COEP Technological University

(COEP Tech)

A Unitary Public University of Government of Maharashtra

w.e.f 21st June 2022

(Formerly College of Engineering Pune)

Department of Instrumentation and Control Engineering

Curriculum Structure & Detailed Syllabus (PG Program)

M. Tech -Artificial Intelligence in Healthcare

(Effective from: A.Y. 2025-26)

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	4	5.88
PSBC	Program Specific Bridge Course	1	3	4.41
PCC	Program Core Course	5	16	23.53
PEC	Program Specific Elective Course	3	9	13.24
LC	Laboratory Course	6	6	8.82
VSEC	Vocational and Skill Enhancement Course	3	20	29.42
OE	Open Elective	1	3	4.41
SLC	Self-Learning Course	2	6	8.82
MLC	Mandatory Learning Course	1	0	0
CCA	Co-curricular & Extracurricular Activities	1	1	1.47
	Total	**24**	**68**	**100%**

PG Program [M. Tech.] Curriculum Structure

Artificial Intelligence in Healthcare

W.e.f AY from AY 2025-26

Semester I

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	PSMC	PSMC-01	Mathematics for AI & ML	3	0	0	3
2.	PSBC	PSBC-01	Anatomy & Physiology for Engineers	2	0	0	2
3.	PCC	PCC-01	Medical Data Acquisition and signal processing	3	0	0	3
4.	PCC	PCC-02	Introduction to Artificial Intelligence (MOOC)	3	0	0	3
5	PCC	PCC-03	Embedded System	3	0	0	3
6	LC	LC-01	Mathematics for AI & ML Lab	0	0	2	1
7.	LC	LC-02	Medical Data Acquisition and signal processing	0	0	2	1
8.	LC	LC-03	Computing Techniques Lab (Python)	0	0	2	1
9.	PEC	PEC-01	**Program Specific Elective –I**	3	0	0	3
10	PEC	PEC-01	**Program Specific Elective –II**	3	0	0	3
11.	VSEC	VSEC-01	Technical Communications Skill	1	0	2	2
				22	2	8	
Total Credits							**25**

Program Specific Elective –I

1. Biomaterials
2. Introduction to Medical Software/Medical Algorithms
3. Biomedical Devices and systems

Program Specific Elective –II

1. Soft computing
2. Biomedical system design
3. Biosystem modelling and simulation

PG Program [M. Tech.] Curriculum Structure

Artificial Intelligence in Healthcare

W.e.f AY from AY 2025-26

Semester II

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	OE	OE-01	Open Elective	3	0	0	3
2.	PCC	PCC-03	Introduction to Machine Learning and Deep Learning	3	0	0	3
3.	PCC	PCC-04	Medical Image Analysis	3	0	0	3
4.	PCC	PCC-05	Wearable Devices and Remote Monitoring	3	0	0	3
5.	LC	LC-04	Predictive Medical Image Analysis Lab	0	0	2	1
6.	LC	LC-05	Introduction to Machine Learning and Deep Learning	0	0	2	1
7.	PEC	PEC-02	Program Specific Elective –III	3	0	0	3
8.	PEC	PEC-03	Program Specific Elective –IV	3	0	0	3
9.	CCA	CCA-01	Liberal Learning Course	1	0	0	1
10.	MLC	MLC-01	Research Methodology	2	1	0	3
				21	1	6	24
Total Credits				**24**			

List of Program Specific Elective –III & IV

1. Healthcare informatics, privacy and security
2. Natural Language Processing in Healthcare
3. Bio-Implants
4. Robotics in surgery
5. Computer Vision

Thesis Project: Preliminary document to be submitted on the chosen project covering Requirement Specifications, Design and resource estimation, existing scenario etc. The document needs to be submitted to the nominated project guide for approval. High value is attached to originality in design aspects. This stage carries 30 percent of the project credit. The balance will be awarded in the second year on project completion and report submission. The degree will be awarded only upon earning minimum credit hours and upon successful completion of the project. The successful completion of the project is the essence of the course. The project topic can be chosen by the student with assistance from the internal guide or an external co-guide.

PG Program [M. Tech.] Curriculum Structure

Artificial Intelligence in Healthcare

W.e.f AY from AY 2025-26

Semester - III

Sr. No.	Course Code	Course Title	L	T	P	S	Cr	Category
01	VSEC-02	Dissertation Phase – I	--	--	22	11	11	VSEC
02	SLC-01	Massive Open Online Course - I	3	--	--	3	3	SLC
03	OJT	Internship	--	--	--	--	3	
Total Academic Engagement and Credits			**3**	**--**	**22**	**14**	**17**	

1. **Thesis Project**
    - Independent research on topics such as AI for diagnostics, predictive models, or surgical robotics that was approved at the end of First year, second semester will continue

Semester - IV

Sr. No.	Course Code	Course Title	L	T	P	S	Cr	Category
01	VSEC-03	Dissertation Phase – II	--	--	22	11	11	VSEC
02	SLC-02	Massive Open Online Course-II	3	--	--	3	3	SLC
Total Academic Engagement and Credits			**3**	**--**	**22**	**14**	**14**	

Mathematics for AI & ML

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes:

- **Analyze:** Analyze and model data using appropriate probability distributions and statistical models
- **Apply:** Apply concepts of linear algebra, calculus, and trigonometry to solve engineering problems
- **Interpret:** Interpret and summarize data using descriptive statistical measures
- **Integrate:** Integrate mathematical and statistical tools to address real-world problems in data science and healthcare technology

Course Content:

Linear Algebra; Calculus; Introduction to Statistics and Probability; Descriptive statistics; Inferential statistics; Probability distributions; Hypothesis testing; Statistical modeling; Trigonometry; Tomographic reconstruction; Fourier Transform

Reference Books

- Introductory Statistics (10th Edition) -, by Neil A. Weiss published by Pearson
- Introductory Statistics (4th Edition) - by Sheldon M. Ross
- Advanced Trigonometry – by C V Durell and A Robson
- Fundamentals of Computerized tomography- by Gabor T Herman
- Fourier Analysis : An Introduction- by Elias M Stein

Anatomy and Physiology for Engineers

Teaching Scheme:
Lectures: 2 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes:

1. **Describe** human body structure.
2. **Understand** working of different physiological systems of human body.
3. **Explain** the functioning of the human body system.
4. **Understand** biological control and feedback mechanism.
5. **Apply** knowledge of human anatomy and physiology to solve different biomedical research problems.

Course Content:

- **Introduction to cell, Blood**: Characteristics of blood, physiology of blood clotting, biochemical cycle
- **Heart (Circulatory System)**- Anatomy of heart and blood vessels, origin and conduction of heartbeat, cardiac cycle, electrocardiogram, blood pressure, control of cardiac cycle.
- **Respiratory System**- Anatomy of respiratory system, physiology of respiration in the alveolar and tissue capillaries, control of respiration.
- **Digestive system**: Anatomy of digestive system, nerve and blood supply, physiology of digestion.
- **Kidney and Urinary system -** Anatomy of urinary system and kidney, physiology of water and electrolyte balance, acid-base regulation.
- **Muscle Tissues -** Anatomy, types of muscles, physiology of muscle contraction, generation of action potential, rhythmicity of cardiac muscle contraction, properties of skeletal and Cardiac muscles.
- **Nervous system -** Neuron, anatomy and function of different parts of brain, spinal cord, autonomic nervous system, Sensory system - Visual, auditory, Vestibular Endocrine system- pituitary, thyroid, parathyroid, adrenal, pancreas, Biological control and feed-back mechanism, clinical and technological implications

Reference Books

- "Ross & Wilson Anatomy and Physiology in Health and Illness", by Allison Grant, Anne Waugh, and Kathleen J. W. Wilson
- Anatomy and Physiology for Engineers- A handbook for biomedical engineers- by P. Manimegalal

Medical Data Acquisition and Signal Processing

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Examination Scheme

Course Outcomes:

- **Apply** appropriate methods for medical data collection, storage, cleaning, and integration.
- **Understand and implement** healthcare data standards such as HL7, ICD, SNOMED, and LOINC.
- **Analyze** big data technologies in the context of healthcare applications.
- **Evaluate** case studies to understand real-world applications of medical data analytics in clinical and administrative settings.

Course Content:

Introduction to Medical Data; Sources of Medical Data; Data Collection and Management; Medical Data Standards and Privacy; Healthcare data standards (HL7, ICD, SNOMED, LOINC); Privacy laws and regulations: HIPAA, GDPR, and their impact on data management; De-identification, data anonymization, and consent; Medical Data Mining; Big Data in Healthcare; Applications and Case Studies

Reference Books

- Hands-on on Healthcare data : Taming the complexity of real world data- by – Andrew Nguyen
- Healthcare Data Analytics -by Chandan K Reddy & Charu A Agrawal

Introduction to Artificial Intelligence

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes

- **Model** real-world problems as search problems
- **Apply** uninformed and heuristic search algorithms
- **Formulate** and **solve** problems using constraint satisfaction techniques.
- **Represent** knowledge using propositional logic and apply satisfiability techniques
- **Apply** principles of decision theory and Markov Decision Processes for sequential decision-making.

Course Content:
Introduction: Philosophy of AI, Definitions; Modeling a Problem as Search Problem, Uninformed Search; Heuristic Search, Domain Relaxations; Local Search, Genetic Algorithms; Adversarial Search; Constraint Satisfaction; Propositional Logic & Satisfiability; Uncertainty in AI, Bayesian Networks; Bayesian Networks Learning & Inference, Decision Theory; Markov Decision Processes; Reinforcement Learning Introduction to Deep Learning & Deep RL

Reference Books

- Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice-Hall, Third Edition (2009)
- Ian Goodfellow, Yoshua Bengio & Aaron Courville, Deep Learning, MIT Press (2016).

Embedded Systems

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Objectives

1. To understand the scientific principles and concepts behind small scale embedded systems.
2. To have direct hands-on experience on both hardware and software elements commonly used in small
scale embedded system design.
3. To have knowledge of hardware/software co-design.
4. Understanding the applications and role of microcontrollers for embedded systems design.

Course Contents

Embedded Systems: Definition, classification, examples and broad overview. Embedded system design criterions, architectural design aspects, embedded programming and tools for building embedded systems, memory types- organization and interfacing. Small scale embedded system design: Architecture of small scale microcontroller (PIC18F4550), I/O programming, Interrupt driven programming, digital and analog sensor
interfacing, actuator interfacing, Programming with: Timers, Counters, PWM, Enhanced PWM, CCP Module,On chip communication protocols: UART and USART (I2C, SPI). Case studies and applications: DC Motor control, Control of conveyer belt, etc. STM 32-bit microcontroller architecture—technology overview,
Architectural Features: Block Diagram, CPU modes, register organization, ROM, RAM, timers, data andaddress bus, Memory and I/O interfacing concepts, memory mapped I/O. CISC Vs RISC design philosophy,pipelining, exceptions and its handling, memory, I/O‗s and addressing modes.

Reference Books:

- Mazidi, PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC 18 series, Pearson, January 2008 edition.
- John B. Peatman-- Design with PIC Microcontrollers, Pearson, 2009 Edition.
- Raj Kamal, ―Embedded Systems – Architecture: Programming and Design, Tata McGraw-HillEducation, 3rd ed.,2003.
- Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers, 2014, Jonathan W Valvano Create space publications ISBN: 978-1463590154.
- Embedded Systems: Introduction to ARM Cortex – M Microcontrollers, 5th edition Jonathan WValvano, Create space publications ISBN-13: 978-1477508992

Mathematics for AI& ML

Laboratory Contents:

The laboratory is designed to provide hands-on experience in the application of mathematical and statistical concepts using computational tools such as Python, MATLAB, or equivalent software. The laboratory includes experiments on matrix operations, solving systems of linear equations, eigenvalue and eigenvector computation, numerical differentiation and integration, trigonometric analysis, descriptive statistical measures, probability distributions, hypothesis testing, regression and statistical modeling using real-world datasets. Students will also perform experiments involving Fourier Transform for signal and data analysis and basic tomographic reconstruction techniques to understand their applications in healthcare technology and artificial intelligence. Through these laboratory exercises, students will develop the ability to analyze, visualize, interpret, and model data while applying mathematical and statistical methods to solve engineering, AI, and machine learning problems, thereby strengthening their computational, analytical, and problem-solving skills

Medical Data Acquisition and Signal Processing

Laboratory Contents:

The laboratory provides hands-on experience in medical data collection, preprocessing, management, and visualization using healthcare datasets. Students will perform experiments on data cleaning, database management, implementation of healthcare data standards (HL7, ICD, SNOMED, and LOINC), and privacy-preserving techniques such as de-identification and anonymization. Practical sessions will include medical data mining, statistical analysis, predictive modeling, and visualization using programming tools to analyze electronic health records and other healthcare data through case studies and mini-projects.

Computing Techniques Lab (Python)

Course Outcomes

- **Apply** knowledge of different numerical methods to solve real world problems using python.
- **Solve** ordinary differential equations (ODEs) using basic and advanced numerical methods including implicit schemes and higher-order methods.
- **Analyze** systems of ODEs, stiff equations, and use Fourier transforms for frequency-domain analysis.
- **Apply** finite difference (FD) methods for solving various PDEs and compare with spectral methods.

Course Content:

Handson 1: Python variables, Python arrays
Handson 2: Python Control Structure, Functions, Programming style
Handson 3: Plotting, Data input/output, Error analysis and nondimensionalization
Handson 4: Lagrange Interpolation, Splines
Handson 5: Numerical Integration: Newton Cotes, Gaussian quadrature, Multidimensional and misc integration

Reference Books

1. Practical Numerical Computing Using Python : Scientific and Engineering Applications (2021)
2.Mark Newmann: Computational Physics with Python, 2nd Ed.
3.J. M. Stewart: Python for Scientists, Cambridge U. Press (2014)
4.J. H. Ferziger, Numerical Methods for Engineering Applications, John Wiley & Sons (in TB section).
5.M. Lutz, Learning Python 5th Edition, O'Reilly Media (2013)

Biomaterials

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes:

- **Identify and classify** various materials used in medicine, including metals, polymers, hydrogels, and biodegradable materials.
- **Understand** mechanisms of material degradation in biological environments, particularly for polymers, metals, and ceramics.
- **Apply** knowledge of biomaterials to various medical and clinical applications such as cardiovascular devices, dental implants, orthopedic devices, drug delivery systems, and biosensors.
- **Analyze** the structure and function of biologically functional materials, ceramics, natural materials, composites, thin films, and nano-biomaterials in medical applications.
- **Assess** the biocompatibility and performance of biomaterials in relation to specific biomedical applications.

Course Content:

Properties of Materials: Bulk properties and Surface properties of Materials. Characterization methods of surface properties of Biomaterials

Materials Used In Medicine: Metals; Polymers; Hydrogels; Bioresorbable and Biodegradable Materials.

Materials Used in Medicine: Biologically Functional Materials; Ceramics; Natural materials; Composites, thin films, grafts and coatings; Pyrolytic Carbon for long-term medical Implants; Porous materials; Nano biomaterials.

Host Reactions to Biomaterials: Inflammation; Wound healing and the Foreign body response; Systemic toxicity and Hypersensitivity; Blood coagulation and Blood-materials Interactions; Tumorigenesis. Degradation of Materials in Biological Environment: Degradation of Polymers, Metals and Ceramics.

Application of Biomaterials Cardiovascular Applications; Dental implants; Adhesives and Sealants; Opthalmologic Applications; Orthopedic Applications; Drug Delivery System; Sutures; Bioelectrodes; Biomedical Sensors and Biosensors

Reference Books

- Ratner, Buddy D., et al. *Biomaterials Science: An Introduction to Materials in Medicine*. 2nd ed. Burlington, MA: Academic Press, 2004. ISBN: 9780125824637.
- Bronzino, J. D. (2000). The Biomedical Engineering Handbook. Germany: CRC Press
- Biomaterials: Principles and Applications- by Joon B Park & Joseph D Bronzino

Introduction to Medical Software/ Medical Algorithms

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes:

- **Interpret** key medical software regulations and standards, including those from CDSCO, SaMD, FDA, and IMDRF.
- **Understand and apply** the stages of the Software Development Life Cycle (SDLC) specific to medical applications.
- **Identify and define** user needs and system requirements for safe and effective medical software.
- **Design** software architecture and apply usability engineering principles in healthcare applications.

Course Content:

Introduction to Medical Software and Digital Health; Medical Software Regulation (CDSCO, SaMD, FDA and IMDRF); The Healthcare Environment (EHR, PACS, Data Privacy, and Cybersecurity); Quality and Risk Management; Software Development Life Cycle; User Needs & System Requirements; Software Architecture Design and Usability Engineering; Construction and Testing; Software Validation, Deployment, Maintenance and Retirement; Role of Artificial Intelligence in Medical software; Business and Management challenges; Case Studies

Reference Books

- Medical Device Software: Verification, Validation, and Compliance *by* David A. Vogel; Artech House publisher
- Handbook of Digital Health: Technologies, Applications, and Challenges *by* Homero Rivas, Katarzyna Wac; Springer

Biomedical Devices and Systems

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes

- **Describe** the operation and clinical applications of therapeutic and life-saving medical devices.
- **Analyze** the working principles and applications of respiratory instrumentation used in clinical settings.
- **Evaluate** electrical safety standards and related instrumentation in the context of patient and operator protection.
- **Understand** the operation of common clinical laboratory instruments and their role in medical diagnostics.

Course Content:

Cardiovascular Devices; Therapeutic devices; Life-saving devices; Respiratory Instrumentation; Clinical Laboratory Instruments; Operation room instruments; Electrical safety and related instruments; Biomechanical Instrumentation; Instrumentation for Medical Imaging

Reference Books

- Leslie Cromwell, Fred J. Weibull, Erich A. Pfeiffer, “Biomedical Instrumentation and Measurements”, Pearson Education, 2nd ed. 1980.
- R. S. Khandpur, “Handbook of Biomedical Instrumentation”, TMH, 2nd ed., 2008
- Vander, Shermen, “Human Physiology” – The Mechanism of Body Functions”, TMH, 13th ed., 2013.
- Tompkins, “Biomedical Digital Signal Processing”, PHI, 5th ed., 2010
- John G Webster, “Encyclopedia of Medical Devices and Instruments”, Wiley Publications, 1988.
- M. Arumugam, “Biomedical Instrumentation”, Amerada Publishers, 2nd ed., 1992
- Carr and Brown “Introduction to Biomedical Equipment Technology”, Pearson LPE, 4th ed., 2001.
- Richard Aston, “Principles of Biomedical Instrumentation and Measurement”, Maxwell Macmillan, International ed., 1990.
- John G. Webster, “Medical Instrumentation Application and Design”, John Wiley& Sons Pvt. Ltd, 3rd ed., 2009

Soft Computing

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes:

- **Describe** the role of soft computing techniques in real world [PEO-1,3][PO-1,5]
- **Recognize** the feasibility of applying appropriate soft computing techniques for a given real world problem [PEO-3][PO-4,5]
- **Examine** the solution of problem based on of the basics of learning and training algorithms [PEO-2][PO-2, 3]
- **Develop** engineering applications using neural network, fuzzy logic, genetic algorithm and hybrid system.[PEO-2, 3][PO-3, 4]

Course Contents

Unit I: Soft Computing (07hrs)

Introduction to Soft Computing, characteristics of Soft computing, Difference between Hard and Soft computing, Requirement of Soft computing, Basic tools of soft Computing – Fuzzy logic, Neural Networks and Evolutionary Computing , Applications of Soft Computing.

Unit II: Neural Network (08hrs)

Introduction to Neural Network, Biological and Artificial Neuron, Neural Networks, Supervised and Unsupervised Learning. Single Layer Perceptron, Multilayer Perceptron, Backpropagation Learning, Neural Networks as Associative Memories, Hopfield Networks, Bidirectional Associative Memory, Topologically Organized Neural Networks, Competitive Learning, Kohonen Maps.

Unit III: Fuzzy Logic (07hrs)

Introduction to Fuzzy Logic, Fuzzy Sets, Properties, Membership Functions, Fuzzy Operations, Fuzzy Inference System, Fuzzification and defuzzifications module, Scaling factors, Fuzzy controllers.

Unit IV: Genetic Algorithm (06hrs)

Introduction to Genetic Algorithms, Introduction and concept, Coding, Reproduction, Cross Applications, Swarm intelligence, and their applications.

Unit V: Evolutionary Computing (07hrs)

Evolutionary Computation, Overview of Bio-inspired Algorithms - Swarm Intelligence Algorithms, Particle Swarm optimization, Ant Colony optimization, Grey-Wolf optimization, Hybrid systems: Neuro-fuzzy, Genetic-neuro, Genetic-fuzzy.

Text Books

S. Rajasekaran and G. A. Vijayalakshmi Pai, “Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications”, 2nd Edition, PHI Learning, 2003.

Samir Roy and Udit Chakraborty “Soft Computing: Neuro-Fuzzy and Genetic Algorithms”, 1st Edition, Pearson, 2006.

Reference Books

Dan W. Patterson, “Introduction to Artificial Intelligence and Expert Systems”, 3rd edition , Prentice-Hall International, 2000.

J. M. Zurada, “Introduction to Artificial Systems”, 5th Edition, Jaico Publishing House, 2004.

James A. Anderson, “An Introduction to Neural Networks”, 2nd edition , Prentice Hall of India, New

Delhi, 1999.
D. Drainkov, H. Hellendoorn and M. Reinfrank, “An Introduction to Fuzzy Control”, 6th edition , Springer-Verlag Berlin Heidelberg Publisher, 2008.
T. J. Ross, “Fuzzy Logic with Engineering Applications”, 3rd edition, MIT Press, Inc 2011.
Kosko Bart, “Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence”, Prentice Hall of India, New Delhi, 2001.
Melanie Mitchell, “An Introduction to Genetic Algorithms”, 2nd Edition, MIT Press, 1999.

Biomedical System Design

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

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

CO1: Explain the working principles and applications of various biomedical technologies and medical systems.
CO2: Describe medical device classifications, relevant standards, and regulatory requirements governing the development and commercialization of medical devices.
CO3: Describe and apply the various steps involved in biomedical system design such as design controls, risk assessment, and mitigation strategies.
CO4: Analyze and evaluate engineering design processes, project management methodologies, and performance metrics used in biomedical system design and development.

Course Contents:

Problem Formulation in Product Design, Business Context for Design, Engineering Product Design Process, Product Development Life Cycle, Project Management in Product Design, Medical Instrumentation Approach - Extraction of Physiological Parameters such as pressure and flow, Bio-potential Recording, ECG, EMG, Requirements Management, Medical Instruments Requirements and Standards, Medical System / Device Classification, General Design System Model, Design Process - Conceptual Design, System Architectural Design, Risk Management, Applied electronics, Medical Software, Certification Process,Bioethics and Privacy, Biocompatibility and Sterilization Techniques, Designof Clinical Trials, Testing and Validation, Case Studies such as Biopotential Measurements, Medical Diagnostics (In-vitro diagnostics), Minimally Invasive Devices, Surgical Tools, etc.

Reference Books:

1. Claudio Becchetti,Alessandro Neri, Medical Instrument Design and Development from requirements to Market placements includes a case study in ECG implementation, WILEY, John Wiley & Sons Ltd., 2013
2. Paul H. King, Richard C. Fries, Arthur T. Johnson, Design of Biomedical Devices and Systems, CRC Press, 3rd Edition, 2014
3. John G. Webster (ed), Medical Instrumentation: Application and Design,: John Wiley & Sons, 4th Edition, 2009
4. Peter Ogrodnik, Medical Device Design: Innovation from Concept to Market, Academic Press, Elsevier, 2012

Biosystem Modelling and Simulation

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Upon successful completion of this course, students will be able to:
CO1: Explain the fundamental concepts of physiological modelling, model classification, model characteristics & simulation techniques
CO2: Analyze and formulate electrical models of excitable cells to study membrane dynamics and action potential generation
CO3: Develop and evaluate mechanical and physiological process models to investigate the behaviour and control of biological systems.
CO4: Apply modelling and simulation tools to analyze biological systems & validate physiological models using experimental data.

Course Contents:
Introduction of physiological modelling, importance of physiological modelling, Classification of models, characteristics of model, model simulation, model validation, Time invariant and time varying systems for physiological modelling
Electrical models: Models of neuron - Electromotive, resistive and capacitive properties of cell membrane, change in membrane potential with distance, voltage clamp experiment and Hodgkin and Huxley‘s model of action potential, the voltage dependent membrane constant, model for strength- duration curve, model of the whole neuron.
Mechanical models: Modelling neuromuscular system - modelling of skeletal muscle, mono and polysynaptic reflexes, stretch reflex, reciprocal innervations, two control mechanism, Golgi tendon, experimental validation, Parkinson‘s syndrome. Huxley model of isotonic muscle contraction; Eye movement model
Physiological Process Models: Thermoregulatory model - Thermoregulatory mechanisms, model of thermoregulatory system, controller model, validation and application; Modelling of Immune response - Linearized model of the immune response: Germ, Plasma cell, Antibody, system equation and stability criteria.
Other models - Models of drug delivery, Modelling of insulin glucose feedback system

Reference Books:

1. Michael C. K. Khoo, Physiological Control Systems: Analysis, Simulation and Estimation, IEEE Press, 2nd Edition, 2018.
2. James Keener and James Sneyd, Mathematical Physiology, Springer, 2nd Edition, 2009.
3. Eugene N. Bruce, Biomedical Signal Processing and Signal Modelling, Wiley-Interscience, 2nd Edition, 2001.
4. Henk Nijmeijer, Arjan van der Schaft, Nonlinear Dynamical Control Systems, Springer, 1990.
5. A. Teri Bahil, Bioengineering, Biomedical, Medical and Clinical Engineering, Prentice-Hall, Englewood Cliffs, N.J.,1981

Seminar

Examination Scheme

MID Semester exam	30 marks
End Semester exam	50 marks
Continuous Evaluation	20 marks

Course Outcomes

- **Identify** a real-world problem and formulate it as a machine learning or AI task.
- **Design and develop** a small-scale AI/ML-based solution using appropriate algorithms and methodologies.
- **Implement** the solution using relevant programming languages, tools, and frameworks.
- **Evaluate** the performance of the developed model using suitable metrics and validation techniques.
- **Present** the project findings, demonstrating problem-solving and critical thinking skills

Course Content:

- Design and develop a small-scale project that demonstrates understanding of AI and ML principles
- Deploy and evaluate the project using relevant tools and metrics
- Present seminar on above mentioned area

Introduction to Machine Learning and Deep Learning

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes

- **Understand** the foundations of statistical decision theory, including regression, classification, and the bias-variance tradeoff.
- **Apply** various linear regression techniques, including multivariate regression, subset selection, shrinkage methods, and dimensionality reduction approaches like PCR and PLS.
- **Implement** linear classification techniques such as logistic regression, linear discriminant analysis, and support vector machines.
- **Understand and build** early neural network models including perceptron and multilayer perceptron's, using backpropagation and parameter estimation techniques (MLE, MAP, Bayesian).

Course Content:

Introduction: Statistical Decision Theory - Regression, Classification, Bias Variance
Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least squares
Linear Classification, Logistic Regression, Linear Discriminant Analysis
Perceptron, Support Vector Machines
Neural Networks - Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation
Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures
Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting
Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks
Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation
Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering
Gaussian Mixture Models, Expectation Maximization

Introduction to Deep Learning, Bayesian Learning, Decision Surfaces
Linear Classifiers, Linear Machines with Hinge Loss
Optimization Techniques, Gradient Descent, Batch Optimization
Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning
Unsupervised Learning with Deep Network, Autoencoders
Convolutional Neural Network, Building blocks of CNN, Transfer Learning
Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam
Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization
Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network,

Fully Connected CNN etc.
Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection etc.
LSTM Networks
Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network
Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam

Reference Books

1. The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman
2. Deep Learning- Ian Goodfelllow, Yoshua Benjio, Aaron Courville, The MIT Press
3. Pattern Recognition and Machine Learning, by Christopher Bishop

Medical Image Analysis

Examination Scheme

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes

- **Understand** the fundamentals and physics behind various medical imaging techniques and image acquisition processes.
- **Apply** basic image processing techniques to enhance and analyze medical images.
- **Implement** rigid and non-rigid image registration methods and evaluate their applications in medical imaging.
- **Develop and apply** deep learning models, such as 3D convolutional neural networks, for complex medical image analysis tasks.

Course Content:

Introduction to medical imaging; Physics of Medical Imaging Techniques; Medical Image Acquisition; Basic image processing techniques; Image registration – 1- Rigid models; Image registration – 2- Non-Rigid models; Image registration – 3- Application and demonstration; Image segmentation - Statistical shape model; Image segmentation – PDE based methods; Image segmentation – application and demonstration; Computer Aided Diagnosis – Case Study 1; Computer Aided Diagnosis – Case Study 2; Deep Learning for Medical image analysis – 3D Convolutional Neural Networks; Deep Learning for Medical image analysis – Generative models for synthetic data

Reference Books

1. Rangaraj M. Rangayyan, ―Biomedical Image Analysis‖ CRC Press, 2005
2. Rafael G. Gonzaleg, Kichard E. Wood, ―Digital Image Processing‖ Pearson Education, LPE
3. Bishop, C., ―Pattern Recognition and Machine Learning:,‖ Berlin: Springer-Verlag, 2006
4. Thomas S. Curry, Jumer E. Dowdey, Robert C. Murry, ―Christensen‗s physics of Diagnostic Radiology‖, Lippincott Williams & Wilkins, ISBN -10 0812113101
5. John G. Webster, ―Encyclopedia of Medical Devices and Instrumentation Vol. I , II, III, IV‖,Wiley Publication.
6. KavyanNajarian and Robert Splerstor,‖ Biomedical signals and Image processing‖, CRC – Taylor and Francis, New York, 2006

Wearable Devices and Remote Monitoring

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
MSE: 30 Marks: CA 20 Marks
ESE: 50 Marks

Course Outcomes

- **Analyze** the principles and applications of wearable haptic and tactile devices in healthcare.
- **Understand** the design, challenges, and applications of chemical and biochemical wearable sensors.
- **Describe** flexible electronics and energy harvesting systems, including low-power circuit design for biopotential sensing and energy harvesting techniques from human body and ambient sources.
- **Apply** knowledge of wearable sensors to monitor physical and physiological parameters related to cardiovascular, neurological, and gastrointestinal diseases.
- **Evaluate** assistive wearable technologies and devices designed for individuals with severe paralysis, such as tongue drive systems.
- **Understand** the concepts and technologies behind remote patient monitoring and telehealth, including practical applications and case studies.

Course Content:

Introduction to Wearable sensors – Attributes of wearables – Meta-wearable – Challenges and opportunities – Future of wearables – Social interpretation of Aesthetics – Case study – Google glass – Wearable haptics – Need for wearable haptic devices – Categories of wearable haptic and tactile display – Wearable Sensors – Chemical and Biochemical sensors – System design – Challenges in chemical biochemical sensing – Applications

Flexible Electronics and Energy Harvesting Systems – Thin-film transistors – Low-power Integrated Circuit design for biopotential sensing – Analog circuit design techniques – Lowpower design for ADCs – Digital circuit design techniques – Architectural design for low power biopotential acquisition – Practical considerations – Energy harvesting from human body – Temperature gradient – Foot motion – Wireless energy transmission – Energy harvesting from light and RF energy – Energy and power consumption issues – Future considerations

Monitoring Physical and Physiological Parameters – Wearable sensors for physiological signal measurement – Physical measurement – cardiovascular diseases – Neurological diseases – Gastrointestinal diseases – Wearable and non-invasive assistive technologies – Assistive devices for individuals with severe paralysis – Wearable tongue drive system – Dual-mode tongue drive system.

Introduction to Remote patient monitoring system, Concept of telehealth, Remote patient monitoring devices, Case studies and applications

Reference Books

1. Edward Sazonov, Michael R Neuman, Wearable Sensors: Fundamentals, Implementation and Applications, Academic Press, USA, 2014.
2. Tom Bruno, Wearable Technology: Smart Watches to Google Glass for Libraries, Rowman & Littlefield Publishers, Lanham, Maryland, 2015.
3. Raymond Tong, Wearable Technology in Medicine and Health Care, Academic Press, USA, 2018.
4. Haider Raad, The Wearable Technology Handbook, United Scholars Publication, USA, 2017.

Predictive Medical Image Analysis lab

Examination Scheme

Continuous Evaluation	50 marks
Lab exam	50 marks

Course Outcomes

- **Understand** the fundamentals and physics behind various medical imaging techniques and image acquisition processes.
- **Apply** basic image processing techniques to enhance and analyze medical images.
- **Implement** rigid and non-rigid image registration methods and evaluate their applications in medical imaging.
- **Develop and apply** deep learning models, such as 3D convolutional neural networks, for complex medical image analysis tasks.

Course Content:

- Deep Learning and Medical Image Analysis with Keras
    - Apply deep learning to medical image analysis for malaria testing
    - Use Keras to automatically analyze medical images
    - Use pre-trained models or existing code to quickly train a deep learning model
- Building a Deep Learning + Medical Imaging Dataset
    - Split data into training, validation, and testing sets
    - Create three new sub-directories in the malaria/ directory
    - Automatically copy the images into their corresponding directories
- Configuring Your Development Environment
    - Install TensorFlow 2.0 on Ubuntu or macOS
    - Configure your system with all the necessary software for this blog post in a convenient Python virtual environment
- Building and Training a Model
    - Build a deep learning model on medical images to predict if a given patient's blood smear is positive for malaria or not
    - Review results and assess the model's performance
- Exploring Medical Image Analysis
    - Explore the malaria dataset and understand the different classes and images
    - Understand how deep learning and medical imaging can be applied to the malaria endemic
    - Examine the directory structure for the project and understand the different files and their purposes
- Reviewing Results and Assessing Performance
    - Review the results of the model and assess its performance
    - Understand how to improve the model and increase its accuracy
    - Explore ways to deploy the model and use it for real-world applications

Reference Books

1. Rangaraj M. Rangayyan, —Biomedical Image Analysis‖ CRC Press, 2005
2. Rafael G. Gonzaleg, Kichard E. Wood, —Digital Image Processing‖ Pearson Education, LPE
3. Bishop, C., —Pattern Recognition and Machine Learning:,‖ Berlin: Springer-Verlag, 2006
4. Thomas S. Curry, Jumer E. Dowdey, Robert C. Murry, —Christensen's physics of Diagnostic Radiology‖, Lippincott Williams & Wilkins, ISBN -10 0812113101
5. John G. Webster, —Encyclopedia of Medical Devices and Instrumentation Vol. I , II, III, IV‖,Wiley Publication.
6. KavyanNajarian and Robert Splerstor,‖ Biomedical signals and Image processing‖, CRC – Taylor and Francis, New York, 2006

Healthcare Informatics privacy and security

Examination Scheme

MID Semester exam	30 marks
End Semester exam	50 marks
Continuous Evaluation	20 marks

Course Outcomes

- **Analyze** privacy, security, and ethical considerations in managing healthcare data.
- **Evaluate** the role of mobile technologies, telemedicine, and mobile health applications in modern healthcare delivery.
- **Understand** the concepts of quality improvement and patient safety in healthcare informatics, including PACS systems.
- **Apply** ethical principles and legal frameworks to the use of artificial intelligence in healthcare.

Course Content:

Module 1: Introduction to Health Informatics: Overview of health informatics Stakeholder perspectives

Module 2: Healthcare Data Trends

Electronic health records

Architecture of information systems

Module 3: Privacy and Security

Health information privacy and security

Ethics in healthcare data

Module 4: Mobile Technology in Healthcare

Telemedicine

Mobile health applications

Module 5: Quality Improvement and Patient Safety

PACS (Picture Archiving and Communication Systems)

Quality improvement in healthcare

Patient safety and informatics

Module 6: Ethics of using AI in healthcare

Basic ethical principles (beneficence, autonomy, fairness) and frameworks applied in healthcare

- **Legal/Regulatory Issues**: Understanding healthcare laws (e.g., HIPAA, GDPR) and AI-related legal responsibilities.
- **Responsible AI Design**: Best practices for ethical, human-centered ML systems in healthcare.
- **Case Studies**: Real-world examples highlighting successes and ethical failures in healthcare ML.
- **Future Challenges**: Emerging issues in AI, including genomics and personalized medicine.

Reference Books

- "Healthcare Information Security and Privacy" *By Sean P. Murphy*
- "Security and Privacy in the Health Care Sector" *Edited by K. El Emam & Lucila Ohno-Machado*
- "Biomedical Informatics: Computer Applications in Health Care and Biomedicine" *By Edward H. Shortliffe & James Cimino*
- "Information Security and Privacy in Healthcare: Current State of Research" *Edited by Hamid Jahankhani, Stefan Kendzierskyj, Kevin Lomas*
- "HIPAA Plain and Simple" *By Carolyn P. Hartley & Edward D. Jones*
- "Protecting Patient Information: A Decision-Maker's Guide to Risk, Prevention, and Damage Control" ***By Paul Cerrato***

Natural Language Processing in Healthcare

Examination Scheme

MID Semester exam	30 marks
End Semester exam	50 marks
Continuous Evaluation	20 marks

Course Outcomes

- **Understand and implement** fundamental text processing techniques, including spelling correction and language modeling with advanced smoothing methods.
- **Apply** Part-of-Speech (POS) tagging and sequential tagging models such as Maximum Entropy (MaxEnt) and Conditional Random Fields (CRF).
- **Implement** entity linking and information extraction methods from unstructured text.
- **Develop** systems for text summarization, classification, and sentiment analysis, including opinion mining.

Course Content:

Introduction and Basic Text Processing; Spelling Correction, Language Modeling; Advanced smoothing for language modeling, POS tagging; Models for Sequential tagging – MaxEnt, CRF; Syntax – Constituency Parsing; Dependency Parsing
Distributional Semantics; Lexical Semantics; Topic Models; Entity Linking, Information Extraction; Text Summarization, Text Classification; Sentiment Analysis and Opinion Mining

Reference Book

1. Dan Jurafsky and James Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition. Prentice Hall, Second Edition, 2009.

2. Some draft chapters of the third edition are available online: https://web.stanford.edu/~jurafsky/slp3/

3. Chris Manning and Hinrich Schütze. Foundations of Statistical Natural Language Processing. MIT Press, Cambridge, MA: May 1999.

Bio-implants

Examination Scheme

MID Semester exam	30 marks
End Semester exam	50 marks
Continuous Evaluation	20 marks

Course Outcomes

- **Describe** different types of bio-implants, their applications, and historical evolution with insights into future trends.
- **Understand** the properties of biomaterials, criteria for selection, and concepts of biocompatibility and tissue engineering.
- **Apply** AI and machine learning methods for predictive modeling, image analysis, and bio-signal processing related to bio-implants.
  Analyze case studies on AI-powered bio-implants to evaluate real-world applications and challenges.

Course Content:

- **Module 1: Introduction to Bio-implants**
  - Types of bio-implants and their applications
  - Historical perspective and future directions
- **Module 2: Biomaterials and Biocompatibility**
  - Properties and selection of biomaterials
  - Biocompatibility and tissue engineering
- **Module 3: Bioelectrical Interfaces and Sensors**
  - Electrode design and signal processing
  - Implantable sensors and biosensors
- **Module 4: AI and ML in Bio-implants**
  - Predictive modeling for personalized medicine
  - Image analysis for implant placement and monitoring
  - ML algorithms for bio-signal processing
- **Module 5: Case study**
  - AI powered bio-implant

Reference Book

1. "Biomaterials Science: An Introduction to Materials in Medicine" *By Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons*
2. "Fundamentals of Biomaterials" *By Vasif Hasirci & Nesrin Hasirci*
3. "Implantable Biomaterials: Science and Applications" *By Kip A. Surface*
4. "Biodegradable Systems in Tissue Engineering and Regenerative Medicine" *By Rui L. Reis and Julio San Román*

Robotics in surgery

Examination Scheme

MID Semester exam	30 marks
End Semester exam	50 marks
Continuous Evaluation	20 marks

Course Outcomes

- **Understand** the mechanical design, control systems, and principles of human-robot interaction in surgical robotics.
- **Apply** AI and machine learning techniques, including computer vision and predictive modeling, to enhance robotic surgery performance.
- **Analyze** clinical benefits of robotic-assisted surgery, including minimally invasive techniques, improved precision, and reduced patient recovery time.
- **Evaluate** the challenges in robotic surgery such as regulatory, ethical, and training aspects, and discuss emerging innovations and future directions in the field.

Course Content:

- **Module 1: Introduction to Robotics in Surgery**
  - Historical perspective and evolution of robotic surgery
  - Types of robotic systems and their applications
- **Module 2: Robotic System Design and Development**
  - Mechanical design and engineering principles
  - Control systems and human-robot interaction
- **Module 3: AI and ML in Robotic Surgery**
  - Computer vision for image-guided surgery
  - Predictive modeling for surgical outcome prediction
  - ML algorithms for robotic control and navigation
- **Module 4: Clinical Applications and Benefits**
  - Minimally invasive surgery and robotic-assisted procedures
  - Enhanced dexterity and precision
  - Reduced complications and recovery time
- **Module 5: Challenges and Future Directions**
  - Regulatory frameworks and ethical considerations
  - Training and education for robotic surgeons
  - Emerging trends and innovations (e.g., autonomous surgery, soft tissue robotics)

- **Reference Book**

1. "Surgical Robotics: Systems Applications and Visions" edited by Jacob Rosen, Iake Hannaford, and Richard M. Satava.
2. Artificial Intelligence in Surgery: Understanding the Role of AI in Surgical Practice Authored by Daniel A. Hashimoto, Ozanan R. Meireles, and Guy Rosman.
3.

Computer Vision

Examination Scheme

MID Semester exam	30 marks
End Semester exam	50 marks
Continuous Evaluation	20 marks

Course Outcomes

- **Understand** and apply fundamental concepts of image processing and 2-D projective geometry, including homography and its properties.
- **Apply** camera and stereo geometry principles and their applications in 3D vision.
- **Implement** feature detection, description, and feature matching techniques, along with robust model fitting methods.
- **Apply** color image processing and range image processing techniques to real-world problems.
- **Utilize** clustering, classification, dimensionality reduction, and sparse representation methods in image analysis.

Course Content:

Fundamentals of Image processing; 2-D Projective Geometry, homography, and Properties of homography; Camera geometry; Stereo geometry; Stereo geometry
Feature detection and description; Feature matching and model fitting; Color processing; Range image processing; Clustering and classification; Dimensionality reduction and sparse representation; Deep neural architecture and applications

Reference Books

1.Multiple View Geometry in Computer Vision: R. Hartley and A. Zisserman, Cambridge University Press.
2.Computer Vision: Algorithms & Applications, R. Szeleski, Springer.
3.Computer vision: A modern approach: Forsyth and Ponce, Pearson.

Research Methodology

Teaching Scheme:
Lectures: 2hrs/week

Course Outcomes

1. Define research problem formulation and approaches of investigation of solutions for research problems.
2. Learn and use ethical practices to be followed in research and apply research methodology in case studies and acquire skills required for presentation of research outcomes.
3. Analyze IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario.
4. Summarize that it is an incentive for further research work and investment in R & D, leading to the creation of new and better products and generation of economic and social benefits.

Course Contents

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations.

Effective literature studies approaches, analysis, Use Design of Experiments /Taguchi Method to plan a set of experiments or simulations or build prototype, Analyze your results and draw conclusions or Build Prototype, Test and Redesign, Plagiarism, Research ethics, Effective technical writing, how to write report, Paper.

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Reference Books:

- Aswani Kumar Bansal : Law of Trademarks in India
- B L Wadehra : Law Relating to Patents, Trademarks, Copyright,Designs and Geographical
- Indications.
- G.V.G Krishnamurthy : The Law of Trademarks, Copyright, Patents and Design.
- Satyawrat Ponkse: The Management of Intellectual Property.