



# **First Year Curriculum**

**Admission Year 2026-27**

**First Year Curriculum for the Admission Year 2026-27 Batch**

**MTech in  
Automation and Robotics  
Faculty of Engineering & Technology**

**Parul University**

**Vadodara, Gujarat, India**

## SEMESTER 1

- a. **Course Name:** Biostatistics
- b. **Course Code:** 03023101PC01
- c. **Prerequisite:** Basic Knowledge of Calculus, Linear algebra, Probability theory is must.
- d. **Rationale:** To explain various statistics techniques for design of biological experiments, especially in medicine, pharmacy; the collection, summarization, and analysis of data from those experiments; and the interpretation of, and inference from, the results.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts, principles, and applications of biostatistics in biomedical, healthcare, and research fields.
<b>CLOBJ 2</b>	Develop knowledge of data collection methods, measurement scales, sampling techniques, and experimental design.
<b>CLOBJ 3</b>	Apply descriptive statistical methods to organize, summarize, and interpret biological and medical data.
<b>CLOBJ 4</b>	Understand probability concepts and probability distributions used in statistical analysis and decision-making.
<b>CLOBJ 5</b>	Develop analytical skills for estimation, hypothesis testing, and interpretation of statistical results.
<b>CLOBJ 6</b>	Apply regression and correlation methods for analyzing relationships among variables in biomedical and scientific studies.

- f. **Course Learning Outcomes:**

<b>CLO 1</b>	Understand the foundational concepts of biostatistics including measurement scales, sampling, statistical inference, and design of experiments, and demonstrate their relevance in biological and health sciences.
<b>CLO 2</b>	Apply descriptive statistical tools to summarize, organize, and interpret data using measures of central tendency and dispersion.
<b>CLO 3</b>	Analyze probabilistic events and distributions (discrete and continuous) including standard normal distribution to solve real-life biological problems.
<b>CLO 4</b>	Estimate population parameters using different estimation techniques and interpret the outcomes in the context of biological data.
<b>CLO 5</b>	Perform hypothesis testing and regression analysis, and interpret the statistical significance and relationships among variables using appropriate tests and models.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L-Lectures; T- Tutorial; P-Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continues Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Topics	W (%)	T
1	<b>Introduction to Biostatistics</b> Introduction, Some basic concepts, Measurement and Measurement Scales, Sampling and Statistical Inference, The Scientific Method and the Design of Experiments, Computers and Biostatistical Analysis.	15%	6
2	<b>Descriptive Statistics</b> Introduction, The Ordered Array, Grouped Data: The Frequency Distribution, Descriptive Statistics: Measures of Central Tendency, Descriptive Statistics: Measures of Dispersion	20%	9
3	<b>Probability</b> Definition of Probability, Law of Probability, Conditional Probability, Discrete Probability Distributions, Random Variables, Continuous Probability Distributions, Standard Normal Distribution, Case Study.	25%	12
4	<b>Estimation</b> Overview of Estimation, Estimation of the Mean of a Distribution, Variance of a Distribution, Binomial Distribution, Poisson Distribution, Case Study.	20%	9
5	<b>Hypothesis Testing &amp; Regression Methods</b> Hypothesis Testing: A Single Population Mean, Difference between Two Population Means, A Single Population Proportion, Difference Between Two Population Proportions, A Single Population Variance, The Ratio of Two Population Variances, The Type II Error and the Power of a Test. Overview of Regression and Correlation Methods, Fitting Regression Lines:- The Method of Least Squares, F-Test for Simple Linear Regression, t-Test for Simple Linear Regression, Partial and Multiple Correlation.	20%	9
<b>Total:</b>		100%	60

**i. Text Book and Reference Book:**

1. Introduction to Statistics for Biomedical Engineers By Kristina M. Ropella
2. A foundation for analysis in the health sciences By Wayne S. Daniel, Biostatistics | John Wiley & Sons
3. Primer of biostatistics By Stanton A. Glantz | Mc Graw Hill
4. Fundamentals of Biostatistics By Bernard Rosner | 6th edition

- a. **Course Name:** Advanced Biomedical Signal Processing
- b. **Course Code:** 03023101PC03
- c. **Prerequisite:** Fundamental Knowledge of signal processing is must.
- d. **Rationale:** The course aims at providing the students with the knowledge and methodology for extracting useful information, implement the advanced signal processing and pattern classification techniques on different biomedical signals like ECG, EEG, and EMG and from that interpret the results and validate the descriptors obtained in the light of knowledge of the biological system involved.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the principles of biomedical signal conversion, sampling techniques, and signal acquisition systems.
<b>CLOBJ 2</b>	Develop knowledge of digital signal processing concepts including Z-transform, digital filters, and transfer functions.
<b>CLOBJ 3</b>	Analyze and design finite impulse response (FIR) and infinite impulse response (IIR) filters for biomedical signal processing applications.
<b>CLOBJ 4</b>	Understand the concepts and applications of integer filters, adaptive filters, and signal averaging techniques in noise reduction and signal enhancement.
<b>CLOBJ 5</b>	Develop knowledge of biomedical data reduction techniques for efficient signal storage and processing.
<b>CLOBJ 6</b>	Apply digital signal processing techniques for ECG analysis, QRS detection, arrhythmia monitoring, and interpretation of biomedical signals.

- f. **Course Learning Outcomes:**

<b>CLO 1</b>	Understand the fundamental concepts of signal conversion and sampling techniques essential for biomedical signal processing.
<b>CLO 2</b>	Apply the basics of digital filtering including Z-transform and pole-zero plots to analyze and design biomedical digital filters.
<b>CLO 3</b>	Design and implement Finite and Infinite Impulse Response (FIR & IIR) filters for smoothing, notch filtering, and ECG signal analysis.
<b>CLO 4</b>	Analyze the structure and function of integer and adaptive filters and evaluate their applications in biomedical noise cancellation.
<b>CLO 5</b>	Apply signal averaging and data reduction algorithms such as AXEC, Huffman, and CORTES to extract meaningful biomedical data.
<b>CLO 6</b>	Evaluate ECG signals using QRS detection, ST segment analysis, and arrhythmia monitoring systems for diagnostic purposes.

- g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				T	CE	P	Theory	P	
3	-	0	3	20	20	-	60	-	100

**L:** Lectures; **T-** Tutorial; **P-**Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continues Evaluation, **ESE-** End Semester Examination

#### h. Course Content:

Sr. No.	Topics	W (%)	T
1	<b>Signal Conversion</b> Sampling basics, simple signal conversion system, conversion requirements for biomedical signals, signal conversion circuits.	10%	5
2	<b>Basics of Digital Filtering</b> Digital filters, Z transform, Elements of digital filters, types of digital filters, Transfer function of a differential equation, Z-plane pole zero plots, The rubber membrane concept.	15%	6
3	<b>Finite &amp; Infinite Impulse Response Filters</b> Filters Characteristics, Smoothing Filters, Notch Filters, Derivatives, window design, Frequency sampling, minimax design. Infinite Impulse Response filters: Generic equation of IIR filters, simple one-pole example, Integrator, Design method of two-pole filters, IIR Digital filter for ECG Analysis	25%	11
4	<b>Integer &amp; Adaptive Filters</b> Basic Design Concept, LP, HP BP and Band reject filters, The effects of filter cascades, Adaptive filters: Principle of noise canceler model, 60 Hz adaptive canceling using a sine wave model, other applications of adaptive filtering.	20%	8
5	<b>Signal Averaging</b> Basics of Signal Averaging, Signal averaging as a digital filter, a typical averager, software for signal averaging, limitations of signal averaging.	10%	5
6	<b>Data Reduction</b> Techniques Turning point algorithm, AZTEC algorithm, CORTES, Fan algorithm, Huffman algorithm.	10%	5
7	<b>ECG QRS Detection and Analysis System</b> Bandpass filtering Techniques, Differentiation techniques, Template matching techniques, QRS detection algorithm. ECG interpretation, ST segment analyser, portable arrhythmia Monitor	10%	5
<b>Total:</b>		100%	45

#### i. Text Book and Reference Book:

1. Biomedical Signal processing By J. A. Tompkins and J. A. White | PHI
2. Biomedical Signal Analysis, A Case Study Approach By Rangaraj M. Rangayyan
3. Digital Signal Processing: Principles, Algorithms and Applications By John G. Proakis Dimitris K Manolakis | PHI | 3
4. Discrete-Time Signal Processing By Alan V. Oppenheim | PHI | 2

- a. **Course Name:** Advanced Biomedical Signal Processing Lab
- b. **Course Code:** 03023101PC04
- c. **Prerequisite:** Fundamental Knowledge of signal processing is must.
- d. **Rationale:** This laboratory course is designed to provide practical experience in analyzing, processing, and interpreting biomedical signals using advanced digital signal processing techniques. The lab focuses on real-world applications involving ECG, EEG, EMG, and other physiological signals.

e. **Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts of digital signal processing and MATLAB programming for biomedical signal analysis.
<b>CLOBJ 2</b>	Develop practical skills in generating and analyzing standard discrete-time signals using MATLAB.
<b>CLOBJ3</b>	Apply sampling theorem concepts and analyze the effects of aliasing in digital signal processing systems.
<b>CLOBJ4</b>	Understand and implement Z-transform analysis, pole-zero representation, and the rubber membrane concept for system characterization.
<b>CLOBJ 5</b>	Design and implement FIR and IIR digital filters using MATLAB tools and transfer function techniques.
<b>CLOBJ 6</b>	Analyze and apply smoothing and filtering techniques such as Hanning filters, least square methods, and moving average filters for signal enhancement and biomedical applications.

f. **Course Learning Outcomes:**

<b>CLO 1</b>	Acquire and preprocess various biomedical signals such as ECG, EEG, and EMG using appropriate acquisition tools and preprocessing techniques.
<b>CLO 2</b>	Apply digital filtering methods including FIR and IIR filters to remove noise and artifacts from biomedical signals.
<b>CLO 3</b>	Implement signal averaging, feature extraction, and adaptive filtering techniques for enhancing diagnostic information.
<b>CLO 4</b>	Analyze biomedical signal characteristics using time-domain and frequencydomain methods.
<b>CLO 5</b>	Develop algorithms for QRS detection, ST segment analysis, and event detection using ECG signals.
<b>CLO 6</b>	Evaluate signal compression techniques and data reduction methods to optimize storage and transmission of biomedical data.

g. **Teaching Examination scheme:**

<b>Teaching Scheme</b>	<b>Evaluation Scheme</b>
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L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation , ESE- End Semester Examination

**h. Course Content:**

Sr. No.	List of Experiments
1.	Write a program in MATLAB to generate the standard signals.
2.	To verify sampling theorem and check the effect of aliasing in MATLAB.
3.	To perform Z-transform from zeros and poles of a given system function.
4.	To Perform the Rubber Membrane Concept.
5.	Design and Implementation of filters using FDA tool in MATLAB.
6.	Write a MATLAB Code for design of filter using transfer function.
7.	To study about the Smoothing Filter using Hanning Filter and Least Square technique.
8.	To study about the Smoothing Filter using Moving Average Filter.
9.	To study about IIR Filter.
10.	To study about FIR Filter.

- a. **Course Name:** Healthcare Management
- b. **Course Code:** 03023101PC05
- c. **Prerequisite:** Basic understanding of healthcare systems, management principles, and statistics is recommended.
- d. **Rationale:** The course aims at introduction to general management principles and basic healthcare application, to explore on International and national healthcare problems and issues, to discuss Planning, budgeting and uses of computers and information technology, to Explore International standards and protocol for hospital management
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental principles of management and their applications in healthcare and hospital environments.
<b>CLOBJ 2</b>	Develop knowledge of healthcare service providers, hospital systems, organizational hierarchy, and leadership in healthcare management.
<b>CLOBJ 3</b>	Understand the structure, functions, and services of hospitals including outpatient, inpatient, emergency, nursing, dietary, and support services.
<b>CLOBJ 4</b>	Analyze hospital planning requirements including budgeting, communication systems, power supply, sanitation, safety, and infrastructure management.
<b>CLOBJ 5</b>	Develop knowledge of computer applications and information management systems used in hospital administration and patient care.
<b>CLOBJ 6</b>	Understand hospital standards, biomedical equipment management, maintenance procedures, and the role of biomedical engineers in healthcare services.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Analyze the healthcare system, including its structure, financing, and delivery.
<b>CLO 2</b>	Understand the roles and responsibilities of healthcare managers and leaders.
<b>CLO 3</b>	Apply management principles to healthcare organizations, including planning, organizing, and controlling.
<b>CLO 4</b>	Evaluate healthcare policies and programs, including their impact on healthcare outcomes.
<b>CLO 5</b>	Develop strategic plans to improve healthcare quality, safety, and efficiency.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage(%)	Teaching Hours
1	<b>Introduction</b> Principles of Management – Origin of principles of Management, Henry Fayol’s 14 principles of Management, elements of management, organizational hierarchy, Introduction to principles of management in Healthcare environment, health ergonomics.	10%	5
2	<b>Healthcare Service Providers</b> Role of the healthcare service providers Conventional hospital setup, types of leadership in healthcare environment, Private clinics, Corporate hospitals.	20%	10
3	<b>Classification of Hospital Systems</b> General Hospital –Specialist Hospital –Teaching – Research, Primary Health Centre –Their role, Functions. Role of Biomedical Engineers, Aspects of Hospital Services- Outpatient- Inpatient supportive emergency, drug and medical supply, Nursing Services, Dietary services, Transport services.	15%	5
4	<b>Hospital Planning</b> Orientation, Budgeting, Communication within the hospital and outside the hospitals - Electric power supply for various theatres and rooms, Diesel generator, Standby power supply- Air conditioning of important theatres and equipment housings - Water supply requirements & management, Lifts and firefighting equipment’s - Sanitation within the hospitals, Laundry services	20%	10
5	<b>Computer and Information Management in Hospital</b> Computer aided hospital management- Application, Administration/Discharge records of patients, Patient billing, Maintenance of patient records and their history - Maintenance of inventory of medicines and drugs – Purchase.	20%	10
6	<b>Hospital Standards and Maintenance</b> Introduction to ISO - WHO standards, FDA standards, Indian standards for biomedical equipment services, Their purchase, Servicing and maintenance- Keeping intact and	15%	5

	throwing the condemned equipment, Training personal for medical equipment, Preventive and periodical maintenance procedures.		
<b>Total:</b>		<b>100 %</b>	<b>45</b>

**i. Text books:**

1. Management Principles for Health Professionals By Joan Gratto Liebler, Charles R. McConnell | Jones and Bartlett Learning, Massachusetts | 6
2. Introduction to Health Care Management By Sharon Bell Buchbinder, Nancy H. Shanks | Jones and Bartlett Learning, Massachusetts | 1
3. Healthcare Management By Walshe, Kieran, Smith, Judith | McGraw Hill, New York | 2011

- a. **Course Name:** Advance Biomaterials
- b. **Course Code:** 03023101PE01
- c. **Prerequisite:** Fundamental Knowledge of Material science is required.
- d. **Rationale:** The course aims at providing the students with the knowledge of biomaterials, classification (metals, polymers, and ceramics, bio-resorbable and biodegradable materials), different properties on materials used in medicine.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the history, classification, and fundamental concepts of biomaterials used in medical and biomedical applications.
<b>CLOBJ 2</b>	Develop knowledge of the mechanical, bulk, and surface properties of biomaterials and their characterization techniques.
<b>CLOBJ 3</b>	Understand the structure, properties, and biomedical applications of metallic, ceramic, polymeric, biodegradable, and bioresorbable biomaterials.
<b>CLOBJ 4</b>	Analyze the biocompatibility, stability, degradation, and host response associated with biomaterials in biological environments.
<b>CLOBJ 5</b>	Develop knowledge of testing methods for evaluating tissue compatibility, blood-material interactions, and performance of biomaterials.
<b>CLOBJ 6</b>	Understand international and Indian standards, specifications, and contemporary issues related to biomaterials and medical implants.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the history, classification, and general properties of biomaterials used in medicine.
<b>CLO 2</b>	Analyze the bulk and surface properties of materials and evaluate their mechanical characteristics for biomedical applications.
<b>CLO 3</b>	Classify and compare various metallic and ceramic biomaterials, and assess their suitability in cardiovascular, dental, and orthopedic applications.
<b>CLO 4</b>	Evaluate different types of polymeric biomaterials and their sterilization, stability, and biocompatibility with human tissue systems.
<b>CLO 5</b>	Perform and interpret in-vitro and in-vivo testing of biomaterials, analyzing the interaction of materials with biological environments.
<b>CLO 6</b>	Examine host responses, toxicity, and regulatory standards for biomaterials, and interpret issues related to foreign body reactions and implant-related complications.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage(%)	Teaching Hours
1	<b>Introduction</b> Define medical care and a hospital, Role of hospital in health care: Changing role of hospitals, Environmental health services, Health and medical care, Hospital Planning and design: Classification of Hospitals, Different guiding principles in hospital planning, Various factors influencing hospital utilization.	10%	5
2	<b>Out/In patient &amp; Nursing Services</b> Out/In patient: Introduction of outpatient services: Outpatient, Emergency outpatient, referred outpatient, general outpatient, outpatient visit, unit of service & service time. Flowchart of an outpatient department, Common problems in outpatient services. Nursing Services: Various functions and roles of nursing services, Factors influencing the number of nurses.	15%	7
3	<b>Intensive Care Unit and Central Sterile Supply Department</b> Intensive Care Unit: Introduction, Role and functions of an ICU, Types of ICU, Layout of an ICU. Central Sterile Supply Department: Introduction of CSSD, Functions of CSSD, Flowchart of CSSD.	25%	10
4	<b>Effective hospital management</b> Introduction, Principles of hospital management, Various managerial activities of a hospital. Roles and functions of hospital administration, Skills of Effective Managers, Characteristics of Effective Managers.	20%	8
5	<b>Administrative services</b> Introduction, Various functions of medical records, Flowchart of an inpatient record, Material Management: Operative goals of materials management, material management process.	10%	5
6	<b>Disposal of Hospital Waste</b> Define waste, types of waste, characteristics of a good waste disposal system, General classification of waste, Colour coding of containers, Transportation of waste: On-site and Off-site waste, Symbols of Hospital Hazards.	10%	5

7	<b>Disposal of Hospital Waste</b> Define waste, types of waste, characteristics of a good waste disposal system, General classification of waste, Colour coding of containers, Transportation of waste: On-site and Off-site waste, Symbols of Hospital Hazards.	<b>10%</b>	<b>5</b>
<b>Total:</b>		<b>100 %</b>	<b>45</b>

**i. Text books:**

1. Materials: engineering, science, processing and design By Michael F. Ashby, Hugh Shercliff, David Cebon | Elsevier Ltd, Cambridge | 3
2. Biomaterials Science By Ratner, Hoffman, Schoen, Lemons | Academic Pres | 1
3. PEEK Biomaterials Handbook By Steven M. Kurtz | Elsevier, Atlanta | 1

- a. **Course Name:** Networking and Information System in Medicine
- b. **Course Code:** 03023101PE03
- c. **Prerequisite:** Basics of Computer Networks and Medical Terminology is required.
- d. **Rationale:** This subject introduces students to the design, implementation, and application of healthcare IT systems, including Hospital Information Systems (HIS), Picture Archiving and Communication Systems (PACS), Electronic Health Records (EHR), and telemedicine platforms. Students will also learn about networking standards, security protocols, data interoperability, and the role of IoT and cloud technologies in modern healthcare delivery systems.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts of networking, communication systems, and security principles in healthcare environments.
<b>CLOBJ 2</b>	Develop knowledge of communication networks, data transmission methods, internet technologies, and wireless communication systems used in healthcare applications.
<b>CLOBJ 3</b>	Understand standards and protocols for medical data exchange, telemedicine, and video conferencing systems.
<b>CLOBJ 4</b>	Analyze the structure, functions, and modules of Hospital Management Information Systems (HMIS) and Hospital Information Systems (HIS).
<b>CLOBJ 5</b>	Develop knowledge of computerized patient records (CPR), healthcare data management, and healthcare information system development tools.
<b>CLOBJ 6</b>	Understand Picture Archival and Communication Systems (PACS), DICOM standards, medical image storage, retrieval, compression, and computeraided diagnosis systems.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the basic concepts of computer networking, network components, services, system security, and network management in healthcare systems.
<b>CLO 2</b>	Analyze various communication types, including PSTN, POTS, ATN, ISDN, and wireless systems, and their applications in medical information exchange.
<b>CLO 3</b>	Explain the standards for real-time telemedicine and data exchange protocols such as H.320, H.324, and T.120 for video and text communication in clinical settings.
<b>CLO 4</b>	Evaluate the structure, development, and functional areas of Hospital Management Information Systems (HMIS) including specialized modules like blood bank, pharmacy, and diet planning.
<b>CLO 5</b>	Design and interpret features and functionalities of Hospital Information Systems with emphasis on CPR (Computer-based Patient Record) and HMIS development tools.
<b>CLO 6</b>	Apply knowledge of PACS systems, including DICOM standards, image compression, storage, retrieval, and CAD tools, in the management of diagnostic imaging data.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage(%)	Teaching Hours
1	<b>Introduction of Microprocessor</b> Introduction, System Components, Networked Communities, Host Management, User Management- Application Level Services, Network Level Services, and Principles of Security, Security Implications, and Analytical System Administration.	10%	5
2	<b>Communication Network and Services</b> Types of information: Audio, Video, Still Images, Text and data, and Fax - Types of Communication and Network: PSTN, POTS, ATN, and ISDN - Basic concepts of Communication and Network: Internet, and Wireless communications.	25%	11
3	<b>Standards for Data Exchange</b> Real-time Telemedicine. Data Exchange: Network Configuration, circuit and packet switching, H.320 series (Video phone based ISBN) T.120, H.324 (Video phone based PSTN). Video Conferencing	10%	5
4	<b>Hospital Management</b> Need for HMIS, Capabilities & Development of HMIS, functional area, modules forming HMIS, (like Pathology Lab, Blood bank, Pharmacy, Diet planning).	25%	11
5	<b>Hospital Information System</b> Maintenance and development of HMIS-Ideal Features and functionality of CPR, Development tools for CPR.	20%	8
6	<b>Picture Archival Communication Systems (PACS)</b> Types of image formats, DICOM standard, PACS system: Block diagram, Storing & retrieving images, Algorithm for retrieving images, Compressions and its significance, Lossless data Storage and in-house communication, Computer aided diagnosis (CAD), Centralized Database.	10%	5
<b>Total:</b>		<b>100 %</b>	<b>45</b>

**i. Text books:**

1. Computer Networks By Andrew S. Tanenbaum | Fifth edition
2. Medical Informatics: An Executive primer By Kenneth R. Ong | HIMSS Publishing | 1st 2015
3. Telemedicine Technologies: Information Technologies in Medicine and Telehealth By Bernard Fong, A.C.M. Fong and C.K. Li, | Wiley- Blackwell, New Jersey | 1
4. Web-based Application in Healthcare and Biomedicine By Lazakidu | Springer, New York. | 1

- a. **Course Name:** MEMS & NEMS For Biomedical Applications
- b. **Course Code:** 03023101PE05
- c. **Prerequisite:** Students should have prior knowledge in signal conditioning and measurement systems, Familiarity with physiological systems and biomedical instrumentation.
- d. **Rationale:** This Course is offered to Introduce and discuss the historical background of evolution of MEMS and Microsystems, Comprehend various modern micromachining techniques and discuss scaling effects in miniaturizing devices, To discuss and compare various tools and techniques to create microfluidic devices for various BioMEMS and Microfluidic applications.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts, history, materials, and technologies involved in Micro Electro Mechanical Systems (MEMS) and biomedical nanotechnology.
<b>CLOBJ 2</b>	Develop knowledge of microfabrication and micromachining techniques including lithography, etching, ion implantation, wafer bonding, and LIGA processes.
<b>CLOBJ 3</b>	Analyze scaling laws and their significance in MEMS design related to mechanics, electrostatics, fluid mechanics, and heat transfer.
<b>CLOBJ 4</b>	Understand the principles and operation of microfluidic systems, microsensors, actuators, micropumps, and intelligent materials used in biomedical applications.
<b>CLOBJ 5</b>	Develop knowledge of BioMEMS applications in healthcare including drug delivery systems, biosensors, biochips, microneedles, neural prostheses, and catheter-based sensors.
<b>CLOBJ 5</b>	Understand nanotechnology applications in biomedicine, nanofabrication techniques, diagnostic systems, and the effects and toxicity of nanomaterials in the human body.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Describe the fundamental principles of Micro-Electro-Mechanical Systems (MEMS) and Nano-Electro-Mechanical Systems (NEMS).
<b>CLO 2</b>	Explain the design, fabrication, and characterization of MEMS and NEMS devices for biomedical applications.
<b>CLO 3</b>	Analyze the applications of MEMS and NEMS in biomedical fields, including diagnostics, therapeutics, and tissue engineering.
<b>CLO 4</b>	Design and develop MEMS and NEMS-based biomedical devices, such as biosensors, lab-on-a-chip, and implantable devices.
<b>CLO 5</b>	Evaluate the performance and limitations of MEMS and NEMS-based biomedical devices.
<b>CLO 6</b>	Apply microfabrication and nanofabrication techniques to create MEMS and NEMS devices.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage(%)	Teaching Hours
1	<b>Introduction to MEMS</b> MEMS Introduction, Historical Background- Smart materials and structures-Microsystems and their advantages Materials used- Technology involved in MEMS	10%	5
2	<b>Micro Machining Technology</b> Lithography, etching, Ion implantation, Wafer bonding, Integrated processing- Bulk micro machining, Surface micro machining, Coating technology and CVD, LIGA process	20%	8
3	<b>Scaling</b> Scaling in Geometry-Scaling in Rigid, Body Dynamics, Scaling in Electrostatic Forces, Scaling in Electromagnetic Forces-Scaling in Electricity, Scaling in Fluid Mechanics, Scaling in Heat Transfer	10%	5
4	<b>Microfluidic System</b> General principles, Micro sensors, Pressure sensors, Actuators, Electrostatic forces, Piezoelectric crystals, Intelligent materials and structures - Important consideration on microscale fluid, Properties of fluid, Fluid actuation methods, Micro-pumps, Typical Micro-fluidic channel, Micro fluid dispenser	20%	9
5	<b>MEMS Application in Medicine (BioMEMS)</b> Special features/requirements for medical applications. Current scenario of MEMS for health care. Drug delivery systems and MEMS. Application models – Blood pressure sensors – Biochip –Micro needles-Microelectrodes. Neural prosthesis and catheter end sensors	20%	8
6	<b>Biomedical Nanotechnology</b> Nanotechnology and biomedicine- Medical applications of Nanotechnology- Drug synthesis and delivery-Nanobiomedicine and diagnostic	10%	5
7	<b>Nanofabrication Techniques</b> Nanofabrication methods – Nano materials in human body-Toxicity in nano-materials	10%	5
<b>Total:</b>		<b>100 %</b>	<b>45</b>

**i. Text books:**

1. Introduction to Biomems By Albert Folch | CRC Press | 1
2. Microfluidics and Biomems application By Francis E. H. Tay | Springer, Berlin | 1
3. MEMS & Microsystem, Design and manufacture By Tai-Ran Hsu | McGraw Hill, New York | 1

- a. **Course Name:** Ergonomics
- b. **Course Code:** 03023101PE07
- c. **Prerequisite:** Basic knowledge of human anatomy, physiology and biomechanics is required.
- d. **Rationale:** This course will provides students with a comprehensive understanding of the principles and practices of designing and optimizing systems, products, and environments to reduce stress, discomfort, and injury, thereby promoting safety, efficiency, and well-being.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts of ergonomics and human factors engineering in healthcare systems.
<b>CLOBJ 2</b>	Develop knowledge of human-machine interaction, human reliability, and control mechanisms in biomedical and healthcare environments.
<b>CLOBJ 3</b>	Analyze workplace design principles, anthropometric factors, and environmental conditions affecting healthcare workers and patient safety.
<b>CLOBJ 4</b>	Understand physiological stress and fatigue assessment techniques using biomedical signals such as EMG and EEG.
<b>CLOBJ 5</b>	Develop knowledge of ergonomic methodologies including workflow analysis, risk management, simulation-based training, and healthcare system evaluation.
<b>CLOBJ 6</b>	Apply ergonomic principles and patient safety strategies in hospitals, intensive care units, emergency departments, and other healthcare settings.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the fundamentals of ergonomics and human factors in healthcare, and analyze their impact on patient safety, work design, and healthcare worker performance.
<b>CLO 2</b>	Explain the principles of human-machine interaction and evaluate manual, automated, and technological systems involved in healthcare environments.
<b>CLO 3</b>	Design workplace layouts using anthropometry and ergonomic principles for healthcare settings, including environmental considerations and digital workspace ergonomics.
<b>CLO 4</b>	Apply measurement tools and evaluation methods for assessing physical stress, fatigue, and musculoskeletal disorders using EMG and EEG data.
<b>CLO 5</b>	Implement ergonomic methodologies such as cognitive work analysis, workflow simulations, and technology design to improve patient safety and healthcare delivery.
<b>CLO 6</b>	Evaluate ergonomic interventions in various hospital departments (ICU, emergency, primary care, anesthesia, etc.) for improving system performance and safety through real-life case studies.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage(%)	Teaching Hours
1	<b>Ergonomics In Healthcare</b> Human factors and ergonomics in health care, ergonomic challenges in patient safety, work system design in healthcare, effect of workplace on healthcare workers, and healthcare work schedule. Human error in healthcare, error reduction strategies.	15%	6
2	<b>Human–Machine System</b> Human machine interaction, human technological system, manual, mechanical, automated system, human system reliability, human system modeling, Human Output And Control, material handling, motor skill, human control of systems, controls and data entry devices, hand tools and devices.	15%	6
3	<b>Workplace Design</b> Applied anthropometry, workspace design and seating, design of computer worktable, case studies. Environmental conditions. Workplace design.	20%	10
4	<b>Measurement System</b> Physical stress and fatigue measurement using EMG and EEG. Assessment and evaluation tools for musculoskeletal disorder and patient handling techniques. Design of assessment system: Case study. Deep learning in EMG, EEG analysis.	20%	11
5	<b>Ergonomics Methodologies</b> Cognitive work analysis in healthcare, risk management for medical products, analysis of workflow, simulation based trainings, Information technology design and development, programmes and implementation models, 15% 6 patient safety and ergonomics for patient safety. Data analytics in ergonomic analysis.	15%	6
6	<b>Ergonomics Applications In Hospital</b> Human factors and ergonomics in ICU, emergency department, paediatrics, home care, primary care, anaesthesia, medication safety, infection prevention, and surgical excellence. Case study.	15%	6

	<b>Total:</b>	<b>100 %</b>	<b>45</b>
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**i. Text books:**

1. Introduction to Ergonomics By Bridger R S, Taylor and Francis, Pub. Year 2003
2. Advances in Human Factors and Ergonomics in Healthcare By Vincent G. Duffy, Pub. Year 2017
3. Human factors in Engineering and Design By McCormic.E.J., and Sanders.M.S | McGraw Hill, Pub. Year 1993
4. Medical Instrumentation Application and Design By Webster | Wiley India Pte Ltd, Pub. Year 2014
5. Handbook of Human Factors and Ergonomics in Health Care and Patient Safety By Pascale Carayon | CRC Press, Pub. Year 2012
6. Human Factors Engineering and Ergonomics: A Systems Approach By Stephen J. Guastello | CRC Press | Second Edition, Pub. Year 2013

- a. **Course Name:** Medical Instrumentation & Systems
- b. **Course Code:** 03023101PE09
- c. **Prerequisite:** Basic Knowledge of Circuit analysis techniques with dependent sources, equivalence, Basic systems analysis concepts using Laplace techniques and Bode Plots, Transient and frequency response of 1st-order circuit is required.
- d. **Rationale:** This course is offered to aid postgraduate biomedical engineering students by helping them to understand the analog electronic circuits used in signal conditioning in biomedical instrumentation. Because many bioelectric signals are in the microvolt range, noise from electrodes, amplifiers, and the environment is often significant compared to the signal level. This course illustrates how op amps can be used to build instrumentation amplifiers, isolation amplifiers, active filters, and many other systems and subsystems used in biomedical instrumentation.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental principles and characteristics of operational amplifiers used in biomedical instrumentation systems.
<b>CLOBJ 2</b>	Develop knowledge of active filter design, transfer functions, switched capacitor filters, and signal conditioning techniques.
<b>CLOBJ 3</b>	Understand the operation and applications of instrumentation amplifiers, medical isolation amplifiers, and electrical safety standards in medical electronic systems.
<b>CLOBJ 4</b>	Analyze noise sources, noise characteristics, and low-noise amplifier design techniques for biomedical signal acquisition and processing.
<b>CLOBJ 5</b>	Develop knowledge of special analog circuits and systems including oscillators, phase-locked loops, comparators, converters, and sample-and-hold circuits used in biomedical applications.
<b>CLOBJ 6</b>	Understand digital interfacing concepts including sampling theorem, aliasing, analog-to-digital conversion, and digital-to-analog conversion for biomedical instrumentation systems.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Describe the fundamental principles of medical instrumentation, including sensors, transducers, and signal processing.
<b>CLO 2</b>	Explain the operation and application of various medical instruments, such as ECG, EEG, and ultrasound.
<b>CLO 3</b>	Analyze the performance characteristics of medical instruments, including accuracy, precision, and safety.
<b>CLO 4</b>	Design and develop medical instrumentation systems, including hardware and software components.
<b>CLO 5</b>	Evaluate the clinical effectiveness and limitations of medical instrumentation

	systems.
<b>CLO 6</b>	Apply safety and regulatory standards to medical instrumentation systems.
<b>CLO 7</b>	Troubleshoot and maintain medical instrumentation systems.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100 %

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<b>Operational Amplifier Fundamentals</b> Circuits With Resistive Feedback, Static Op Amp Limitations, Dynamic Op-Amp Limitations	10%	5
2.	<b>Active filters</b> The transfer function, first-order active filters, standard second-order responses, KRC filters, filter approximations, cascade design, generalized impedance converters, the switched capacitor, the switched-capacitor filters	25%	11
3.	<b>Instrumentation and Medical Isolation Amplifiers</b> Instrumentation Amps, Medical Isolation Amps, Safety Standards in Medical Electronic Amplifiers, Medical-Grade Power Supplies, Electrical safety issues in medical devices	10%	5
4.	<b>Noise and the Design of Low-Noise Amplifiers for Biomedical Applications</b> Noise Properties, Noise Dynamics, Sources of Noise, Noise Factor and Figure of Amplifiers, Noise in Differential Amplifiers, Effect of Feedback on Noise, Low-Noise Amplifiers, Low-Noise Signal Conditioning System Design	25%	11
5.	<b>Special Analog Circuits and Systems in Biomedical Instrumentation</b> The Phase-Sensitive Rectifier, Phase Detectors, Voltage and Current-Controlled Oscillators, Phase-Locked Loops, IC Thermometers, Voltage Comparators, Sample-and-Hold Circuits, V-F and F-V Converters, Voltage References and Regulators	20%	8
6.	<b>Digital Interfaces</b>	10%	5

	Aliasing and the Sampling Theorem, Digital-to-Analog Converters (DACs), Hold Circuits, Analog-to-Digital Converters (ADCs)		
<b>Total:</b>		<b>100%</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation By Robert B. Northrop | CRC press | 2004
2. Design with Operational Amplifiers and Analog ICs By Sergio Franco | WCB/McGrawHill | 3
3. Design And Development of Medical Electronic Instrumentation By David Prutchi, Michael Norris | John Wiley & Sons, Inc. Publications | 2005

- a. **Course Name:** Embedded Systems and IoT for Biomedical Applications
- b. **Course Code:** 03023101PE11
- c. **Prerequisite:** Basic knowledge of Programming fundamentals (C/C++/Python), Digital Logic, and Microprocessors is required. Basic knowledge of biomedical engineering concepts is also recommended.
- d. **Rationale:** This Course is offered to develop a comprehensive understanding of the technologies behind the embedded systems. It is also used to discover the programming concepts and embedded programming in Linux, discuss the overview of embedded networking and Introduce student to the Internet of things (IOT) with interfacing sensors, actuators for portable gadgets.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts, architectures, and design methodologies of embedded systems for biomedical applications.
<b>CLOBJ 2</b>	Develop knowledge of ARM processors, embedded peripherals, and real-time embedded healthcare monitoring systems.
<b>CLOBJ 3</b>	Understand embedded Linux programming concepts including shell scripting, process management, threading, and single board computer applications.
<b>CLOBJ 4</b>	Analyze embedded networking technologies and communication protocols such as UART, I2C, SPI, WiFi, Bluetooth, Zigbee, and Ethernet.
<b>CLOBJ 5</b>	Develop knowledge of IoT architectures, IoT protocols, cloud connectivity, sensor interfacing, and hardware platforms used in smart healthcare systems.
<b>CLOBJ 6</b>	Apply embedded systems and IoT concepts for biomedical applications including remote healthcare monitoring, smart medical devices, rural healthcare systems, and data-driven healthcare solutions.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the fundamental concepts of embedded systems and their design challenges for biomedical applications.
<b>CLO 2</b>	Apply ARM-based embedded system design techniques to develop healthcare monitoring systems using general-purpose processors.
<b>CLO 3</b>	Demonstrate proficiency in Linux-based embedded programming for biomedical applications using Raspberry Pi or similar SBCs.
<b>CLO 4</b>	Analyze and configure embedded networking protocols (e.g., Zigbee, Wi-Fi, Bluetooth) for medical device communication and data transfer
<b>CLO 5</b>	Design IoT architectures and integrate sensors with cloud platforms to monitor biomedical parameters and manage data.
<b>CLO 6</b>	Evaluate IoT-driven biomedical applications and utilize big data and visualization tools for improving healthcare services in smart environments.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100 %

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<b>Introduction to Embedded Systems</b> Characteristics of embedded computing applications, concepts of real-time systems, general-purpose and customised processors, different architectures, caches, and virtual memory. Embedded design life cycle – Tools used in Design Process – Challenges in Embedded system design for bio-medical applications	10%	5
2.	<b>Health care System design using general purpose processor</b> ARM instruction set, ARM Cortex MX architecture, bus, exception, floating point implementation, memory map, bit banding, peripherals, Programming the peripherals, ADC,DAC, GPIO, Timer, PWM, UART, SPI, I2C, Embedded health care monitoring systems (Temperature, BP, Blood Glucose, non-invasive pulse oximeter, ECG & panic alarm).	20%	8
3.	<b>Embedded Linux programming</b> Fundamentals of Linux, shell scripting, process and thread creation, semaphores, and single board computers (Raspberry Pi).	10%	5
4.	<b>Embedded Networking</b> UART, I2C, WIFI, Bluetooth, Zigbee, Ethernet, Infrastructures for networking , LAN, Routers, Switches, hub, WLAN, Access Points, Hubs, Linux Network configuration Concepts: Networking configurations in Linux Accessing Hardware & Device Files interactions, IP and MAC addressing.	20%	8
5.	<b>IoT Architecture and platforms</b> History of IoT, M2M communication, Web of Things, IoT protocols, IOT reference layer, IoT Communication Pattern, IoT protocol Architecture,6LoWPAN, Security aspects in IoT, Hardware platforms- ARM Cortex Processors, TI	15%	7

	CC3200 Launch pad, Intel Galileo boards, fast prototyping using Proteus, Single board computers (SBC), Aurdino.		
6.	<b>Sensors with Cloud and Internet connectivity</b> Streaming sensor data to Internet, Control of IO ports on Sensor hardware from Internet, Headless systems programming and configuring, Working with MAC Addresses, Cloud Dashboards and Monitoring.	15%	7
7	<b>IoT in Biomedical Applications</b> IoT client and IoT gateway in healthcare, IoT driven smart health care application for everyday use, life critical applications, Health care IOT for rural area, Use of Big Data and Visualization in IoT, Industry4.0 concepts., sensor markup language.	10%	5
<b>Total:</b>		<b>100%</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. The Internet of Things By Samuel Greengard | MIT press | 1
2. Learning Internet of Things By Peter Waher | Packt Publishing | 1
3. "Internet of Things (A Hands-on-Approach)", By Vijay Madiseti and Arshdeep Bahga, | VPT
4. Designing the Internet of Things By Adrian McEwen, Hakim Cassimall | Wiley | 1st

- a. **Course Name:** Biomedical Sensors and Data Acquisition Techniques
- b. **Course Code:** 03023101PE13
- c. **Prerequisite:** Understanding of major body systems along with sensors, transducers, and signal conditioning knowledge is required.
- d. **Rationale:** This Course is offered to relate the principles of bio potential sensing and electrodes to biomedical applications, to identify the type of signal conditioning needed and the data acquisition cards for a specific sensor output, to acquaint the students with the communication standards and PC buses for data acquisition, to introduce virtual instrumentation and the hardware interfacing.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the principles of bioelectric signal generation, bioelectrodes, and electrode-skin interface characteristics used in biomedical measurements.
<b>CLOBJ 2</b>	Develop knowledge of physiological transducers and sensing principles including piezoelectric, thermoelectric, piezoresistive, Hall effect, and magnetostrictive sensors.
<b>CLOBJ 3</b>	Understand the fundamentals of bioelectric signal acquisition, interface systems, and signal quantization techniques.
<b>CLOBJ 4</b>	Analyze the design and operation of bioamplifiers, isolation amplifiers, filtering techniques, and electrical safety measures in biomedical instrumentation.
<b>CLOBJ 5</b>	Develop knowledge of data acquisition systems, DAQ cards, online biosignal monitoring, and waveform acquisition techniques.
<b>CLOBJ 6</b>	Understand interface standards, communication protocols, PC buses, and virtual instrumentation concepts including graphical programming and LabVIEW-based biomedical data acquisition systems.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Explain the principles of bioelectrodes and physiological transducers used in biomedical signal acquisition.
<b>CLO 2</b>	Interpret the structure and configuration of bioelectric signals and apply quantization concepts for signal digitization.
<b>CLO 3</b>	Design and evaluate different types of bio-amplifiers and isolation techniques used in medical instrumentation.
<b>CLO 4</b>	Demonstrate the functionality and applications of DAQ cards in acquiring physiological data with accuracy and speed considerations.
<b>CLO 5</b>	Compare various interface standards and PC bus systems used in biomedical data communication.
<b>CLO 6</b>	Develop and implement virtual instrumentation techniques using graphical tools like LabVIEW for multi-channel biomedical data acquisition.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100 %

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<b>Bioelectrodes</b> Origin of bio potential and its propagation. Electrode-electrolyte interface, Electrode-skin interface, Half-cell potential, Impedance, Polarization effects of electrode – Non-polarizable electrodes. Types of electrodes - Surface, Needle and Micro electrodes and their equivalent circuits. Recording problems - Measurement with two electrodes.	10%	5
2.	<b>Physiological Transducers</b> Thermoresistive – Thermoelectric – Semiconductor - Piezoelectric sensors- Electrets in Capacitive transducers Pyroelectric effect – Piezoresistive effect-strain gauges- Hall Effect-Magnetostrictive effect, SQUID – AC/DC bridges - Temperature compensation	20%	8
3.	<b>Fundamentals of Bioelectric Signal Acquisition</b> Introduction to bioelectric signals- Configuration and structure- Interface systems- Review of quantization in amplitude and time axis	10%	5
4.	<b>Bioamplifiers</b> Need for bio-amplifier - Single ended bio-amplifier, Differential bio-amplifier – Right leg driven ECG amplifier Band-pass filtering, Isolation amplifiers – Transformer and optical isolation - Isolated DC amplifier and AC carrier amplifier. Chopper amplifier- Power line interference, Macroshock and Microshock, Preventive measures to reduce shock hazards.	20%	9
5.	<b>DAQ cards</b> Analog to digital conversion and Data acquisition cards- Analog and digital inputs, Counter timer I/O-accuracy and dynamic range, Speed vs throughput-Acquisition of general waveforms and biosignals- Issues in online monitoring- Web-based	20%	8

	online monitoring.		
<b>6.</b>	<b>Interface Standards and PC Buses</b> RS232, RS422, RS485, GPIB, USB – Firewire - Backplane buses - PCI, PCI-Express, PXI, PXI Express, VME, VXI - Ethernet –TCP/IP protocols.	<b>10%</b>	<b>5</b>
<b>7</b>	<b>Virtual Instrumentation</b> Virtual instrument and traditional instrument, hardware and software-Building Graphical User interfaces for use in data acquisition- Graphical programming- Multi-channel data acquisition in LabVIEW.	<b>10%</b>	<b>5</b>
<b>Total:</b>		<b>100%</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. Biomedical Instrumentation and Measurements By Leslie Cromwell
2. Medical Instrumentation Application and Design By J. G. Webster | John Wiley & Sons, N.Y
3. Introduction to Data Acquisition with LabVIEW By Robert H King | McGraw Hill, NewYork. | 2
4. Handbook of Biomedical Engineering By Joseph Bronzino and Donal R. Peterson | CRC Press | 4th Edition, Pub. Year 2015

- a. **Course Name:** Medical Product Design: Standards & Regulation
- b. **Course Code:** 03023101PE15
- c. **Prerequisite:** Basic understanding of Biomedical Engineering, Medical Device Design, or equivalent; or permission from the instructor.
- d. **Rationale:** The course aims to gain knowledge in various aspects of health informatics and medical standards, to apply these techniques in proper health care delivery.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the concepts of Electronic Patient Records (EPR), healthcare data management, and medical informatics systems.
<b>CLOBJ 2</b>	Develop knowledge of healthcare data standards, medical coding systems, and interoperability standards such as HL7, DICOM, ICD, SNOMED, and HIPAA.
<b>CLOBJ 3</b>	Understand biomedical decision-making processes and the role of clinical decision support systems in healthcare applications.
<b>CLOBJ 4</b>	Develop knowledge of bioinformatics tools and databases used for genomic analysis, sequence alignment, and phylogenetic studies.
<b>CLOBJ 5</b>	Understand hospital design, construction guidelines, and healthcare infrastructure standards followed by national and international organizations.
<b>CLOBJ 6</b>	Analyze voluntary and mandatory hospital standards related to mechanical systems, electrical safety, medical gas systems, and biomedical waste management.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the basic concepts in Biomedical Informatics.
<b>CLO 2</b>	Apply the various aspects of health informatics and medical standards.
<b>CLO 3</b>	Develop clinical decision support systems.
<b>CLO 4</b>	Comprehend the basics of bioinformatics and the resources in the field.
<b>CLO 5</b>	Analyze various bioinformatics tools and explore the databases available in NCBI.
<b>CLO 6</b>	Design and implement the construction standards in a hospital.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme		
L	T	P	C	Internal Evaluation	ESE	Total

				<b>MSE</b>	<b>CE</b>	<b>P</b>	<b>Theory</b>	<b>P</b>	
<b>3</b>	-	-	<b>3</b>	<b>20</b>	<b>20</b>	-	<b>60</b>	-	<b>100 %</b>

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

#### **h. Course Content:**

<b>Sr. No.</b>	<b>Content</b>	<b>Weightage (%)</b>	<b>Teaching Hours</b>
<b>1.</b>	<b>Electronic Patient Record and Standards</b> Electronic Patient Record, Medical data formats, Medical Standards, HL7, DICOM, LOINC, PACS, Medical Standards for Vocabulary, ICD 10, DRG, MeSH, UMLS, SNOMED. Healthcare Standards - JCAHO, HIPAA	<b>15%</b>	<b>6</b>
<b>2.</b>	<b>Electronic Decision Support Systems</b> Biomedical decision making. Probabilistic clinical reasoning. Medical Knowledge and Decision Support, Methods for decision support, Clinical decision-support systems, Strategies for medical knowledge acquisition, Predictive tools for clinical decision support.	<b>20%</b>	<b>9</b>
<b>3.</b>	<b>Bioinformatics Tools</b> NCBI, Human Genome Project, GenBank, Sequence alignment, BLAST, FASTA, CLUSTALW, Phylogenetic analyses.	<b>25%</b>	<b>12</b>
<b>4.</b>	<b>Norms for Hospitals</b> Design and construction standards for the hospitals, BIS -India, JCIA, AIA and NHS, general guidelines and standard for out-patient area, in-patient area and diagnostic area in the hospitals.	<b>20%</b>	<b>9</b>
<b>5.</b>	<b>Standards for Hospitals</b> Voluntary & Mandatory standards, General standards, Mechanical standards, Electrical Standards, Standard for centralized medical gas system, Standards for biomedical waste.	<b>20%</b>	<b>8</b>
<b>Total:</b>		<b>100%</b>	<b>45</b>

#### **i. Text Book and Reference Book:**

1. Biomedical Informatics: Computer Applications in Health Care and Biomedicine (Health Informatics) By Edward H. Shortliffe, James J. Cimino | Springer, New York | 4
2. Medical Informatics: An Executive primer By Kenneth R. Ong | HIMSS Publishing | 1st 2015
3. Web-Based Applications in Healthcare and Biomedicine, Annals of Information Systems By Lazakidou, Athina A., | Springer, New York | 7

- a. **Course Name:** Research Methodology & IPR
- b. **Course Code:** 03020201HM01
- c. **Prerequisite:** Basic Analytical and analysis skill
- d. **Rationale:** The course introduces AI concepts and tools that can be applied to the design process, enabling students to create innovative, efficient, and user-centric designs in various creative domains.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts, objectives, types, and significance of research in scientific and engineering fields.
<b>CLOBJ 2</b>	Develop knowledge of research methodology, research problem formulation, and research process design.
<b>CLOBJ 3</b>	Understand literature review techniques for identifying research gaps, theoretical concepts, and limitations of existing studies.
<b>CLOBJ 4</b>	Analyze and design exploratory, descriptive, and experimental research models for scientific investigations.
<b>CLOBJ 5</b>	Develop skills in mathematical modeling, simulation, experimental analysis, data interpretation, and research-based problem solving.
<b>CLOBJ 6</b>	Understand the fundamentals of Intellectual Property Rights (IPR), patents, copyrights, trademarks, trade secrets, and technology transfer processes.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the basic concepts in Biomedical Informatics.
<b>CLO 2</b>	Understand Mathematical Modeling – Explain the principles of mathematical modeling and its applications in research and problem-solving
<b>CLO 3</b>	Develop Experimental and Simulation Skills – Gain proficiency in designing and executing experiments, as well as using simulation techniques for data-driven research.
<b>CLO 4</b>	Perform Data Analysis and Interpretation – Apply statistical and computational tools to analyze research data and derive meaningful insights
<b>CLO 5</b>	Utilize Simulation Techniques – Implement various simulation methods to model real-world scenarios and validate research hypotheses
<b>CLO 6</b>	Understand Intellectual Property Rights (IPR) – Explain the importance of IPR, including trademarks, copyrights, patents (and their types), trade secrets, and technology transfer in research and innovation.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
4	-	-	4	20	20	-	60	-	100 %

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

#### h. Course Content:

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<b>INTRODUCTION</b> Research: Definition, Characteristics, Motivation and Objectives, Research Methods vs Methodology, Types of Research — Descriptive vs Analytical, Applied vs Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical.	10%	4
2.	<b>METHODOLOGY</b> Research Process, Formulating the Research Problem, Defining the Research Problem, Research Questions, Research Methods vs. Research Methodology.	10%	4
3.	<b>LITERATURE REVIEW</b> Review Concepts and Theories, Identifying and Analyzing the Limitations of Different Approaches	20%	6
4.	<b>FORMULATION AND DESIGN</b> Concept and Importance in Research, features of a Good Research Design, Exploratory Research Design, Concept, Types and Uses, Descriptive Research Designs, Concept, Types and Uses, Experimental Design: Concept of Independent & Dependent Variables .	20%	6
5.	<b>DATA MODELING AND SIMULATIONS:</b> Mathematical Modeling, Experimental Skills, Simulation Skills, Data Analysis and Interpretation.	20%	6
6	<b>INTRODUCTION TO IPR</b> IPR importance, Trademark, copyright, patent and its types, Trade secret, IPR and Technology Transfer	20%	6
<b>Total:</b>		<b>100%</b>	<b>32</b>

#### i. Text Book and Reference Book:

1. John W. Creswell, "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches", SAGE Publications Ltd
2. C.R. Kothari, "Research Methodology: Methods and Techniques", New Age International Publishers.
3. David Silverman, "Qualitative Research", SAGE Publications Ltd

- a. **Course Name:** English for Research Paper Writing
- b. **Course Code:** 03020001MC01
- c. **Prerequisite:** Basic Knowledge about sentence formation using different words in present, past tenses and future time. Also, basic knowledge on use of suitable nouns, adjectives, verbs, preposition, etc.
- d. **Rationale:** To provide a better insight into the effective use of grammar knowledge especially in writing and to put their own thoughts into writing.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the principles and structure of technical and research paper writing for scientific and engineering communication.
<b>CLOBJ 2</b>	Develop effective writing skills for organizing sentences, paragraphs, and research content with clarity, coherence, and conciseness.
<b>CLOBJ 3</b>	Understand methods to avoid ambiguity, redundancy, plagiarism, and improper paraphrasing in academic writing.
<b>CLOBJ 4</b>	Develop knowledge of the structure and purpose of different sections of a research paper including title, abstract, introduction, literature review, methodology, results, discussion, and conclusion.
<b>CLOBJ 5</b>	Enhance skills in presenting research findings, scientific arguments, critical analysis, and scholarly discussion effectively.
<b>CLOBJ 6</b>	Develop the ability to prepare high-quality research manuscripts suitable for journal publication and first-time submission.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand how to improve your writing skills and level of readability
<b>CLO 2</b>	Learn about what to write in each section
<b>CLO 3</b>	Understand the skills needed when writing a Title
<b>CLO 4</b>	Ensure the good quality of paper at the very first-time submission

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	0	-	50	-	-	-	50 %

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

#### **h. Course Content:**

<b>Sr. No.</b>	<b>Content</b>	<b>Weightage (%)</b>	<b>Teaching Hours</b>
<b>1.</b>	<b>Unit 1</b> Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.	<b>16%</b>	<b>5</b>
<b>2.</b>	<b>Unit 2</b> Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction	<b>17%</b>	<b>5</b>
<b>3.</b>	<b>Unit 3</b> Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	<b>17%</b>	<b>5</b>
<b>4.</b>	<b>Unit 4</b> Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.	<b>17%</b>	<b>5</b>
<b>5.</b>	<b>Unit 5</b> Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions.	<b>16%</b>	<b>5</b>
<b>6</b>	<b>Unit 6</b> Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.	<b>16%</b>	<b>5</b>
<b>Total:</b>		<b>99%</b>	<b>30</b>

#### **i. Text Book and Reference Book:**

1. Writing for Science By Goldbort R | Springer
2. How to Write and Publish a Scientific Paper By Day R | Cambridge University Press
3. Handbook of Writing for the Mathematical Sciences By Highman N | SIAM. Highman's book
4. English for Writing Research Papers By Adrian Wallwork | Springer New York Dordrecht Heidelberg London, | 2011

- a. **Course Name:** Disaster Management
- b. **Course Code:** 03021601MC01
- c. **Prerequisite:** Basic knowledge of Environmental Science or Geography
- d. **Rationale:** This course enables students to understand, assess, and manage various types of disasters, their impacts, and mitigation strategies, thereby fostering resilience and sustainable development.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts of disaster, hazard, vulnerability, risk, capacity, and disaster management.
<b>CLOBJ 2</b>	Develop knowledge of different types of natural, technological, biological, and man-made disasters along with their causes, consequences, and control measures.
<b>CLOBJ 3</b>	Understand the disaster management cycle including risk assessment, prevention, preparedness, mitigation, response, rehabilitation, reconstruction, and recovery processes.
<b>CLOBJ 4</b>	Analyze disaster management frameworks, policies, institutional mechanisms, and disaster management practices in India.
<b>CLOBJ 5</b>	Develop knowledge of disaster communication systems, early warning systems, and disaster-safe planning and construction techniques.
<b>CLOBJ 6</b>	Apply modern technologies such as GIS, GPS, and geo-informatics for disaster monitoring, mitigation, preparedness, and management applications.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Differentiate types of disasters, identify their causes, and evaluate their impact on the environment and society.
<b>CLO 2</b>	Analyse disaster damage and apply effective management strategies.
<b>CLO 3</b>	Assess vulnerability and recommend appropriate risk mitigation measures.
<b>CLO 4</b>	Develop a hazard and vulnerability profile using relevant tools and techniques.
<b>CLO 5</b>	Classify structural and non-structural disaster mitigation strategies.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	0	-	50	-	-	-	50 %

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<b>Introduction to Disaster:</b> Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity Disaster and Development and disaster management Types ( Geological Disasters, Hydro-Meteorological Disasters, Biological Disasters, Technological Disasters and Man-made Disasters) , Global Disaster Trends, Causes, Consequences and Control of Disasters.	20%	12
2.	<b>Disaster Management Cycle and Framework:</b> Disaster Management Cycle -Paradigm Shift in Disaster Management, Pre-Disaster -Risk Assessment and Analysis, Risk Mapping, zonation and Microzonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness During Disaster -Evacuation -Disaster Communication -Search and Rescue -Emergency Operation Centre -Incident Command System -Relief and Rehabilitation -Postdisaster -Damage and Needs Assessment, Restoration of Critical Infrastructure -Early Recovery -Reconstruction and Redevelopment; IDNDR, Yokohama Strategy, Hyogo Framework of Action.	30%	14
3.	<b>Disaster Management in India:</b> Disaster Profile, Lessons Learnt from Major Disasters, Disaster Management Act 2005 -Institutional and Financial Mechanism National Policy on Disaster Management, Roles and responsibilities of Government (States, Centre) and other stakeholders- Institutional Processes and Framework at State and Central Level- State Disaster Management Authority (SDMA).	30%	12
4.	<b>Technology for Disaster Management &amp; Mitigation:</b> Geo-informatics in Disaster Management (GIS, GPS), Disaster Communication System (Early Warning system), Land Use Planning and Development Regulations, Disaster Safe Designs and Constructions, Structural and Non-Structural Mitigation of Disasters S&T Institutions for Disaster Management in India.	20%	10
<b>Total:</b>		<b>100%</b>	<b>48</b>

**i. Text Book and Reference Book:**

1. 'Introduction to Disaster Management' By Modh Satish | Macmilan Publishers

## India

2. An overview on natural & man-made disasters and their reduction By R K Bhandani
3. Disaster Administration And Management Text And Case Studies By Goel S. L., | Deep & Deep Publication Pvt. Ltd., New Delhi.
4. Disaster Management By B.Narayan | Rawat Publication



-	0	4	2	-	-	50	-	50	100
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L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**i. List of Practical :**

Sr. No.	List of Practical
1	To perform basic arithmetic operations using LabVIEW.
2	To perform Boolean operations using LabVIEW.
3	To find the sum of 'n' numbers using 'FOR' and 'WHILE' Loop.
4	To perform the factorial of a given number using 'FOR' and 'WHILE' Loop.
5	To perform ARRAY operation using LabVIEW.
6	To perform functions using flat and stacked sequence
7	To perform functions using Case structure.
8	To design sine wave Generator.
9	To perform convolution of two signals.
10	To apply filtering technique for a given input signal.
11	To perform transform technique on the given signal.
12	To apply different windowing technique on the given input signal.
13	To Design a Calculator in LabVIEW.
14	To Design a Traffic-Light Functioning in LabVIEW.
15	To design Temperature Conversion programming using LabVIEW.
16	To generate Random numbers using LabVIEW.
17	To Perform Temperature Sensing (High, Moderate and Low Temperature) in LabVIEW.
18	To acquire and analyze an ECG signal using Lab VIEW.
19	To perform Blood Pressure measurement using LabVIEW.
20	To perform Heart rate measurement and analysis of HRV using LabVIEW.

- a. **Course Name:** Advanced Biomedical Imaging
- b. **Course Code:** 03023102PC03
- c. **Prerequisite:** Basic knowledge of Biomedical Imaging, physics, mathematics, and computer programming is recommended.
- d. **Rationale:** The course aims to provide comprehensive understanding of medical image acquisition in different modalities and the historical evolution of these imaging methods, to acquaint the students with different reconstruction techniques and noise removal for medical images and to apprise the manipulation of acoustic radiation fields for medical applications, to relate all the modules employed in magnetic resonance imaging and to demonstrate knowledge, clinical and technical skills and decision-making capabilities with respect to diagnostic imaging, to investigate the relevant theory to apply imaging principles for 3D visualization. .

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental principles, instrumentation, and applications of medical imaging modalities used in healthcare and biomedical diagnosis.
<b>CLOBJ 2</b>	Develop knowledge of X-ray imaging systems, fluoroscopy, mammography, digital radiography, and computed tomography techniques.
<b>CLOBJ 3</b>	Understand the principles and applications of radioisotopic imaging systems including SPECT, PET, and hybrid imaging modalities.
<b>CLOBJ 4</b>	Analyze ultrasonic imaging systems, wave propagation, transducers, imaging modes, and biomedical ultrasound applications.
<b>CLOBJ 5</b>	Develop knowledge of magnetic resonance imaging principles, pulse sequencing, image acquisition, reconstruction, and functional imaging techniques.
<b>CLOBJ 6</b>	Understand optical imaging modalities, image processing techniques, image segmentation, multimodal image registration, visualization, and treatment planning methods used in medical imaging systems.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Explain the principles and techniques of X-ray imaging, including image formation, digital radiology, and artifacts
<b>CLO 2</b>	Describe and compare various CT imaging methods and reconstruction techniques such as back-projection and FDK algorithms.
<b>CLO 3</b>	Analyze the working and application of SPECT, PET, and other radio-isotopic imaging modalities used in diagnostic imaging.
<b>CLO 4</b>	Demonstrate an understanding of ultrasound imaging systems including wave propagation, transducers, and image generation principles.
<b>CLO 5</b>	Evaluate MRI principles, image acquisition techniques, and functional imaging methods like EPI and diffusion imaging

<b>CLO 6</b>	Apply knowledge of image processing techniques such as segmentation, registration, and data visualization for medical image analysis and treatment planning
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**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theor y	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Topics	Weightage (%)	T
1	<b>X-ray Projection Imaging</b> X-Ray tubes, cooling systems, removal of scatters, Fluoroscopy construction of image -Intensifier tubes, Angiographic setup, Mammography, Scanning methods, Area detectors - Digital radiology, DSA - Electronic portal imaging - Noise, Artefacts.	10%	5
2	<b>X ray Computed Tomography</b> Principles of sectional scanning - CT detectors, Helical CT, Multi-slice CT, Cone beam CT imaging methods - Methods of reconstruction- Iterative, Back projection, convolution and Back-Projection, FDK algorithm - Noise, Artefacts.	10%	5
3	<b>Radio Isotopic Imaging</b> SPECT- Radiation detectors, Radionuclides for imaging, Gamma ray camera, scanners, Positron Emission tomography - Iterative reconstruction algorithms, SPECT/CT, PET/CT registration.	25%	11
4	<b>Ultrasonic Systems</b> Wave propagation and interaction in Biological tissues - Acoustic radiation fields, continuous and pulsed excitation - Transducers and imaging systems - Scanning methods, Imaging Modes, Principles and theory of image generation - lap top style units - Applications.	20%	8
5	<b>Magnetic Resonance Imaging</b> NMR - Principles of MRI, Relaxation processes and their measurements, Pulse sequencing and MR image acquisition, Image reconstruction, Functional MRI, Diffusion imaging, EPI. .	10%	5
6	<b>Optical and other imaging modalities</b> Microscopic imaging principle and applications - Optical coherence tomography, principle, applications - Endoscopic	10%	5

	image processing and applications - Electrical source imaging -Electrical impedance tomography - Microwave imaging.		
7	<b>Image processing for medicine</b> Image segmentation - Computational anatomy - Registration of multimodality images - Synthesis of parametric images - Data visualization -Treatment planning	15%	6
<b>Total:</b>		<b>100%</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. Webb's Physics of Medical Imaging By M A Flower | CRC Press, Florida | 2
2. Medical Imaging Signals and Systems By Jerry L. Prince and Jonathan M. Links | Pearson Education Inc., London | 2
3. Fundamentals of Medical Imaging By Paul Suetterlin | Cambridge University Press, Cambridge | 3
4. Principles of Medical Imaging By K. Kirk Shung, Michael B. Smith, and Benjamin Tsui. | Academic Press

- a. **Course Name:** Advanced Biomedical Imaging Lab
- b. **Course Code:** 03023102PC04
- c. **Prerequisite:** Students are expected to have basic knowledge of Human anatomy and physiology, Fundamentals of biomedical instrumentation, Basics of digital signal and image processing and Physics of radiation and wave propagation.
- d. **Rationale:** This lab course provides practical exposure to core imaging modalities such as X-ray, CT, MRI, Ultrasound, Nuclear Medicine (SPECT/PET), and Optical imaging techniques. By engaging in hands-on simulations, image acquisition, and postprocessing methods, students develop technical competence in operating imaging systems and interpreting diagnostic images. The lab complements theoretical knowledge, enhances diagnostic reasoning, and prepares students for clinical and research applications in biomedical imaging and healthcare technologies.
- e. **Course Learning Objective:**

<b>CLOBJ1</b>	Understand the working principles, components, and operational characteristics of various medical imaging systems.
<b>CLOBJ2</b>	Develop practical knowledge of X-ray imaging systems, computed tomography, and image acquisition techniques.
<b>CLOBJ3</b>	Understand the principles and clinical applications of nuclear imaging modalities such as SPECT and PET systems.
<b>CLOBJ4</b>	Analyze ultrasound imaging techniques including Doppler flow measurement and echocardiography applications.
<b>CLOBJ5</b>	Develop knowledge of magnetic resonance imaging principles, pulse sequences, and MRI system operation.
<b>CLOBJ6</b>	Understand endoscopic imaging and biomedical image processing techniques used in diagnostic and clinical applications.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Demonstrate the working principles of X-ray, CT, MRI, Ultrasound, and nuclear medicine imaging systems.
<b>CLO 2</b>	Operate and simulate basic imaging equipment and analyze output images.
<b>CLO 3</b>	Apply image enhancement and segmentation techniques using software tools
<b>CLO 4</b>	Evaluate medical images for anatomical and pathological features.
<b>CLO 5</b>	Interpret and document diagnostic imaging findings in a clinical context.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	0	2	1	-	-	20	-	30	50

**h. List of Practical :**

Sr. No.	List of Practical
1	Study and demonstration of X-ray system components and image acquisition.
2	Study and demonstration of Computed Tomography Machine
3	Study on Working principle and analysis of SPECT and PET imaging.
4	Demonstration of Ultrasound imaging and Doppler effect for blood flow measurement.
5	Study of NMR principles and pulse sequences.
6	Study of Single Photon Emission Computed Tomography.
7	Study of Positron Emission Tomography
8	Study of Magnetic Resonance Imaging systems.
9	Study of Color Doppler Flow Imaging and 2-D echo Cardiography.
10	Study Endoscopic image processing.

- a. **Course Name:** Biofluid Mechanics in Cardiovascular Systems
- b. **Course Code:** 03023102PC05
- c. **Prerequisite:** Fundamentals Knowledge of Anatomy and Physiology of Heart, Blood Flow is required.
- d. **Rationale:** The course aims to attain comprehensive knowledge and understanding of the vascular system, the heart and the blood system in terms of function and basic structure. This will enable the students to understand the types of blood flow that occurs into the blood vessel and how blood interacts with the walls of the blood vessel. The reason for emphasizing on the fundamental aspects is that it will provide a detailed understanding of the properties associated with the system.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental principles of fluid mechanics and solid mechanics related to biomedical systems and physiological flows.
<b>CLOBJ 2</b>	Develop knowledge of fluid properties, viscosity, flow dynamics, Reynolds number, Bernoulli's equation, and pulsatile blood flow in biological systems.
<b>CLOBJ 3</b>	Understand the mechanical behavior of biological materials including elasticity, stress-strain relationships, viscoelasticity, and vessel wall mechanics.
<b>CLOBJ 4</b>	Analyze the structure and function of the cardiovascular system, cardiac muscle physiology, blood circulation, and hemodynamic parameters.
<b>CLOBJ 5</b>	Develop knowledge of hematology, blood rheology, blood vessel mechanics, vascular pathologies, and clinical cardiovascular conditions.
<b>CLOBJ 6</b>	Understand the mechanics, clinical significance, and biomedical applications of natural and prosthetic heart valves and vascular implants.

f. **Course Learning Outcomes:**

<b>CLO 1</b>	Explain key fluid mechanics concepts such as viscosity, shear stress, Reynolds number, and Poiseuille's Law in the context of biomedical applications
<b>CLO 2</b>	Apply principles like Bernoulli's equation, flow rate calculations, and the Womersley number to understand blood flow in arteries and veins
<b>CLO 3</b>	Analyze the mechanical behavior of biological tissues under stress and strain, using concepts like Poisson's ratio, Hooke's Law, and viscoelasticity
<b>CLO 4</b>	Examine blood composition, measure blood viscosity, and analyze the rheological behavior of blood in health and disease.
<b>CLO 5</b>	Apply fluid and solid mechanics principles to solve real-world biomedical problems, such as cardiovascular diagnostics, prosthetics, and medical device design.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<p><b>Review of Basic Fluid Mechanics Concepts</b>            A Brief History of Biomedical Fluid Mechanics, Fluid Characteristics and Viscosity: Displacement, Shear stress, Fundamental Method for Measuring Viscosity: Introduction to Pipe Flow, Reynolds number, Poiseuille's law, Flow rate, Bernoulli Equation, Conservation of Mass: Venturi meter example, Example Problem: Fluid Statics, The Wormersley Number, <math>\alpha</math>, a Frequency Parameter for Pulsatile Flow.</p>	15%	6
2	<p><b>Introduction to Solid Mechanics</b>            Introduction to Mechanics of Materials: Elastic Behavior, Engineering and True Strain, Incremental Elastic Modulus, Poisson's Ratio, Shearing Stresses and Strains, Generalized Hooke's Law, Bulk Modulus, Analysis of Thin Walled Cylindrical Tubes, Analysis of Thick-Walled Cylindrical Tubes: Equilibrium Equation, Compatibility Condition, Viscoelasticity.</p>	15%	6
3	<p><b>Cardiovascular Structure and Function</b>            Introduction, Clinical Features, Functional Anatomy, The Heart as a Pump, Cardiac Muscle: Bio potential in myocardium, Excitability, Automaticity, Heart Valves: Clinical features, Cardiac Cycle, Heart Sounds: Clinical features, Factors Influencing Flow and Pressure, Coronary Circulation: Control of the coronary circulation, Clinical features, Pulmonary Circulation and Gas Exchange in the Lungs, Cerebral and Renal Circulations: Cerebral Circulation, Renal Circulation, Microcirculation: Capillary structure, Capillary wall structure.</p>	20%	10
4	<p><b>Hematology and Blood Rheology</b>            Introduction, Elements of Blood, Blood Characteristics, Erythrocytes: Hemoglobin, Clinical Features, Erythrocyte indices, Abnormalities of the blood, Leukocytes: Neutrophils, Lymphocytes, Monocytes, Eosinophils, Basophils, Leukemia, Thrombocytes, Blood Types: Rh blood groups, M and N blood group system, Plasma: Plasma viscosity, Electrolyte composition of plasma, Blood pH, Clinical Features.</p>	20%	11

5	<b>Anatomy and Physiology of Blood Vessels</b> Introduction, General Structure of Arteries: Tunica intima, Tunica media, Tunica externa, Types of Arteries: Elastic arteries, Muscular arteries, Arterioles, Mechanics of Arterial Walls, Compliance, Pressure-Strain Modulus, Vascular Pathologies: Atherosclerosis, Stenosis, Aneurysm, Thrombosis, Clinical aspects, Stents, Coronary Artery Bypass Grafting: Arterial grafts.	15%	6
6	<b>Mechanics of Heart Valves</b> Introduction, Aortic and Pulmonic Valves, Mitral and Tricuspid Valves, Clinical Features, Prosthetic Mechanical Valves: Case study–the Björk-Shiley convexo-concave heart valve, Prosthetic Tissue Valves.	15%	6
<b>Total:</b>		<b>100 %</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. Biofluid mechanics in cardiovascular system By Lee Waite | . Mc Grawhill
2. Biofluid Mechanics By Krishna B. Chandran, Stanley E. | The Human Circulation | 2
3. Biomechanics: Circulation By Y.C.Fung | Springer Verlay. New York
4. Biofluid Dynamics By P. Nithiarasu | School of Engineering, Swansea University, SWansea
5. Biofluid Mechanics By Jagan. N. Mazumdar | World scientific
6. The Cardiovascular System: Mathematical Modeling, Numerical Algorithms  
By A.; Manzoni, A.; Vergara, C., Politecnico di Milano, Milano

- a. **Course Name:** Biofluid Mechanics in Cardiovascular Systems Lab
- b. **Course Code:** 03023102PC06
- c. **Prerequisite:** Fundamentals Knowledge of Human Physiology, Fluid Mechanics and Biomechanics is must
- d. **Rationale:** This laboratory course is designed to provide students with practical insights into fluid mechanics and biomechanics as applied in biomedical engineering. Through experiments on blood flow, pressure measurement, elasticity of biological tissues, and ECG analysis, students will develop a foundational understanding of how physical principles govern physiological functions. The lab bridges theoretical knowledge with real-world applications, preparing students for roles in clinical diagnostics, biomedical device development, and research.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental principles of fluid mechanics and solid mechanics through biomedical engineering experiments.
<b>CLOBJ 2</b>	Develop practical skills in measuring fluid properties, viscosity, flow rate, pressure variations, and Reynolds number in fluid flow systems.
<b>CLOBJ 3</b>	Apply principles of Poiseuille’s law, Bernoulli’s theorem, and Venturi meter analysis for biomedical fluid flow applications.
<b>CLOBJ 4</b>	Analyze mechanical properties of biological materials including stress-strain behavior and Poisson’s ratio.
<b>CLOBJ 5</b>	Develop practical knowledge of physiological measurements such as blood pressure monitoring, ECG recording, and blood group identification.
<b>CLOBJ 6</b>	Understand and analyze blood flow characteristics and flow dynamics in prosthetic heart valve systems and cardiovascular applications.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Apply Poiseuille’s law and Bernoulli’s principle to analyze blood flow in simulated environments.
<b>CLO 2</b>	Differentiate between laminar and turbulent flow using Reynolds number in biomedical systems.
<b>CLO 3</b>	Perform mechanical testing on biological materials and interpret stress-strain behavior.
<b>CLO 4</b>	Use appropriate tools to measure and analyze physiological parameters such as blood pressure and ECG.
<b>CLO 5</b>	Demonstrate basic laboratory techniques in hematology such as blood grouping.
<b>CLO 6</b>	Simulate and interpret flow dynamics in prosthetic valves and cardiovascular models

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50 %

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

**h. List Of Practicals:**

Sr. No.	List Of Practicals
1.	Determine the viscosity of liquids using a viscometer and apply Poiseuille's Law.
2.	Observe laminar and turbulent flow transitions and calculate Reynolds number.
3.	Use a Bernoulli's apparatus to measure pressure variations along a streamline.
4.	Calculate flow rate through a Venturi meter and compare with theoretical values.
5	Study elastic behavior by plotting stress-strain curves for biological samples.
6	Measure lateral and longitudinal strain to calculate Poisson's ratio.
7	Use a sphygmomanometer to measure blood pressure and analyze results.
8	Record and interpret ECG signals, identifying key waveforms and heart rate.
9	Determine ABO and Rh blood groups using agglutination reactions.
10	Simulate blood flow through prosthetic valves and analyze flow patterns.

- a. **Course Name:** Biomedical Image Processing and Analysis
- b. **Course Code:** 03023102PE01
- c. **Prerequisite:** Introduction to Biomedical Engineering, programming fundamentals (MATLAB/Python/C++) and mathematical prerequisites (Linear Algebra, Calculus, Probability/Statistics) is required.
- d. **Rationale:** The course aims to define the principles of image sampling, quantization, enhancement and filtering techniques, to discover the different image compression methods and morphological based processes and machine learning techniques for image segmentation, to develop the methods of image registration and visualization for medical applications, to acquire the student with the techniques of shape analysis and image classification using neural networks for brain computer interface and computer aided diagnosis.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts of digital image processing, image perception, image modeling, sampling, and transformation techniques.
<b>CLOBJ 2</b>	Develop knowledge of image enhancement, restoration, filtering methods, and noise reduction techniques used in biomedical imaging applications.
<b>CLOBJ 3</b>	Understand image compression techniques and morphological image processing operations for efficient image analysis and segmentation.
<b>CLOBJ 4</b>	Analyze machine learning-based image segmentation methods and dimensionality reduction techniques such as PCA, SVD, and ICA.
<b>CLOBJ 5</b>	Develop knowledge of medical image registration, image fusion, and visualization techniques used in multimodal biomedical imaging systems.
<b>CLOBJ 6</b>	Apply image classification, clustering, neural network approaches, and statistical analysis techniques for biomedical image interpretation and analysis.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Explain the fundamental concepts of biomedical image processing and analysis
<b>CLO 2</b>	Apply image processing techniques, such as filtering, segmentation, and registration on medical images.
<b>CLO 3</b>	Analyze biomedical images using various techniques, including feature extraction and pattern recognition
<b>CLO 4</b>	Implement image processing algorithms using programming languages, such as MATLAB or Python.
<b>CLO 5</b>	Evaluate the quality and limitations of biomedical images and image processing techniques.

<b>CLO 6</b>	Apply biomedical image processing and analysis techniques to real-world applications, such as medical diagnosis and research.
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**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	2	20	20	-	60	-	100 %

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<b>Image Fundamentals</b> Image perception- Image model- Image sampling and quantization - 2D DFT and DCT.	10%	3
2.	<b>Image Enhancement and Filtering</b> Image enhancement- Histogram modelling, Spatial operations - Image restoration, Noise models, Image degradation model, Wiener filtering, Maximum entropy restoration.	10%	3
3.	<b>Image Compression and Morphological Processing</b> Image compression - Lossy and lossless Compression, Predictive techniques - Dilation, Erosion, Open, Close, Skeleton operations, Tophat algorithm - Morphology based segmentation.	15%	5
4.	<b>Image Segmentation</b> Machine Learning based segmentation algorithms - Singular Value Decomposition (SVD) -Principal Component Analysis and its applications - Support Vector Machine and its applications -Independent Component Analysis and its application	25%	7
5	<b>Image Registration and Visualization</b> Image Registration - Medical image Fusion, SPECT/CT, MR/CT, PET/CT - Image visualization -Volume Rendering, Surface rendering and Maximum Intensity Projection.	15%	5
6	<b>Shape Analysis and Image Classification</b> Topological attributes - Shape orientation descriptors, Fourier descriptors, - K means clustering, machine learning, Neural Network approaches- Statistical Parametric Mapping in Imaging -Regression analysis.	25%	7

<b>Total:</b>	<b>100%</b>	<b>30</b>
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**i. Text Book and Reference Book:**

1. Biomedical Imaging: Principles and Applications By Reiner Salzer | Wiley, New Jersey. | 1st 2012
2. Brain-Computer Interfaces: Principles and Practice By Jonathan Wolpaw, Elizabeth Winter, (Eds.) | Oxford University Press, Oxford | 1st 2012
3. 3D Imaging, Analysis and Applications By Pears, Nick, Liu, Yonghuai, Bunting, Peter (Eds.) | Springer, Berlin | 2
4. Digital Image Processing By Rafael C. Gonzalez and Richard E. Woods | Pearson Education | Third Edition
5. Digital Image Processing By S Sridhar | Oxford University press

- a. **Course Name:** Biomedical Image Processing and Analysis Lab
- b. **Course Code:** 03023102PE02
- c. **Prerequisite:** Working knowledge of programming tools like MATLAB, Python, or OpenCV is required.
- d. **Rationale:** This lab course is designed to provide hands-on experience with biomedical image processing techniques including image enhancement, segmentation, filtering, registration, and classification. Through the use of software tools and real-world biomedical datasets, students will explore and implement algorithms to analyze and visualize medical images. The lab activities aim to reinforce theoretical concepts, develop problem-solving skills, and foster innovation in the development of automated diagnostic solutions and clinical decision support systems.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts and tools used in digital image processing with MATLAB/Python environments.
<b>CLOBJ 2</b>	Develop practical skills in image enhancement techniques including histogram equalization, smoothing, averaging, sharpening, and intensity slicing.
<b>CLOBJ 3</b>	Apply spatial filtering, edge detection, and morphological operations for medical image analysis and preprocessing.
<b>CLOBJ 4</b>	Understand and implement image segmentation techniques including ROI extraction and watershed algorithms.
<b>CLOBJ 5</b>	Develop knowledge of image restoration, transform techniques, and image compression methods for biomedical imaging applications.
<b>CLOBJ 6</b>	Analyze and process medical images using computational techniques for improved visualization, feature extraction, and diagnostic interpretation.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Implement and visualize fundamental operations such as image sampling, quantization, and basic transforms (DFT/DCT) on medical images.
<b>CLO 2</b>	Apply image enhancement techniques including filtering, histogram equalization, and noise reduction for improving image quality.
<b>CLO 3</b>	Perform morphological operations and implement various compression algorithms to process biomedical images.
<b>CLO 4</b>	Apply image registration and visualization techniques to align and interpret multi-modality medical image data.
<b>CLO 5</b>	Develop shape analysis and classification models using clustering and neural networks to support diagnostic applications.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	0	-	50	-	-	-	50 %

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

**h. List Of Practicals:**

Sr. No.	List Of Practicals
1.	Introduction to Image Processing Concepts using MATLAB/Python
2.	Perform Histogram Equalization for Image Contrast Enhancement
3.	Apply Smoothing and Averaging Filters in the Spatial Domain.
4.	Implement Morphological Operations Opening and Closing on Medical Image.
5	Perform Region of Interest (ROI) Selection and Extraction from Medical Images
6	Implementation of edge detection algorithm on Medical Image.
7	Implementation of Gradient Mask Techniques for Sharpening Images.
8	Implementation of Image Intensity slicing technique for image enhancement.
9	Implementation of image restoring techniques.
10	To Implement Image Compression algorithm.
11	Implementation of Transform techniques on Medical Images.
12	Implementation of Watershed Algorithm on Images.

- a. **Course Name:** Biomedical Equipment
- b. **Course Code:** 03023102PE03
- c. **Prerequisite:** Fundamentals Knowledge of Medical Electronics, Biomedical Instrumentation is required.
- d. **Rationale:** The course aims to discuss and express the basic principle, working and design of various bio potential recording equipment. To acquaint the students with the different types of flowmeters and radiation detectors and the analytical equipment used in medical field.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the principles, recording methods, waveform characteristics, and clinical significance of bioelectric signals such as ECG, EEG, EMG, PCG, and EOG.
<b>CLOBJ 2</b>	Develop knowledge of analytical and diagnostic biomedical instruments used in hospitals and clinical laboratories.
<b>CLOBJ 3</b>	Understand the working principles, operation, and performance characteristics of cardiac devices including pacemakers, defibrillators, and heart-lung machines.
<b>CLOBJ 4</b>	Analyze the principles, components, and monitoring systems of hemodialysis machines and artificial kidney systems.
<b>CLOBJ 5</b>	Develop knowledge of ventilators, respiratory support systems, anaesthesia delivery systems, and breathing circuits used in critical care applications.
<b>CLOBJ 6</b>	Understand the biomedical instrumentation and monitoring techniques used for patient diagnosis, life support, and therapeutic applications in healthcare systems.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand and demonstrate the working principles and clinical significance of bio-potential recording systems including ECG, EEG, EMG, and EOG.
<b>CLO 2</b>	Operate and analyze diagnostic instruments such as blood flow meters, pulmonary analyzers, blood gas analyzers, and understand their applications in clinical laboratories.
<b>CLO 3</b>	Explain the construction, working, and clinical relevance of cardiac devices including pacemakers, defibrillators, and heart-lung machines.
<b>CLO 4</b>	Analyze the principles, types, and components of hemodialysis machines, including portable systems and wearable artificial kidneys.

<b>CLO 5</b>	Understand and evaluate various types of ventilators and anesthesia systems, their control mechanisms, and applications in critical care
<b>CLO 6</b>	Perform laboratory-based practicals for biomedical equipment and apply theoretical knowledge to simulate, troubleshoot, and interpret clinical diagnostic results.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	2	20	20	-	60	-	100 %

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<b>Bio Potential Recording</b> Introduction to ECG, EEG, EMG, PCG, EOG, lead system and recording methods, typical waveform, frequency spectrum, abnormal waveforms. Evoked response, Electroencephalography, Electrocardiography, Electromyography.	15%	5
2.	<b>Analytical &amp; Diagnostic Instruments</b> Common analytical equipment used in hospitals and those in Biochemistry laboratories - Blood Flow meters - Pulmonary function analyzers - Blood gas analyzers - Blood pressure measurement - Blood cell counters.	15%	5
3.	<b>Cardiac Devices</b> External and Implantable Pacemaker, Performance aspects of Implantable Pacemaker - DC defibrillator, Modes of operation and electrodes, Performance aspects of dc-defibrillator, Implantable defibrillator, defibrillator analyzers - Heart lung machine- Different types of Oxygenators, Pumps.	25%	7

4.	<b>Hemodialysis Machine</b> Basic principle of Hemodialysis and its type - Membrane, Dialysate, Different types of hemodialyzers, Monitoring Systems, Portable and Wearable Artificial Kidney, Implanting Type - Different types of dialyzer membrane.	20%	6
5	<b>Ventilators and Anaesthesia System</b> Basic principles of ventilators, Different generators, Inspiratory phase and expiratory phase, Different ventilator adjuncts, Neonatal ventilators, Ventilator testing - Breathing Apparatus Operating Sequence, Electronic IPPB unit with monitoring for all respiratory parameters. Anaesthesia - Need of anaesthesia, Gas used and their sources, Gas blending and vaporizers, Anaesthesia delivery system, Breathing circuits.	25%	7
<b>Total:</b>		<b>100%</b>	<b>30</b>

**i. Text Book and Reference Book:**

1. "Introduction to Biomedical Equipment Technology" By Carr & Brown, | Pearson Education, Asia.
2. Medical Instrumentation Application and Design By J. G. Webster | John Wiley & Sons, N.Y
3. Handbook of Biomedical Instrumentation By R. S. Khandpur | Tata McGraw Hill, New Delhi

**b. Course Code:** 03023102PE04

**c. Prerequisite:** Basic understanding of Medical Electronics, Biomedical Instrumentation, and knowledge of physiological systems such as cardiovascular and respiratory systems. Familiarity with the operation of hospital-based biomedical equipment is required.

**d. Rationale:** This lab aims to provide hands-on experience with critical biomedical equipment used in clinical and diagnostic settings. Through practical implementation, students will understand the working principles, calibration, and troubleshooting of devices such as ECG/EEG/EMG machines, analytical instruments, ventilators, pacemakers, dialysis units, and anesthesia systems. This will strengthen their ability to operate, analyze, and validate biomedical systems, bridging the gap between theory and clinical application.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the identification, handling, and application of biomedical electrodes and patient cable systems used for physiological signal acquisition.
<b>CLOBJ 2</b>	Develop practical skills in measuring and recording physiological parameters such as ECG, EEG, EMG, and blood pressure.
<b>CLOBJ 3</b>	Understand the operation, calibration, and maintenance procedures of biomedical diagnostic instruments and monitoring systems.
<b>CLOBJ 4</b>	Develop knowledge of the components, working principles, and operational procedures of hemodialysis machines.
<b>CLOBJ 5</b>	Analyze the performance and functioning of biomedical therapeutic devices such as defibrillators, ventilators, and anesthesia machines.
<b>CLOBJ 6</b>	Apply biomedical instrumentation techniques for patient monitoring, clinical diagnosis, and healthcare equipment management in medical environments.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Demonstrate the ability to operate and analyze signal acquisition equipment such as ECG, EEG, and EMG machines for biopotential recording.
<b>CLO 2</b>	Use and evaluate analytical diagnostic tools including blood gas analyzers, flow meters, and pulmonary analyzers
<b>CLO 3</b>	Simulate and explain the function and programming of cardiac devices like pacemakers and defibrillators.
<b>CLO 4</b>	Identify the components of hemodialysis equipment and demonstrate its working principles and safety protocols.
<b>CLO 5</b>	Operate ventilators and anesthesia machines, understanding their control settings and critical care applications.

<b>CLO 6</b>	Analyze real-time biomedical data from equipment and apply troubleshooting skills to ensure proper functionality and patient safety.
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**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50 %

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. List Of Practicals:**

Sr. No.	List Of Practicals
1.	Identification of ECG electrodes and patient cable.
2.	Identification of EEG electrodes and patient cable.
3.	Identification of EMG electrodes.
4.	Measurement of blood pressure using a sphygmomanometer.
5	Identification of components of a hemodialysis machine.
6	Calibration and maintenance of ECG machine.
7	To obtain EEG of patient using EEG machine.
8	Demonstration of EMG system performance.
9	Demonstration of blood cell counter operation.
10	Identify parts of Hemodialysis machine
11	Demonstration of defibrillator operation.
12	Demonstration of ventilator and Anesthesia machine operation.

- a. **Course Name:** Bioinformatics
- b. **Course Code:** 03023102PE05

- c. Prerequisite:** Basic knowledge of Molecular Biology, Genetics, and Biochemistry is required
- d. Rationale:** This course is designed to provide a comprehensive foundation in the concepts, tools, and techniques used in the field of bioinformatics. It focuses on the computational analysis of biological data such as DNA, RNA, and protein sequences. Through this course, students will understand how to utilize algorithms for sequence alignment, phylogenetic analysis, and protein structure prediction, along with tools like BLAST, HMMs, and neural networks. Emphasis is also laid on scripting using PERL for automation and data handling. The course aims to prepare students for advanced research and applications in genomics, proteomics, and systems biology.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts of bioinformatics, computational biology, biological databases, and operating system utilities used in biological data analysis.
<b>CLOBJ 2</b>	Develop knowledge of biological sequence analysis, pairwise and multiple sequence alignment methods, and sequence comparison algorithms.
<b>CLOBJ 3</b>	Understand phylogenetic analysis methods, evolutionary tree construction techniques, and protein structure prediction approaches.
<b>CLOBJ 4</b>	Analyze machine learning techniques and bioinformatics tools used in genomics, proteomics, systems biology, and drug discovery applications.
<b>CLOBJ 5</b>	Develop knowledge of genome assembly, functional annotation, microarray analysis, and computational methods in biological research.
<b>CLOBJ 6</b>	Apply PERL programming concepts, file handling, and scripting techniques for bioinformatics data processing and analysis.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand and apply fundamental bioinformatics tools, databases, and operating systems used for biological data analysis.
<b>CLO 2</b>	Perform sequence analysis using various alignment techniques and algorithms such as BLAST, Needleman-Wunsch, and SmithWaterman
<b>CLO 3</b>	Evaluate evolutionary relationships through phylogenetic analysis using different tree-building methods and molecular clock concepts.
<b>CLO 4</b>	Predict protein structures and analyze protein functions using machine learning techniques, structural genomics, and pattern recognition models like HMM and SVM.
<b>CLO 5</b>	Develop and execute PERL scripts for handling biological data, performing text mining, and automating repetitive bioinformatics tasks.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	2	20	20	-	60	-	100 %

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<b>Introduction</b> Introduction to Operating systems, Linux commands, File transfer protocols ftp and telnet, Introduction to Bioinformatics and Computational Biology, Biological sequences, Biological databases, Genome specific databases, Data file formats, Data life cycle, Database management system models, Basics of Structured Query.	15%	4
2.	<b>Sequence Alignment</b> Sequence Analysis, Pair wise alignment, Dynamic programming algorithms for computing edit distance, string similarity, shotgun DNA sequencing, end space free alignment. Multiple sequence alignment, Algorithms for Multiple sequence alignment, Generating motifs and profiles, Local and Global alignment, Needleman and Wunsch algorithm, Smith Waterman algorithm, BLAST, PSIBLAST and PHIBLAST algorithms.	20%	6
3.	<b>Phylogenetic Methods</b> Introduction to phylogenetics, Distance based trees UPGMA trees, Molecular clock theory, Ultrametric trees, Parsimonious trees, Neighbour joining trees, trees based on morphological traits, Bootstrapping. Protein Secondary structure and tertiary structure prediction methods, Homology modeling, abinitio approaches, Threading, Critical Assessment of Structure Prediction, Structural genomics.	25%	8

4.	<b>Protein Structure Analysis</b> Machine learning techniques: Artificial Neural Networks in protein secondary structure prediction, Hidden Markov Models for gene finding, Decision trees, Support Vector Machines. Introduction to Systems Biology and Synthetic Biology, Microarray analysis, DNA computing, Bioinformatics approaches for drug discovery, Applications of informatics techniques in genomics and proteomics: Assembling the genome, STS content mapping for clone contigs, Functional annotation, Peptide mass fingerprinting.	20%	6
5	<b>Perl Programming</b> Basics of PERL programming for Bioinformatics: Data types: scalars and collections, operators, Program control flow constructs, Library Functions: String specific functions, User defined functions, File handling.	20%	6
<b>Total:</b>		<b>100%</b>	<b>48</b>

**i. Text Book and Reference Book:**

1. Biomedical Informatics: Computer Applications in Health Care and Biomedicine (Health Informatics) By Edward H. Shortliffe, James J. Cimino | Springer, New York | 4
2. Medical Informatics: An Executive primer By Kenneth R. Ong | HIMSS Publishing | 1st 2015
3. Web-Based Applications in Healthcare and Biomedicine, Annals of Information Systems By Lazakidou, Athina A | Springer, New York | 7th

**a. Course Name:** Bioinformatics Lab

**b. Course Code:** 03023102PE06

**c. Prerequisite:** Basic knowledge of Biology, Genetics, and Molecular Biology is required.

**d. Rationale:** This laboratory course provides hands-on experience with essential bioinformatics tools and techniques used for analyzing biological data. It emphasizes real-time problem-solving in sequence analysis, gene prediction, phylogenetics, protein modeling, and data mining using various bioinformatics software and databases. The lab equips students with technical expertise to handle large biological datasets, perform computational analysis, and develop scripts for automating

bioinformatics tasks. It bridges the gap between biology and computational sciences, empowering students for research and industrial applications in genomics, proteomics, and personalized medicine.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the practical applications of bioinformatics tools and computational techniques for biological data analysis.
<b>CLOBJ 2</b>	Develop practical skills in sequence alignment, genome assembly, genomic annotation, and phylogenetic analysis using standard bioinformatics software tools.
<b>CLOBJ 3</b>	Apply computational methods for protein structure prediction, molecular interaction analysis, and biomolecular visualization.
<b>CLOBJ 4</b>	Develop knowledge of transcriptomic and clinical genomics data analysis using modern bioinformatics pipelines and tools.
<b>CLOBJ 5</b>	Understand multi-omics data integration, biological network analysis, and machine learning applications in bioinformatics.
<b>CLOBJ 6</b>	Apply scripting and programming techniques for biological database retrieval, data processing, and bioinformatics workflow automation.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Retrieve and interpret biological data using public databases and tools like BLAST.
<b>CLO 2</b>	Perform sequence alignment and gene prediction using standard algorithms and tools.
<b>CLO 3</b>	Construct phylogenetic trees and analyze evolutionary relationships using software tools.
<b>CLO 4</b>	Visualize and model protein structures using online and offline tools.
<b>CLO 5</b>	Analyze gene expression and protein interaction networks using computational platforms.
<b>CLO 6</b>	Apply scripting in Perl/Python for automating biological data processing tasks

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme		
L	T	P	C	Internal Evaluation	ESE	Total

				<b>MSE</b>	<b>CE</b>	<b>P</b>	<b>Theory</b>	<b>P</b>	
-	-	<b>2</b>	<b>1</b>	-	-	<b>20</b>	-	<b>30</b>	<b>50 %</b>

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

#### **h. List Of Practicals:**

<b>Sr. No.</b>	<b>List Of Practicals</b>
<b>1.</b>	To perform pairwise sequence alignment using BLAST.
<b>2.</b>	To perform multiple sequence alignment using ClustalW.
<b>3.</b>	To assemble a genome using SPAdes.
<b>4.</b>	To annotate genomic data using Prokka.
<b>5</b>	To predict protein structure using Swiss-Model.
<b>6</b>	To analyze protein-protein interaction networks using STRING.
<b>7</b>	To construct a phylogenetic tree using MEGA.
<b>8</b>	To analyze RNA-Seq data using HISAT2 and DESeq2.
<b>9</b>	To predict molecular interactions using AutoDock.
<b>10</b>	To visualize 3D structures of biomolecules using PyMOL.
<b>11</b>	To integrate multi-omics data using Cytoscape.
<b>12</b>	To script bioinformatics tasks using Biopython.
<b>13</b>	To retrieve biological data from public databases like NCBI.
<b>14</b>	To analyze clinical genomics data using GATK.
<b>15</b>	To apply machine learning techniques in bioinformatics using Scikit-learn.

**a. Course Name:** Artificial Intelligence Tools and Technologies

**b. Course Code:** 03023102PE07

**c. Prerequisite:** Basic knowledge of programming and Strong foundation in Data Structures and Algorithms is must.

**d. Rationale:** This course introduces students to the foundational concepts and modern approaches of AI including intelligent agent design, search algorithms, knowledge representation, logical reasoning, and machine learning. The course further explores Artificial Neural Networks (ANNs) and their real-world applications. It equips students with the theoretical understanding and algorithmic tools required for developing intelligent systems and solving complex computational problems across various domains.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts, history, and applications of Artificial Intelligence and intelligent agent systems.
<b>CLOBJ 2</b>	Develop knowledge of search techniques, heuristic algorithms, and game-playing strategies used in AI problem solving.
<b>CLOBJ 3</b>	Understand knowledge representation methods, logical reasoning, rule-based systems, and uncertainty handling techniques in artificial intelligence.
<b>CLOBJ 4</b>	Analyze inference mechanisms, machine learning approaches, decision trees, reinforcement learning, and statistical learning methods.
<b>CLOBJ 5</b>	Develop knowledge of artificial neural networks, their architectures, activation functions, and learning mechanisms.
<b>CLOBJ 6</b>	Apply AI and neural network concepts for data processing, signal analysis, image analysis, and intelligent biomedical applications.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the fundamentals and scope of Artificial Intelligence including intelligent agents, rationality, and problem formulation
<b>CLO 2</b>	Apply classical and heuristic search strategies to solve computational problems and optimize decision-making.
<b>CLO 3</b>	Represent and infer knowledge using logic, semantic nets, rules, and probabilistic models.
<b>CLO 4</b>	Analyze and implement reasoning techniques including forward/backward chaining, decision trees, and reinforcement learning approaches.
<b>CLO 5</b>	Comprehend the structure and functioning of Artificial Neural Networks and implement ANN-based solutions for classification and decision-making problems.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	2	20	20	-	60	-	100 %

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<p><b>Introduction Artificial Intelligence</b>            AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation.</p>	15%	4
2.	<p><b>AI Search and Game Playing Strategies</b>            Searching- Searching for solutions, uniformed search strategies – Breadth first search, depth first Search. Search with partial information (Heuristic search) Hill climbing, A*, AO* Algorithms. Problem reduction, Game Playing Adverbial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning and Evaluation functions.</p>	25%	8
3.	<p><b>Knowledge Representation and Reasoning in AI</b>            Knowledge representation issues, predicate logic- logic programming, semantic nets- frames and inheritance, constraint propagation, representing knowledge using rules, rules based deduction systems. Reasoning under uncertainty, review of probability, Baye’s probabilistic interferences and dempstershafer theory.</p>	15%	4
4.	<p><b>Logical Inference, Learning, and Reasoning</b>            First order logic. Inference in first order logic, propositional vs. first order inference, unification &amp; lifts forward chaining, Backward chaining, Resolution, Learning from observation Inductive learning, Decision trees, Explanation based learning, Statistical Learning methods, Reinforcement Learning.</p>	20%	6

<b>5</b>	<p><b>Artificial Neural Networks: Structure, Function, and Applications</b></p> <p>Artificial Neural Networks (ANN) and their biological roots and motivations. ANNs as numerical data/signal/image processing devices. a summing dendrite, synapses and their weights, pre- and postsynaptic signals, activation potential and activation function. Excitatory and inhibitory synapses. The biasing input. Types of activating functions. Encoding (training phase) and decoding (active phase). Taxonomy of neural networks:-feedforward and recurrent networks with supervised and unsupervised learning laws, static &amp;dynamic processing systems</p>	<b>25%</b>	<b>8</b>
<b>Total:</b>		<b>100%</b>	<b>30</b>

**i. Text Book and Reference Book:**

1. Artificial Intelligence – A Modern Approach By S. Russel and P. Norvig | Pearson Education | Second Edition
2. Computational Intelligence: a logical approach By David Poole, Alan Mackworth, Randy Goebel | Oxford University Press
3. Artificial Intelligence: Structures and strategies for Complex Problem Solving. By Luger G.F. and Stubblefield W.A | Addison Wesley, 6th edition., Pub. Year 2008
4. Artificial Intelligence: A New Synthesis, Harcourt Publishers By N. J. Nilsson | Harcourt Publishers

- a. **Course Name:** Artificial Intelligence Tools and Technologies Lab
- b. **Course Code:** 03023102PE08
- c. **Prerequisite:** Students enrolling in this lab should possess Working knowledge of any programming language also Basic understanding of AI concepts such as search strategies, reasoning, and learning.
- d. **Rationale:** The lab enables students to develop solutions using AI algorithms such as uninformed and informed search, game playing strategies, knowledge-based systems, decision trees, and neural networks. It prepares students to apply AI techniques in real-world scenarios, enhance logical and problem-solving skills, and work on AI tools and environments.



-	-	2	1	-	-	20	-	30	50 %
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**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

**h. List Of Practicals:**

Sr. No.	List Of Practicals
1.	Develop a simple reflex agent or model-based agent that reacts to environmental changes.
2.	Implement Breadth-First Search (BFS) and Depth-First Search (DFS) for solving a graph-based problem.
3.	Implement Hill Climbing Algorithm and A Algorithm* for an optimization problem.
4.	Develop a Tic-Tac-Toe or Chess AI using the Mini-Max Algorithm.
5	Optimize the Mini-Max algorithm using Alpha-Beta Pruning.
6	Implement Forward Chaining and Backward Chaining for logical inference.
7	Build a decision tree classifier for a given dataset using ID3 or C4.5 Algorithm.
8	Apply Naïve Bayes Algorithm for text classification (e.g., spam detection).
9	Train and test a simple Feedforward Neural Network using Backpropagation Algorithm for handwritten digit recognition (MNIST dataset).
10	Implement Q-Learning Algorithm for an AI agent to learn an optimal policy in a grid-based environment (e.g., solving a maze).
11	Solve a Sudoku puzzle or 8-Queens problem using a constraint satisfaction approach such as Backtracking or Forward Checking.
12	Develop a Fuzzy Inference System (FIS) for applications like weather prediction or automatic fan speed control using Mamdani or Sugeno method.

**a. Course Name:** Applied Biomechanics

**b. Course Code:** 03023102PE09

**c. Prerequisite:** Basic knowledge of Human Anatomy & Physiology, Mechanics of Solids, and Fluid Mechanics is required.

**d. Rationale:** This course is offered for understanding the principles of solid and fluid mechanics, forces and relevant motions in day-to-day motion or activities. The course aims to make students familiar with the application of biomechanics in motion and exercises and research.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts, principles, and scope of biomechanics in medicine and biomedical engineering applications.
<b>CLOBJ 2</b>	Develop knowledge of kinematic and kinetic principles for qualitative and quantitative analysis of human movement.
<b>CLOBJ 3</b>	Understand the structure, growth, development, and mechanical behavior of human bone tissue under physiological loading conditions.
<b>CLOBJ 4</b>	Analyze the biomechanics of skeletal articulations including joint stability, flexibility, and common musculoskeletal disorders and injuries.
<b>CLOBJ 5</b>	Develop knowledge of skeletal muscle structure, function, force generation, muscular performance, and muscle injury mechanisms.
<b>CLOBJ 6</b>	Understand the biomechanics of upper and lower extremities, load distribution, equilibrium, stability, balance, and human body movements.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand and apply the principles of solid mechanics including stress-strain relationships, elasticity, and mechanical properties of biological tissues.
<b>CLO 2</b>	Analyze fluid mechanics concepts related to blood flow and body fluids using principles of viscosity, flow types, and physiological fluid dynamics.
<b>CLO 3</b>	Examine joint biomechanics by studying human motion, types of joints, and mechanical forces acting on joints.
<b>CLO 4</b>	Evaluate the role of biomechanics in sports and rehabilitation by applying motion analysis techniques like gait and postural analysis.
<b>CLO 5</b>	Interpret cardiovascular biomechanics by understanding heart valve mechanics, blood rheology, and vessel-wall interactions
<b>CLO 6</b>	Investigate musculoskeletal injuries and disease conditions based on biomechanical analysis of stress, loading, and movement mechanics

**g. Teaching & Examination Scheme:**

<b>Teaching Scheme</b>				<b>Evaluation Scheme</b>		
<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>	<b>Internal Evaluation</b>	<b>ESE</b>	<b>Total</b>

				<b>MSE</b>	<b>CE</b>	<b>P</b>	<b>Theory</b>	<b>P</b>	
<b>3</b>	-	-	<b>3</b>	<b>20</b>	<b>20</b>	-	<b>60</b>	-	<b>100 %</b>

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

#### **h. Course Content:**

<b>Sr. No.</b>	<b>Content</b>	<b>Weightage (%)</b>	<b>Teaching Hours</b>
<b>1.</b>	<b>Introduction to Biomechanics</b> Scope of biomechanics, concept of force, moment, center of gravity, equilibrium. Importance of biomechanics in medicine and engineering. Overview of human musculoskeletal system.	<b>10%</b>	<b>4</b>
<b>2.</b>	<b>Kinematic and Kinetics for Analyzing Human Motion</b> <b>Kinematic:</b> Forms of Motion, Standard Reference Terminology, Joint Movement Terminology, Qualitative Analysis of Human Movement, Tools for Measuring Kinematic Quantities. <b>Kinetics:</b> Basic Concepts, Mechanical Loads on the Human Body, The Effects of Loading, Tools for Measuring Kinetic Quantities, Vector Algebra.	<b>15%</b>	<b>7</b>
<b>3.</b>	<b>Biomechanics of Human Bone Growth and Development</b> Composition and Structure of Bone Tissue, Bone Growth and Development, Bone Response to Stress, Osteoporosis, Common Bone Injuries.	<b>10%</b>	<b>4</b>
<b>4.</b>	<b>Biomechanics of Human Skeletal Articulations</b> Joint Architecture, Joint Stability, Joint Flexibility, Techniques for Increasing Joint Flexibility, Common Joint Injuries and Pathologies: Sprains, Dislocations, Bursitis, Arthritis, Rheumatoid Arthritis, Osteoarthritis.	<b>10%</b>	<b>4</b>

5	<b>Biomechanics of Human Skeletal Muscle</b> Behavioral Properties of the Musculotendinous Unit, Structural Organization of Skeletal Muscle, Skeletal Muscle Function, Factors Affecting Muscular Force Generation, Muscular Strength, Power, and Endurance, Common Muscle Injuries: Strains, Contusions, Cramps, Delayed-Onset Muscle Soreness, Compartment Syndrome	20%	10
6	<b>Biomechanics of Lower and Upper Extremities</b> <b>Lower Extremities:</b> Structure and movements of hip joint, Loads on the hip; structure and movements of knee, Loads on the knee; Structure and movements of ankle; Foot structure and movements, Loads on the ankle and foot. <b>Upper Extremities:</b> Structure and movements of shoulder joint, Loads on the shoulder; Structure and movements of elbow joint, loads on the elbow; Structure and movements of wrist, loads on wrist; Structure and movements of joints of the hand.	25%	12
7	<b>Equilibrium and Human Movements</b> Anatomical levers in the human body, Equilibrium, Equation of static and dynamic equilibrium, Center of Gravity of human body, Stability and balance	10%	4
<b>Total:</b>		<b>100%</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. Basic Biomechanics By Sujan J Hall | Mc Graw Hill
2. Biomechanics: Mechanical Properties of Living Tissues By Y C Fung | Springer | 2nd edition, Pub. Year 1993
3. Fundamental of Biomechanics By Knudson Duane | Springer | Second Edition, Pub. Year 2007
4. Biomechanics- Principles and Applications By D. J. Schneck and J. D. Bronzino | CRC Press | 2nd edition, Pub. Year 2000

5. **Course Name:** Medical Optics

6. **Course Code:** 03023102PE11

7. **Prerequisite:** Basic knowledge of Analog & Digital Electronics, Physics, & engineering mathematics is required.

8. **Rationale:** The course aims to understand various aspects of optics in Tissues, to identify and develop an understanding for various applications of laser in diagnosis and therapy.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the optical properties of biological tissues and the principles
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	of laser-tissue interactions in biomedical applications.
<b>CLOBJ 2</b>	Develop knowledge of photonic instrumentation including light sources, optical filters, detectors, and measurement systems used in biomedical optics.
<b>CLOBJ 3</b>	Understand the principles and clinical applications of lasers in surgical procedures such as ophthalmology, dermatology, dentistry, urology, and tissue welding.
<b>CLOBJ 4</b>	Analyze non-thermal optical diagnostic techniques including optical coherence tomography, fluorescence imaging, Raman spectroscopy, elastography, and holographic imaging.
<b>CLOBJ 5</b>	Develop knowledge of therapeutic laser applications including phototherapy, photodynamic therapy, bio-stimulation, and related biomedical treatment techniques.
<b>CLOBJ 6</b>	Understand laser safety standards, procedures, and precautions required for biomedical and clinical laser applications.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the optical properties of biological tissues and describe various laser-tissue interactions (chemical, thermal, mechanical, etc.) relevant to biomedical applications.
<b>CLO 2</b>	Demonstrate knowledge of instrumentation used in photonics, including detectors, light sources, and measurement techniques for absorption, scattering, and emission in biological samples.
<b>CLO 3</b>	Evaluate and explain surgical applications of lasers in different medical domains like dermatology, urology, ophthalmology, and tissue welding.
<b>CLO 4</b>	Analyze non-thermal diagnostic techniques using laser-based imaging methods for medical diagnostics.
<b>CLO 5</b>	Explain principles and therapeutic applications of lasers in treatments such as photodynamic therapy (PDT), including oncology and photo bio-stimulation, while considering safety protocols.

**g. Teaching & Examination Scheme:**

<b>Teaching Scheme</b>				<b>Evaluation Scheme</b>		
<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>	<b>Internal Evaluation</b>	<b>ESE</b>	<b>Total</b>

				<b>MSE</b>	<b>CE</b>	<b>P</b>	<b>Theory</b>	<b>P</b>	
<b>3</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>20</b>	<b>20</b>	<b>-</b>	<b>60</b>	<b>-</b>	<b>100 %</b>

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

#### **h. Course Content:**

<b>Sr. No.</b>	<b>Content</b>	<b>Weightage (%)</b>	<b>Teaching Hours</b>
<b>1.</b>	<b>Optical Properties of the Tissues</b> Refraction, Scattering, Absorption, Light transport inside the tissue, Tissue properties, Laser Characteristics as applied to medicine and biology-Laser tissue Interaction-Chemical-Thermal-Electromechanical – Photoablativ processes.	<b>10%</b>	<b>7</b>
<b>2.</b>	<b>Instrumentation In Photonics</b> Instrumentation for absorption, Scattering and emission measurements, excitation light sources high pressure arc lamp, LEDs, Lasers, Optical filters, - optical detectors Time resolved and phase resolved detectors.	<b>20%</b>	<b>9</b>
<b>3.</b>	<b>Surgical Applications Of Lasers</b> Lasers in ophthalmology- Dermatology – Dentistry-Urology- Otolaryngology - Tissue welding.	<b>25%</b>	<b>10</b>
<b>4.</b>	<b>Non-Thermal Diagnostic Applications</b> Optical coherence tomography, Elastography, Laser Induced Fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM – Holographic and speckle application of lasers in biology and medicine.	<b>25%</b>	<b>10</b>
<b>5</b>	<b>Therapeutic Applications</b> Phototherapy, Photodynamic therapy (PDT) - Principle and mechanism - Oncological and nononcological applications of PDT - Bio stimulation effect – applications-Laser Safety Procedures.	<b>20%</b>	<b>9</b>
<b>Total:</b>		<b>100%</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. Laser-Tissue Interaction Fundamentals and Applications By MarkolfH.Niemz | Crime Analysis and Prediction in 7 states of India using statistical software Rstudio, 4th Internati | 2007
2. Introduction to Biophotonics By Paras N. Prasad | A. John Wiley and Sons, Inc. Publications | 2003
3. Handbook of Biomedical Instrumentation By R. S. Khandpur | Tata McGraw Hill, New Delhi
4. Medical Instrumentation Application and Design By J. G. Webster | John Wiley & Sons, N.Y

**a. Course Name:** Design of Medical Implants and Artificial Organs

**b. Course Code:** 03023102PE13

**c. Prerequisite:**Basic knowledge of Human Anatomy and Physiology, Biomechanics, Biomaterial and implants, CAD is required.

**d. Rationale:** This course is essential for biomedical engineering students to understand the principles and practices of designing medical implants and artificial organs. This course provides students with the knowledge and skills necessary to design, develop, and test medical implants and artificial organs that are safe, effective, and compatible with the human body.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the anatomy and organization of major human organ systems and the concepts of artificial organ replacement.
<b>CLOBJ 2</b>	Develop knowledge of the mechanical properties of biological materials and biomedical design principles used in artificial organ and implant

	development.
<b>CLOBJ 3</b>	Understand the design, materials, manufacturing, and clinical considerations of dental, ophthalmic, and orthopedic implants.
<b>CLOBJ 4</b>	Analyze the engineering challenges, functional requirements, and biomechanical aspects of artificial replacements for bones, joints, lungs, heart, and skin.
<b>CLOBJ 5</b>	Develop knowledge of rapid prototyping techniques, patient-specific implant design, CAD-based biomedical modeling, and implant characterization methods.
<b>CLOBJ 6</b>	Understand the manufacturing, testing, sterilization, ethical considerations, and medical device standards associated with biomedical implants and artificial organs.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the human body's superficial anatomy and major organ systems, and explain the basic concept and scope of artificial organ development.
<b>CLO 2</b>	Explain mechanical properties of biomaterials and apply the principles of adaptive and safety-based design in the context of biomedical applications.
<b>CLO 3</b>	Analyze the biomechanical considerations and design of dental and ophthalmic implants, including contact lenses and bionic eye systems.
<b>CLO 4</b>	Evaluate orthopedic implant needs based on clinical conditions, and design considerations for spinal, hip, and knee replacements
<b>CLO 5</b>	Understand the structure, function, and design principles behind artificial organs like heart, lung, valves, and skin replacements.
<b>CLO 6</b>	Demonstrate knowledge of rapid prototyping techniques, CAD-based design, material testing, and ethical issues in the biomedical device market.

**g. Teaching & Examination Scheme:**

<b>Teaching Scheme</b>				<b>Evaluation Scheme</b>					
<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>	<b>Internal Evaluation</b>			<b>ESE</b>		<b>Total</b>
				<b>MSE</b>	<b>CE</b>	<b>P</b>	<b>Theory</b>	<b>P</b>	
<b>3</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>20</b>	<b>20</b>	<b>-</b>	<b>60</b>	<b>-</b>	<b>100 %</b>

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation,

CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<p><b>Overview of Human System and Its Artificial Replacement</b>                      Human Body's Superficial Anatomy, Body Size, Type, and Proportion, A Brief Outline of the Organization of the Human System, Major Organ Systems, and Brief Idea of Artificial Organs</p>	10%	5
2.	<p><b>Mechanical Properties of Biological Materials, Basics of Design Process</b>                      Adoptive and Adaptive Design, Introduction to Machine Design, Principle of Science or Mechanism to Be Used, Safety of Products: Material and Design Safety aspects, Manufacturability, Standardization, Customization.</p>	15%	7
3.	<p><b>Dental and Eye Implants</b>  <b>Dental Implants:</b> Their Design and Manufacture, Types of Implants in Use, Surface Characteristics, Loading Conditions, Clinical and Biomechanical Considerations for Fixed Tooth Replacement.  <b>Eye and Its Artificial Replacement:</b> Ophthalmic Disorders, Types-Classification and Manufacturing of Contact Lenses, Complications associated with contact lenses, Bionic Eye.</p>	20%	9
4.	<p><b>Orthopedic</b>                      Fracture fixation: Clinical reasons and Functional requirements of fracture fixation devices, Fracture fixation designs. Clinical reasons, Functional requirements, design, Materials used and Design concerns in spinal implants, knee replacements, Hip implant and Its Artificial Replacement. Engineering challenges and design constraints of orthopedic implants</p>	20%	9

<b>5</b>	<p><b>Lung, Heart and Skin</b> Lungs Its transplantation and Artificial replacement, Design of the Total Artificial Heart, The Design of Heart Valves, Skin and the Design of Artificial Skin.</p>	<b>15%</b>	<b>7</b>
<b>6</b>	<p><b>Rapid prototyping in biomedical engineering</b> Introduction, definition of RP systems, Material properties of structural biomaterials, Rapid prototyping – a novel manufacturing approach, Patient-Specific Implants design. Design of various artificial implants in CAD, their Design, testing and characterization. The Medical Device Market and Ethical Issues of Implants, The Manufacturing, Testing, and Sterilization of Implants.</p>	<b>20%</b>	<b>8</b>
<b>Total:</b>		<b>100%</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. Biomaterials: The Intersection of Biology and Materials Science By J.S. Temenoff and A.G. Mikos | Pearson
2. Biomaterials Science: An Introduction to Materials in Medicine By Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen , Jack E. Lemons | Academic Press, Pub. Year 2012
3. Design of Biomedical Devices and Systems By Paul H. King, Richard C. Fries | CRC Press
4. Orthopaedic Biomechanics: Mechanics and Design in Musculoskeletal Systems By Bartel, Davy, Keaveny | Pearson
5. Artificial Organs By Gerald E. Miller | Morgan & Claypool Publishers, Pub. Year 2006
6. Rapid Prototyping in Biomedical Engineering By Bopaya Bidanda | Springer

**a. Course Name:** Medical Robotics

**b. Course Code:** 03023102PE15

**c. Prerequisite:** Basic knowledge of Human Anatomy & Physiology, Mechanics, Sensors, Actuators, and Control Systems is required.

**d. Rationale:** The increasing integration of robotics in the healthcare domain requires biomedical engineers to understand robotic systems, their design, and application in medical and surgical procedures. The course provides an in-depth understanding of Robotic kinematics, dynamics, and control for medical applications, Application-specific robotic solutions in surgery, rehabilitation, and diagnostics, Technological advancements like steerable needles and brain-machine interfaces, Real-time challenges in designing and integrating medical robotic systems.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamental concepts, classifications, components, and mechanical configurations of robotic systems and manipulators.
<b>CLOBJ 2</b>	Develop knowledge of robot kinematics, workspace analysis, forward and inverse kinematics, and mathematical modeling of robotic systems.
<b>CLOBJ 3</b>	Understand spatial positioning, orientation, linkage mechanisms, and motion analysis of robotic manipulators used in biomedical applications.
<b>CLOBJ 4</b>	Analyze robotic systems used in surgical procedures including orthopedic, urologic, cardiac, radiosurgical, and image-guided robotic applications.
<b>CLOBJ 5</b>	Develop knowledge of rehabilitation robotics, robotic-assisted surgery, brain-machine interfaces, haptic systems, and robotic guidance technologies.
<b>CLOBJ 6</b>	Understand the integration of robotics and healthcare technologies for advanced medical diagnosis, rehabilitation, minimally invasive surgery, and patient care applications.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the fundamental structure and classification of robotic systems, along with mathematical modeling, configuration spaces, and kinematics.
<b>CLO 2</b>	Analyze spatial positioning, orientation, and symbolic representation of robotic arms and manipulators for medical applications.
<b>CLO 3</b>	Explore and solve robotic kinematic problems, including inverse solutions for different joint configurations used in surgical robots.
<b>CLO 4</b>	Identify and describe the diverse medical disciplines and surgical procedures where robotic systems are used, such as orthopedics, urology, and cardiac surgeries.
<b>CLO 5</b>	Evaluate rehabilitation systems, haptic feedback mechanisms, and advanced technologies such as brain-machine interfaces, used in medical robotics.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	3	20	20	-	60	-	100 %

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<p><b>Introduction to robots</b>  Robots as mechanical devices - Classification of robotic manipulators - Robotic systems - Accuracy and repeatability - Wrists and end-effectors - Mathematical modeling of robots - Symbolic representation of robots - The configuration space - The state space - The workspace common kinematic arrangements of manipulators - Forward kinematics - Inverse kinematics - Velocity kinematics.</p>	20%	9
2.	<p><b>Spatial Position and Orientation of Robots</b>  Kinematic aspects of robotic systems, including Angles, Linkages, Three-Joint Robot, and Standardizing Kinematic Analysis. Explore the classification of robotic manipulators, robotic systems, accuracy, repeatability, wrists, endeffectors, mathematical modeling, symbolic representation, configuration space and the state space.</p>	20%	9
3.	<p><b>Robot Kinematics</b>  Exploration of robotic systems, encompassing Three-Joint Robot, Six- Joint Robot, Inverse Solution for the SevenJoint DLR-Kuka Robot, along with C-arm, Center-of-Arc Kinematics, and Surgical Microscopes.</p>	15%	6
4.	<p><b>Applications of Surgical Robotics</b>  Comprehensive coverage of medical disciplines including Radiosurgery, Orthopedic Surgery, Urologic Surgery, Robotic Imaging, and Cardiac Surgery, highlighting the diverse realms of expertise in the field.</p>	20%	9

<b>5</b>	<b>Rehabilitation and Surgery using Robotics</b> Assisted laparoscopic surgery, Haptic feedback in robotic heart surgery, Robotic applications in neurosurgery, Miniature robotic guidance for spine surgery, A comprehensive study covering Rehabilitation for Limbs, BrainMachine Interfaces, and the innovative field of Steerable Needles, delving into the advancements and applications in each area to address diverse aspects of healthcare and technology integration	<b>25%</b>	<b>12</b>
<b>Total:</b>		<b>100%</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. Medical Robotics By Achim Schweikard, Floris Ernst | Springer | 2015
2. Medical Robotics By Vanja Bozovic | Springer | 2008
3. Robot Modeling and Control By Mark W. Spong, Seth Hutchinson, M. Vidyasagar | John Wiley & Sons | 2005

**a. Course Name:** Waste to Energy

**b. Course Code:** 03022002UE01

**c. Prerequisite:** Basic knowledge of environmental science, thermodynamics, and chemical engineering processes.

**d. Rationale:** This course focuses on the technological advancements and engineering principles used to convert waste materials into energy. It gives students an in-depth understanding of thermochemical, biochemical, and physicochemical conversion techniques. The course emphasizes sustainability, energy recovery efficiency, and waste management practices in line with environmental regulations.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the fundamentals of waste management, energy recovery, and various waste-to-energy conversion technologies.
<b>CLOBJ 2</b>	Develop knowledge of thermochemical conversion processes such as incineration, pyrolysis, and gasification for energy generation from waste

	materials.
<b>CLOBJ 3</b>	Understand biochemical conversion techniques including anaerobic digestion, fermentation, biogas production, biodiesel generation, and landfill gas recovery.
<b>CLOBJ 4</b>	Analyze physicochemical conversion methods such as transesterification, refuse-derived fuels, briquetting, and pelletisation for sustainable waste utilization.
<b>CLOBJ 5</b>	Develop knowledge of integrated waste-to-energy systems, operational principles of WTE plants, and real-world case studies from India and other countries.
<b>CLOBJ 6</b>	Understand the environmental, economic, regulatory, and sustainability aspects associated with waste-to-energy technologies and waste management systems.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Understand the fundamentals of waste classification and energy conversion pathways.
<b>CLO 2</b>	Analyze thermochemical, biochemical, and physicochemical methods of energy recovery from waste.
<b>CLO 3</b>	Evaluate real-world waste-to-energy systems in terms of efficiency, feasibility, and environmental compliance.
<b>CLO 4</b>	Design conceptual WtE systems based on types of waste and energy needs.
<b>CLO 5</b>	Interpret policy frameworks and perform economic assessments for waste-to-energy projects.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
4	-	-	4	20	20	-	60	-	100 %

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

#### h. Course Content:

Sr. No.	Content	Weightage (%)	Teaching Hours
1.	<b>Introduction to Waste Management and Energy Conversion</b> Definition of waste, types of waste, need for energy recovery, classification of waste-to-energy technologies, and energy flow in ecosystems.	15%	9
2.	<b>Thermochemical Conversion</b> Incineration, pyrolysis, gasification - processes, reaction mechanisms, products, design considerations, advantages & limitations	25%	15
3.	<b>Biochemical Conversion</b> Anaerobic digestion, fermentation - microbial pathways, process parameters, biogas production, biodiesel from waste oil, landfill gas recovery.	20%	12
4.	<b>Physicochemical Conversion</b> Transesterification, refuse-derived fuels (RDF), briquetting, pelletisation.	15%	9
5	<b>Waste to Energy Technologies and Case Studies</b> Overview of WTE plants, Integrated MSW systems, success stories from India and abroad.	15%	9
6	<b>Environmental and Economic Aspects</b> Emissions, ash disposal, life-cycle analysis, policy and regulatory frameworks, cost-benefit analysis.	10%	6
<b>Total:</b>		<b>100%</b>	<b>60</b>

#### i. Text Book and Reference Book:

1. Waste to Energy Conversion Technology (TextBook) By Naomi B Klinghoffer and Marco J. Castald | Woodhead Publishing, Pub. Year 2013
2. Waste-to-Energy Recent Developments and Future Perspectives towards Circular Economy By Abd El-Fatah Abomohra, Qingyuan Wang, Jin Huang | Springer Nature, Pub. Year 2022
3. Biomass to Renewable Energy Processes (TextBook) By Jay Cheng | CRC Press | 2nd, Pub. Year 2017

- a. **Course Name:** Pedagogy Studies
- b. **Course Code:** 03020002MC01
- c. **Prerequisite:** A basic familiarity with education systems, classroom teaching-learning processes, and introductory research concepts is required.
- d. **Rationale:** This course aims to develop a critical and research-informed understanding of pedagogical practices, curriculum, teacher education, and professional development, with a special focus on evidence-based approaches and contextual challenges.

**e. Course Learning Objective:**

<b>CLOBJ 1</b>	Understand the aims, rationale, conceptual frameworks, theories of learning, and research methodologies related to pedagogy and education systems.
<b>CLOBJ 2</b>	Develop knowledge of pedagogical practices, curriculum design, and teacher education approaches used in formal and informal learning environments.

<b>CLOBJ 3</b>	Analyze the effectiveness of pedagogical strategies, teacher beliefs, curriculum support systems, and evidence-based teaching practices.
<b>CLOBJ 4</b>	Understand the role of professional development, peer support, community participation, and institutional support in improving teaching and learning outcomes.
<b>CLOBJ 5</b>	Identify barriers to effective learning such as limited resources, large class sizes, and curriculum-related challenges in educational settings.
<b>CLOBJ 6</b>	Develop the ability to analyze research gaps, educational contexts, curriculum frameworks, and future directions in pedagogy and teacher education research.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Remember key concepts, theories of learning, and pedagogical terminology relevant to curriculum and teacher education.
<b>CLO 2</b>	Understand diverse pedagogical practices used in formal and informal classroom contexts.
<b>CLO 3</b>	Apply appropriate research methodologies to evaluate the effectiveness of pedagogical practices.
<b>CLO 4</b>	Analyze evidence from educational studies to assess strengths, limitations, and research gaps in pedagogy.
<b>CLO 5</b>	Evaluate professional development models and curriculum frameworks to recommend context-sensitive improvements

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	0	-	50	-	-	-	50 %

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE** Continuous Evaluation, **ESE-** End Semester Examination

**h. Course Content:**

<b>Sr. No.</b>	<b>Content</b>	<b>Weightage (%)</b>	<b>Teaching Hours</b>
1.	<b>Introduction and Methodology</b> Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions, Overview of methodology and Searching	25%	6
2.	<b>Thematic overview</b> Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education.	13%	6
3.	<b>Evidence on the effectiveness of pedagogical practices Methodology for the in-depth stage</b> Quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change, Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches, Teacher's attitudes and beliefs and Pedagogic strategies	25%	6
4.	<b>Professional development</b> Alignment with classroom practices and follow-up support, Peer support Support from the head teacher and the community Curriculum and assessment Barriers to learning: limited resources and large class sizes	25%	6
5	<b>Research Gaps</b> Research gaps and future directions, Research design, Contexts Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.	12%	6
<b>Total:</b>		<b>100%</b>	<b>30</b>

**i. Text Book and Reference Book:**

1. Education for All, the Quality Imperative and the Problem of Pedagogy By Alexander, R | CREATE, University of Cambridge, Pub. Year 2008
2. Teaching for Quality Learning at University By Biggs, J. & Tang, C | Open University Press, Pub. Year 2011

3. Studying Teacher Education: The Report of the AERA Panel on Research and Teacher Education By Cochran-Smith, M., & Zeichner, K. | Lawrence Erlbaum Associates, Pub. Year 2005
4. Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement By Hattie, J. | Routledge, Pub. Year 2009
5. Education 2030: Incheon Declaration and Framework for Action By UNESCO | UNESCO, Pub. Year 2015
6. National Curriculum Framework By NCERT | NCERT, Pub. Year 2005