmetic to real-world problems	PO3(3), PO5(3), PO12(2)	3	3
CO4	Design and implement fuzzy rule-based systems, neuro-fuzzy models, and fuzzy logic applications in biomedical signals and medical image processing	PO3(3), PO4(2), PO5(3), PO12(3)	3	3

BM25018	Tissue Engineering	L T P C 3 0 0 3
<p>Course objectives: To understand basics of tissue engineering, cell mechanics and importance of biomaterials in tissue engineering. To understand the importance of stem cell in tissue engineering and tissue culture applications in human healthcare</p>		
<p>Introduction to Tissue Engineering - History and scope of tissue engineering – Scientific and Social Challenges - Structure and organization of Tissues – Development of Tissue – Cell and Extracellular matrix interaction – Morphogenesis and Tissue Engineering – Cell Determination and Differentiation.</p> <p>Fundamentals of Cell Mechanisms - .Cell adhesion, Cell migration and Cell aggregation – Cell growth and Cell cycle. Cellular Interactions: Cell – Cell and Cell – Matrix. Control of Cell migration in Tissue Engineering –Cell delivery and Recirculation – Cell Culture in vitro – 3D culture in Tissue Engineering - In vitro Organogenesis - Cell transplantation.</p> <p>Biomaterials In Tissue Engineering - Biological vs Nonbiological materials – Extra Cellular Matrix – Collagen, Chitin & Degradable and Nondegradable materials – Polymer, Ceramics and Metals – Cell interaction with different materials -- Scaffolds - Control releaser agents in Tissue Engineering – Cell interaction with suspension and gels – Tissue response to implants.</p> <p>Stem Cells in Tissue Engineering - Hemopoetic Stem cells - Embryonic Stem cells - Adult stem cells – Cancer Stem cells – Cord Blood cells – Induced Pluripotent Stem cells - Stem cell identification - Surface markers & FACS analysis – Differentiation, Dedifferentiation and Immortalization – Application of stem cells in tissue Engineering.</p> <p>Tissue Engineering Applications - Synthetic components – Artificial organs – Joints and dental prostheses - Connective Tissue Engineering – Cardiovascular Tissue Engineering – Neural Tissue Engineering - Cell and Drug Delivery systems.</p> <p>Specific Activity:</p> <ul style="list-style-type: none"> • Seminar- Application of stem cells in tissue Engineering 		
<p>References</p> <ol style="list-style-type: none"> 1. R.Lanza, J.Gearhart et.al,(Eds), Essential of Stem cell Biology, Elsevier Academic Press, 2nd edition 2009. 2. Robert P. Lanza, Robert Langer and Joseph Vacanti., Principles of Tissue Engineering,2nd Edition, Academic press, Elsevier 2013. 3. Gary E Wnek, Gary L Browlin – Encyclopedia of Biomaterials and Biomedical Engineering Marcel Dekker Inc New York, 2nd edition, 2008. 4. SujataV.Bhatt, Biomaterials (2nd Edition), Narosa Publishing House, 2005. 5. W. Mark Saltzman Tissue Engineering – Engineering Principles for Design of Replacement Organs and Tissue, Oxford University Press Inc. New York, 2004 		

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamentals of tissue engineering, tissue structure, cell organization, and morphogenesis	-	-	-
CO2	Analyze cell mechanisms including adhesion, migration, growth, interactions, and in vitro culture techniques for tissue engineering	PO2(3), PO4(2), PO5(2)	2	2
CO3	Apply knowledge of biomaterials, scaffolds, and cell–material interactions in tissue engineering applications	PO3(3), PO5(3), PO7(2)	3	2
CO4	Evaluate the role of stem cells and tissue engineering applications in regenerative medicine, artificial organs, and drug/cell delivery systems	PO3(3), PO4(2), PO6(3), PO12(2)	3	3

BM25019	Embedded system and internet of things for Biomedical applications	L T P C 3 0 2 4
<p>Course Objectives: To understand hardware and software for ARM processor ARM processor and Building Blocks of Embedded Systems, provide information about sensor interfacing with Arduino, protocols for IoT and familiarize the student with the various applications in healthcare using IOT</p>		
<p>ARM Processor Hardware and Software - Introduction to ARM Cortex-M Processors, Embedded Software Development, ARM architecture, ARM Instruction Set, Memory System, Exceptions and Interrupts. The C language: The evolution of C, An overview of C programming, C operators, identifiers, keywords and constants; The C preprocessor: commands, definition and replacement, File inclusion, Conditional compilation; storage classes, variable types, expressions and precedence, statements, functions.</p> <p>Embedded System Architecture - ARM Core -ARM organization and implementation, The Thumb Instruction Set, Architectural Support for High-Level Languages. Introduction to Arduino Due; Arduino integrated development environment and programming.</p> <p>Sensor Interfacing with Arduino -Basics of hardware design and functions of basic passive components-sensors and actuators, Arduino code - library file for sensor interfacing-construction of basic applications.</p> <p>IOT: An Introduction - Networked Embedded System types and overview, wireless communication standards-zigbee, Bluetooth & Wi-Fi. OSI & TCP/IP model in a nutshell. Introduction to the Internet and understand how internet works. Introduction to Smart Objects or Things. IOT- understand what IOT is and discuss its application in health-care systems- Patient Monitoring & diagnostics, Home healthcare & Personal care & Fitness. Embedded web server: Basic introduction, its importance and role in IOT. Design of a simple embedded web server: understand the HTTP & HTML basics Overview of different IOT Cloud Services.</p> <p>Specific Activity:</p> <ul style="list-style-type: none"> • Case Study1: Wireless Patient Monitor system • Case Study2: Wearable Fitness & Activity Monitor • Application Design: Design of IOT based pulse oximeter, block diagram, concepts of analog front end, signal process and Wi-Fi integration. 		
<p>Practical exercises: List of experiments</p> <ol style="list-style-type: none"> 1. Code for Sensor interface: Temperature sensor, pressure sensor, Light sensor, IR sensor.[1] 2. Temperature sensor Interfacing using ARM processor [2] 3. Flashing of LEDs using ARM processor [3] 4. ADC/DAC Interfacing using ARM processor 5. EPROM Interfacing using ARM processor. 		

6. Study of basic image processing algorithm using Single board computers such as Raspberry Pi, Beagle Bone block etc
Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%
Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).
References
<ol style="list-style-type: none"> 1. Muhammad Ali Mazidi, Janice GillispieMazidi, Rolin D. McKinlay, "The 8051 microcontroller and embedded systems using assembly and C", 2nd Edition, Pearson, 2005. 2. Brian W. Kernighan, Dennis M. Ritchie, "The C programming language", 2nd Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1988. 3. Andrew Sloss, Dominic Symes, Chris Wright, ARM system developer's guide: designing and optimizing system software, Morgan Kaufmann, 2004. 4. S. Salivahanan, S. Arivazhagam, "Digital circuits and Design", 4th Edition, Vikas Publishing House, 2012. 5. R. S. Khandpur, "Printed Circuit Boards Design - Fabrication, Assembly and Testing", 1st Edition, McGraw Hill Education, 2017. 6. Getting Started with Internet of Things- CunoPfister, 2011 7. Interconnecting Smart Objects with IP- J. P Vasseur, Adam Dunkels, 2010 24 Course

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain ARM processor architecture, embedded software, C programming concepts, and ARM instruction set	-	-	-
CO2	Analyze embedded system architecture, Arduino programming, sensor interfacing, and actuator integration for biomedical applications	PO2(3), PO3(3), PO5(3)	3	3
CO3	Apply IoT protocols, wireless communication standards (Wi-Fi, Bluetooth, Zigbee), and embedded web server concepts in healthcare systems	PO3(3), PO4(2), PO5(3), PO12(2)	3	3
CO4	Design IoT-based healthcare applications such as wireless patient monitoring, wearable fitness devices, and IoT-enabled pulse oximeters	PO3(3), PO4(3), PO5(3), PO12(3)	3	3

BM25020	Medical Informatics	L T P C 3 0 2 4
<p>Course objectives: To learn about operating systems and their uses, databases and their types, processing of data And recent trends in health informatics</p>		
<p>Operating System, Search Engine and Medical Standard - Introduction to Operating systems, Linux commands, File transfer protocols ftp and telnet – Search Engine – Online Medical Resources – Electronic Health Records - Network - Evolution of Medical Standards – IEEE 11073 - HL7 – DICOM – IRMA - LOINC – HIPPA.</p> <p>Introduction to Medical Informatics -Introduction –Medical Informatics– Health Informatics - Structure of Medical Informatics –Functional capabilities of Hospital Information System - On-line services and Off – line services - Dialogue with the computer.</p> <p>Database and Health Informatics - Data management – data life cycle – database technology – interfaces and implementation – biological databases and their uses – Database management system models, Basics of Structured Query Language (SQL). Genome projects, Clinical informatics, Nursing informatics, Public health informatics.</p> <p>Medical Data Storage And Automation - Representation of Data, Data modeling Techniques, Relational Hierarchical and network Approach, Normalization techniques for Data handling - Plug-in Data Acquisition and Control Boards – Data Acquisition using Serial Interface – Medical Data formats – Signal, Image and Video Formats – Medical Databases - Automation in clinical laboratories - Intelligent Laboratory Information System – PACS</p> <p>Recent Trends In Medical Informatics -Medical Expert Systems, Virtual reality applications in medicine, Virtual Environment – Surgical simulation - Telemedicine – virtual Hospitals - Smart Medical Homes – Personalized e-health services – Biometrics - GRID and Cloud Computing in Medicine – Artificial Intelligence in health Informatics.</p>		
<p>Practical exercises:</p> <ol style="list-style-type: none"> 1. Computer and Internet basics 2. Operating systems – Linux and Windows Basics 3. PubMed search engine 4. Types of computer database 5. Typs of graphs 6. Retrivel of data from biological and medical database 7. Data handling and analysis using Excel 		
<p>Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		

References

1. Orpita Bosu and Simminder Kaur Thukral, "Bioinformatics Databases, Tools and Algorithms"
Oxford University press, 2007
2. Yi Ping Phoebe Chen, "Bioinformatics Technologies", Springer International Edition, New Delhi, 2007.
3. R.D.Lele, "Computers in medicine progress in medical informatics", Tata McGraw Hill Publishing Ltd, 2005
4. Mohan Bansal, "Medical informatics", Tata McGraw Hill Publishing Ltd, 2003
5. J.H. van Bommel and M.A. Musen. Handbook of Medical Informatics. Bohn Stafleu Van Loghum,. Springer
6. Robert E. Hoyt. Medical Informatics. Practical Guide for the Healthcare Professional. Published by: Lulu.com

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain operating systems, search engines, medical standards (IEEE 11073, HL7, DICOM, LOINC, HIPAA) and their applications in healthcare	-	-	-
CO2	Analyze the structure and functional capabilities of medical and health informatics systems including Hospital Information Systems (HIS)	PO2(3), PO3(2), PO6(3)	2	2
CO3	Apply database management systems, SQL, data storage, modeling, normalization techniques, and medical automation in clinical environments	PO3(3), PO4(3), PO5(3), PO12(2)	3	3
CO4	Design and evaluate modern medical informatics solutions including telemedicine, virtual hospitals, smart medical homes, AI-based systems, and cloud/GRID computing applications	PO3(3), PO4(3), PO5(3), PO12(3)	3	3

BM25021	Pattern recognition Techniques and Applications	L T P C 3 0 2 4
<p>Course objectives: To understand the fundamentals of Pattern recognition, various clustering techniques, feature extraction and selection and different classification models. To understand Fuzzy Pattern Classifiers and applications.</p>		
<p>Pattern Classifier -Overview of Pattern recognition – Discriminant functions – Supervised learning – Parametric estimation–MaximumLikelihoodEstimation–BayesianparameterEstimation – Problems with Bayes approach– Non Parametric techniques, Perceptron Algorithm -LMSE Algorithm- Pattern classification by distance functions – Minimum distance pattern classifier.</p>		
<p>Clustering - Clustering Concept – Hierarchical Clustering Procedures – Partitional Clustering, k- means algorithm – Clustering of Large Data Sets – EM Algorithm – Grid Based Clustering– Density Based Clustering.</p>		
<p>Feature Extraction and Selection - EntropyMinimization–KLTransforms–Regression-Linear,Non-linearandLogistic,Prediction, Feature Selection through Functions Approximation – Binary Feature Selection.</p>		
<p>Hidden Markov Models and Supportvector Machine – State Machines–Hidden Markov Models: Maximum Likelihood for the HMM, Forward-Backward Algorithm, Sum and Product Algorithm for the HMM, Extensions of the Hidden Markov Model – Support Vector Machines: Maximum Margin Classifiers, Relevance Vector Machines.</p>		
<p>Recent Advances and Applications - Elementary Neural Network for Pattern Recognition, Fuzzy pattern classifier, Application of PR in image segmentation, CAD system in breast cancer detection, ECG signal classification, Fingerprint recognition, cell cytology classification</p>		
<p>Practical Exercises:</p>		
<ol style="list-style-type: none"> 1. Implementation of Image classification using Perceptron model in Matlab /python. 2. Implementation of Fuzzy pattern classifier in Matlab /OpenCV/python. 3. Implementation of Feature extraction using KL transform in Matlab/ OpenCV/python. 4. Implementation of partitional clustering in Matlab/ OpenCV/python. 5. Implementation of density based clustering in Matlab/ OpenCV/python 6. Implementation of Classification using SVM in Matlab/ OpenCV/python. 7. Implementation of Classification using HMM in Matlab/ OpenCV/python. 8. Implementation of Bayes classifier in Matlab/ OpenCV/python. 9. Implementation of Classification using Neural Networks in Matlab/ OpenCV/python. 10. Implementation of image segmentation in Matlab/OpenCV/python 		
<p>Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%</p>		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question</p>		

Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References

1. Andrew Webb, "Statistical Pattern Recognition", Arnold publishers, London, 2002
2. C.M.Bishop, "Pattern Recognition and Machine Learning", Springer, 2006
3. Earl Gose, Richard Johnsonbaugh Steve Jost, "Pattern Recognition and Image Analysis", Prentice Hall of India Pvt Ltd., New Delhi, 1996
4. M. Narasimha Murthy and V. Susheela Devi, "Pattern Recognition", Springer 2011
5. R.O.Duda, P.E.Hart and D.G.Stork, "Pattern Classification", John Wiley, 2001
6. Robert J. Schalkoff, "Pattern Recognition Statistical, Structural and Neural Approaches", John Wiley & Sons Inc., New York, 1992
7. S.Theodoridis and K.Koutroumbas, "Pattern Recognition", 4th Edition, Academic Press, 2008

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain fundamentals of pattern recognition, discriminant functions, supervised/unsupervised learning, parametric and non-parametric methods	-	-	-
CO2	Analyze clustering techniques including hierarchical, k-means, EM, grid-based and density-based clustering for large datasets	PO2(3), PO3(2), PO5(2)	3	2
CO3	Apply feature extraction, selection, and dimensionality reduction techniques including KL transforms, regression, and approximation methods	PO3(3), PO4(3), PO5(3)	3	3
CO4	Design and evaluate classification models including Hidden Markov Models, SVMs, neural networks, and fuzzy classifiers for biomedical applications	PO3(3), PO4(3), PO5(3), PO12(3)	3	3

BM25022	Data Analytics For Healthcare Technologies	L T P C 3 0 2 4
<p>Course objectives: To explore the various forms of electronic healthcare information, techniques adopted to analyse health care data and natural language based analytics. To understand the predictive models for clinical data and gain knowledge health care analytics and its applications.</p>		
<p>Introduction – Introduction to Healthcare Data Analytics – Electronic Health Records– Components of EHR-Coding Systems - Benefits of EHR-Barrier to Adopting HER - Challenges- Pheno typing Algorithms.</p> <p>Data Analysis – Biomedical Image Analysis - Mining of Sensor Data in Healthcare- Biomedical Signal Analysis - Genomic Data Analysis for Personalized Medicine.</p> <p>Analytics – Natural Language Processing and Data Mining for Clinical Text- Mining the Biomedical – Social Media Analytics for Healthcare.</p> <p>Advanced Analytics -Advanced Data Analytics for Healthcare – Review of Clinical Prediction Models- Temporal Data Mining for Healthcare Data-Visual Analytics for Healthcare - Predictive Models for Integrating Clinical and Genomic Data - Information Retrieval for Healthcare- Privacy- Preserving Data Publishing Methods in Healthcare.</p> <p>Applications - Applications and Practical Systems for Healthcare – Data Analytics for Pervasive Health - Fraud Detection in Healthcare-Data Analytics for Pharmaceutical Discoveries - Clinical Decision Support Systems-Computer- Assisted Medical Image Analysis Systems- Mobile Imaging and Analytics for Biomedical Data.</p>		
<p>Practical Exercises:</p> <ol style="list-style-type: none"> 1. Analyse a Sample EHR Dataset and Identify Key Components & Coding Standards 2. Implement a Phenotyping Algorithm to Identify Diabetic Patients 3. Analyse and Classify ECG Signals Using Machine Learning 4. Implement Image Segmentation on Brain MRI using Thresholding and Clustering 5. Analyse Gene Expression Profiles to Identify Cancer Biomarkers 6. Extract Medical Concepts from Clinical Notes using NLP Techniques 7. Analyse Twitter Data for Public Sentiment on Vaccines 8. Build a Predictive Model for Hospital Readmission Risk 9. Apply K-Anonymity or Differential Privacy on Healthcare Dataset 10. Design a Rule-Based CDSS for Hypertension Management 		
<p>Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).</p>		

References

1. Chandan K. Reddy and Charu C Aggarwal, "Healthcare data analytics", Taylor & Francis, 2015
2. Hui Yang and Eva K. Lee, "Healthcare Analytics: From Data to Knowledge to Healthcare Improvement, Wiley, 2016.
3. Michael Berthold, David J.Hand, "Intelligent Data Analysis", Springer, 2007.
4. David J. Lubliner , "Biomedical Informatics: An Introduction to Information Systems and Software in Medicine and Health", CRC Press, Boca Raton, 2016

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain healthcare data types, electronic health records (EHR), coding systems, phenotyping algorithms, and challenges in data adoption	-	-	-
CO2	Analyze biomedical signals, sensor data, genomic data, and image data for healthcare analytics	PO2(3), PO3(3), PO5(2)	3	2
CO3	Apply data mining, natural language processing (NLP), and advanced analytics techniques for clinical and social healthcare data	PO3(3), PO4(3), PO5(3), PO12(2)	3	3
CO4	Design predictive models, clinical decision support systems, and analytics solutions for pervasive healthcare, fraud detection, and biomedical imaging applications	PO3(3), PO4(3), PO5(3), PO12(3)	3	3

BM25023	Mixed Reality	L T P C 3 0 2 4
<p>Course Objectives: Understand core concepts and components of Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). Develop skills in AR/MR technologies and their applications using industry-standard tools. Explore interactive techniques and visual computation for immersive VR environments. Learn I/O interfaces and their integration in VR/MR systems for practical applications.</p> <p>Introduction to Virtual Reality: Overview of Mixed Reality: Definitions and differences between VR, AR, and MR. Core VR Concepts: Virtual environment requirements, benefits, and historical context. 3D Computer Graphics: Virtual world space, perspective projection, stereographic imaging, basic 3D modeling, illumination models (Phong, Gouraud), shading algorithms, hidden surface removal.</p> <p>Interactive Techniques in Virtual Reality: 3D Interaction: Transition from 2D to 3D, 3D space curves, boundary representation. Geometrical Transformations: Frames of reference, modeling transformations, scaling, collision detection.</p> <p>VR Systems: Components (virtual environment, computer environment, VR technology), interaction models, introduction to Unity/Unreal Engine for VR development.</p> <p>Visual Computation in Virtual Reality: Animation in VR: Linear/non-linear interpolation, object animation, shape in-betweening. Physical Simulation: Gravity, elastic collisions, projectiles, basic physics in VR using Unity/Unreal Engine physics engines. Real-Time Rendering: Optimization techniques for VR performance.</p> <p>Augmented and Mixed Reality: AR/MR Fundamentals: Taxonomy, technology, differences between AR and VR, challenges. AR Techniques: Marker-based and marker-less tracking, visualization methods, ARKit/ARCore integration. Applications: AR in education, mobile interfaces, interactive environments.</p> <p>I/O Interfaces and Applications of VR/MR: Human Factors: Eye, ear, haptic feedback in VR/MR. Hardware: Sensors, head-mounted displays (HMDs), motion trackers, haptic devices. Software: VR/MR toolkits (Unity, Unreal Engine, Vuforia), VRML basics, application development. Industry Applications: VR/MR in gaming, film, education, medical visualization (e.g., surgery simulation).</p> <p>Activities</p> <ul style="list-style-type: none"> • VR/AR/MR Concept Mapping and industry use cases brainstorming • 3D interaction design – create story board for 3D navigation and interaction for a concept of student choice • Hardware components Exploration (e.g., HMDs, motion trackers, haptic devices), 		

user need identification for the chosen concept, and human factors analysis

Experiments

1. **VR Scene Development:** Create a VR scene in Unity with 3D objects, lighting, shading, and collision detection.
2. **Physics-Based VR Application:** Build a VR application in Unity with animated objects and physics interactions (e.g., gravity, projectiles).
3. **AR/MR Application:** Develop an AR/MR application using Unity and Vuforia for an educational or gaming use case (e.g., interactive visualization or simple AR game).

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References

1. Burdea, G. C. and P. Coiffet. Virtual Reality Technology, Second Edition. Wiley-IEEE Press, 2003/2006.
2. Alan B. Craig, Understanding Augmented Reality, Concepts and Applications, Morgan Kaufmann, First Edition 2013.
3. Alan Craig, William Sherman and Jeffrey Will, Developing Virtual Reality Applications, Foundations of Effective Design, Morgan Kaufmann, 2009.
4. John Vince, "Virtual Reality Systems", Pearson Education Asia, 2007.
5. Adams, "Visualizations of Virtual Reality", Tata McGraw Hill, 2000.
6. Grigore C. Burdea, Philippe Coiffet, "Virtual Reality Technology", Wiley Inter Science, 2nd Edition, 2006.
7. William R. Sherman, Alan B. Craig, "Understanding Virtual Reality: Interface, Application and Design", Morgan Kaufmann, 2008

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain core concepts of Virtual, Augmented, and Mixed Reality, 3D graphics, visualization, and immersive VR/MR environments	-	-	-
CO2	Analyze 3D interaction techniques, geometrical transformations, animation, physical simulation, and real-time rendering in VR/MR systems	PO2(3), PO3(3), PO5(2)	3	2
CO3	Apply VR/MR software tools (Unity, Unreal Engine, Vuforia) and develop VR/AR/MR applications integrating human-computer interaction and I/O interfaces	PO3(3), PO4(3), PO5(3), PO12(2)	3	3
CO4	Design immersive VR/AR/MR applications for education, medical visualization, gaming, and other industry use cases considering human factors and usability	PO3(3), PO4(3), PO6(3), PO12(3)	3	3