THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Curriculum and Scheme of Courses

for

B. Tech. Biomedical Engineering

Department of Electrical and Instrumentation Engineering

(w.e.f. 2026)

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

SEMESTER I

S. No.	Course Code	Course Name	CODE	L	T	P	Cr
1	UMA015	CALCULUS-I	BSC	4	1	0	4.5
2	UPH015	PHYSICS FOR BIOMEDICAL ENGINEERS	BSC	3	1	2	4.5
3	UHU003	PROFESSIONAL COMMUNICATION	HSS	2	0	2	3.0
4	UBM001	INTRODUCTION TO BIOENGINEERING APPLICATIONS	PCC	3	1	0	3.5
5	UBM004	HUMAN ANATOMY AND PHYSIOLOGY	PCC	3	0	0	3.0
6	UTA032	BOOTCAMP	OTH				1
		TOTAL		15	3	4	19.5

SEMESTER II

S. No.	Course Code	Course Name	CODE	L	T	P	Cr
1	UMA016	CALCULUS-II	BSC	4	1	0	4.5
2	UEN008	ENERGY AND ENVIRONMENT	BSC	3	0	0	3.0
3	UTA003	COMPUTER PROGRAMMING	ESC	3	0	2	4.0
4	UCB010	CHEMISTRY FOR BIOMEDICAL ENGINEERS	BSC	3	1	2	4.5
5	UBM031	ELECTRICAL CIRCUITS	PCC	3	1	2	4.5
		TOTAL		16	3	4	20.5

SEMESTER III

S. No.	Course Code	Course Name	CODE	L	T	P	Cr
1	UMA017	DIFFERENTIAL EQUATIONS	BSC	4	1	0	4.5
2	UBM032	ENGINEERING STATICS	PCC	3	1	0	3.5
3	UBM007	ADDITIVE MANUFACTURING IN BIOMEDICAL ENGINEERING	PCC	2	0	2	3.0
4	UBM301	SENSORS AND TRANSDUCERS IN HEALTHCARE	PCC	3	1	2	4.5
5	UBM505	INTRODUCTION TO ANALOG CIRCUITS AND DEVICES	PCC	3	1	2	4.5
6	UTD003	APTITUTDE SKILLS BUILDING	HSS	2	0	0	2.0
7	UCS321	AI FOR ENGINEERS	ESC	2	0	2	3.0
		TOTAL		19	4	8	25.0

**Counted in bachelor degree credit and 9-credit Micro-Credential Certification in AI Literacy*

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SEMESTER IV

S. No.	Course Code	Course Name	CODE	L	T	P	Cr
1	UBM401	LINEAR ALGEBRA FOR BIOMEDICAL ENGINEERING AND MACHINE LEARNING	PCC	3	1	2	4.5
2	UBM504	FUNDAMENTALS OF SIGNAL AND SYSTEMS	PCC	3	1	2	4.5
3	UBM006	INTRODUCTION TO BIOMECHANICS	PCC	3	1	2	4.5
4	UBM602	INTRODUCTION TO DIGITAL ELECTRONICS	PCC	3	1	2	4.5
5	UBM008	BIOMATERIALS	PCC	3	0	0	3.0
5	UHU050	EVOLUTIONARY BASIS OF HUMAN BEHAVIOUR FOR ENGINEERS (1 SELF-EFFORT HOUR)	HSS	1**	0	0	1.0
6	UCS421	ETHICS AND RISK MITIGATION IN AI	ESC	3	0	0	3.0
		TOTAL		19	4	8	25

**9-credit Micro-Credential Certification in AI Literacy*

***Alternate week*

SEMESTER V

S. No.	Course Code	Course Name	CODE	L	T	P	Cr
1	UBM507	INTRODUCTION TO EMBEDDED SYSTEMS	PCC	3	1	2	4.5
2	UBM605	DATA STRUCTURES AND ALGORITHMS	PCC	3	0	2	4.0
3	UBM508	MEDICAL INSTRUMENTS	PCC	3	1	2	4.5
4		ELECTIVE I	PEC	3	1	0	3.5
5	UTA025	INNOVATION AND ENTREPRENEURSHIP (1 SELF-EFFORT HOUR)	OTH	1	0	2**	3.0
6	UBM509	APPLICATIONS OF AI FOR BIOMEDICAL ENGINEERING	ESC	2	0	2	3.0
		TOTAL		15	3	8	22.5

(**Alternate week & 2 hours as self-effort hours)
**9-credit Micro-Credential Certification in AI Literacy*

SEMESTER VI

S. No.	Course Code	Course Name	CODE	L	T	P	Cr
1	UBM005	BIOMEDICAL QUALITY CONTROL	PCC	3	1	0	3.5
2	UBM694	CAPSTONE PROJECT (START)	PRJ	0	0	2	0
3		ELECTIVE II	PEC	3	1	0	3.5
4	UCS312	DATABASE MANAGEMENT SYSTEM	PCC	2	0	2	3.0
5	UBM701	MEDICAL IMAGE PROCESSING	PCC	3	0	2	4.0
6	UHU005	HUMANITIES FOR ENGINEERS	HSS	2	0	2	3.0
		TOTAL		13	2	8	17.0

SEMESTER VII

S. No.	Course Code	Course Name	CODE	L	T	P	Cr
1	UBM694	CAPSTONE PROJECT	PRJ	0	0	2	8.0
2	UBM706	ROBOTICS IN HEALTHCARE	PCC	2	0	2	3.0
3	UBM707	COMPUTATIONAL NEUROSCIENCE	PCC	3	1	2	4.5
4	UBM608	PHYSIOLOGICAL MODELING AND CONTROL	PCC	3	1	2	4.5
5	UBM708	REGULATORY PROCESSES AND BIOETHICS	PCC	3	0	0	3.0
		TOTAL		11	2	8	23.0

SEMESTER VIII

S. No.	Course Code	Course Name	CODE	L	T	P	Cr
1	UBM891	PROJECT SEMESTER	PRJ	-	-	-	15
1	UBM892	DESIGN PROJECT	PRJ	-	-	-	8
2	UEI613	BIOMETRICS	PCC	2	0	2	3
3	UBM632	ARTIFICIAL ORGANS AND LIMBS	PCC	3	0	2	4
1	UBM893	START-UP SEMESTER	PRJ	-	-	-	15

ELECTIVE I

S. No.	Course Code	Course Name	L	T	P	Cr
1	UBM522	LASER OPTICS AND ULTRASOUND	3	1	0	3.5
2	UBM521	APPLIED BIOTRANSPORT	3	1	0	3.5
3	UBM631	TELEMEDCINE IN HEALTH CARE	3	1	0	3.5
4	UBM523	BIOREGENERATIVE ENGINEERING	3	1	0	3.5

ELECTIVE II

S. No.	Course Code	Course Name	L	T	P	Cr
1	UBM604	BIOSIGNAL PROCESSING	3	1	0	3.5
2	UEI718	VIRTUAL INSTRUMENTATION	2	0	3	3.5
3	UBM633	HOSPITAL WASTE MANAGEMENT	3	1	0	3.5
4	UBM524	TISSUE ENGINEERING	3	1	0	3.5

TOTAL CREDITS: **167.5**

Nature of Course	Code	Total Credits
Basic Science Course	BSC	25.5
Engineering Science Course	ESC	13
Humanities and Social Science Course	HSS	9
Professional Core Courses	PCC	86
Professional Elective Courses	PEC	7
Project	PRJ	23
Others	OTH	4

UMA015 **CALCULUS I**

L	T	P	CR
4	1	0	4.5

Course Objectives: The successful Calculus-I student should be able to apply the following competencies to a wide range of functions, including piecewise, polynomial, rational, algebraic, trigonometric, inverse trigonometric, exponential and logarithmic:

Course Content:

Limits: Determine the existence of, estimate numerically and graphically and find algebraically the limits of functions. Recognize and determine infinite limits and limits at infinity and interpret them with respect to asymptotic behaviour.

Continuity: Determine the continuity of functions at a point or on intervals and to distinguish between the types of discontinuities at a point.

Derivatives: Determine the derivative of a function using the limit definition and derivative theorems. Interpret the derivative as the slope of a tangent line to a graph, the slope of a graph at a point, and the rate of change of a dependent variable with respect to an independent variable.

Indeterminate Forms: Evaluate limits that result in indeterminate forms, including the application of L'Hopital's Rule.

Higher Order Derivatives: Determine the derivative and higher order derivatives of a function explicitly and implicitly and solve related rates problems.

Graph Sketching: Determine absolute extrema on a closed interval for continuous functions and use the first and second derivatives to analyse and sketch the graph of a function, including determining intervals on which the graph is increasing, decreasing, constant, concave up or concave down and finding any relative extrema or inflection points. Appropriately use these techniques to solve optimization problems.

Antiderivatives: Determine antiderivatives, indefinite and definite integrals use definite integrals to find areas of planar regions, use the Fundamental Theorems of Calculus, and integrate by substitution.

Course learning outcome (CLO): Upon completion of this course, the students will be able to:

1. Determine the existence of the limits of functions, recognize and determine infinite limits and limits at infinity and interpret them with respect to asymptotic behavior.

2. Analyze the continuity of functions at a point or on intervals and to distinguish between the types of discontinuities at a point.
3. Determine the derivative of a function using the concept of limit, interpret the derivative as the slope of a tangent line to a graph, the slope of a graph at a point, and the rate of change of a dependent variable with respect to an independent variable.
4. Evaluate limits that result in indeterminate forms, including the application of L'Hôpital's Rule.
5. Determine the definite and indefinite integrals of functions.

Text Books:

1. Thomas' Calculus, George B. Thomas, Pearson Education, 2014, 14th edition.
2. Calculus Volume I, OpenStax (ISBN: 9781938168024), Contributing Authors: Edwin Jed Hermanand Gilbert Strang. The book is available for free at https://openstax.org/details/books/calculus-volume-1.
3. Mathematics, A Text book (Parts I & II), NCERT, New Delhi, 2011.
4. Stewart James, Essential Calculus; Thomson Publishers (2007), 6thed.

Reference Books:

1. Wider David V, Advanced Calculus: Early Transcendentals, Cengage Learning (2007).
2. Apostol Tom M, Calculus, Vol I and II, John Wiley (2003).
3. Brown J.W and Chruchill R.V, Complex variables and applications, MacGraw Hill, (7th edition)
4. Kasana, H.S., Complex Variables: Theory and Applications, Prentice Hall India, 2005 (2nd edition).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UPH015 **PHYSICS FOR BIOMEDICAL ENGINEERS**

L	T	P	CR
3	1	2	4.5

Course Objectives: Introduce the laws of oscillators, ultrasonics, electromagnetic waves, wave optics, lasers, magnetism, superconductivity and nanomaterials. Student will learn measurement principles and their applications in investigating physical phenomena in biomedical technology.

Course Content:

Oscillations and Waves: Oscillatory motion and damping, Applications - Electromagnetic damping – eddy current; Ultrasonics: Production and Detection of Ultrasonic waves, Applications - Ultrasound imaging, green energy, sound signaling, remote sensing, Car's airbag sensor.

Electromagnetic Waves: Scalar and vector fields; Gradient, divergence, and curl; Stokes' and Green's theorems; Concept of Displacement current; Maxwell's equations; Electromagnetic wave equations in free space and conducting media, Application - skin depth.

Optics: Interference: Parallel and wedge-shape thin films, Newton rings, Applications as Non-reflecting coatings, Measurement of wavelength and refractive index. Diffraction: Single and Double slit diffraction, and Diffraction grating, Applications - Dispersive and Resolving Powers. Polarization: Production, detection, Applications polarimeter. Lasers: Basic concepts, Laser properties, Ruby, HeNe, Biomedical LASERs (excimer, CO2, fibre and semiconductor diode lasers), Applications – Optical communication and bio-medical applications, Fibre Optics: Introduction, Types of fibres, Numerical aperture, Propagation and communications in optical fibre, Attenuation and dispersions, Applications – communications, sensors for bio-medical applications, medical diagnosis.

Magnetism and Superconductivity: Dia, Para, Ferro & Ferri magnetism, Magnetic Anisotropy, Magnetostriction, Hysteresis and its application. Signatures of Superconducting state, Meissner Effect, Critical field, Type I & Type II superconductors, Introduction to BCS theory, High temperature superconductors, Applications of superconductors.

Nanomaterials: Introduction – basic principle to nanoscience and technology, Structure and bonding in nanomaterials, Carbon nanotubes, buckyballs, Applications – Nanocomposites, chemical- and bio-sensing, Biological/bio-medical applications

Laboratory Work:

1. Determination of damping effect on oscillatory motion due to various media.

2. Determination of velocity of ultrasonic waves in liquids by stationary wave method.
3. Determination of wavelength of sodium light using Newton's rings method.
4. Determination of dispersive power of Sodium-D lines using diffraction grating.
5. Determination of specific rotation of cane sugar solution.
6. Study and proof of Malus' law in polarization.
7. Determination of beam divergence and beam intensity of a given laser.
8. Determination of displacement and conducting currents through a dielectric.
9. Determination of Planck's constant.

Micro Project: Students will be asked to solve physics-based problems/assignments analytically or using computer simulations, etc.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Analyze damped and simple harmonic motion and generation and detection of ultrasonic waves.
2. Apply Maxwell's equations to describe propagation of EM waves in a medium.
3. Demonstrate interference, diffraction and polarization of light.
4. Illustrate the working principle of Lasers and fibre optics and their different applications.
5. An understanding of magnetic and superconducting properties of materials and their applications.
6. Understand the Nanoscience and applications.

Text Books:

1. Jenkins, F.A. and White, H.E., Fundamentals of Optics, McGraw Hill (2001).
2. Beiser, A., Concept of Modern Physics, Tata McGraw Hill (2007).
3. Griffiths, D.J., Introduction to Electrodynamics, Prentice Hall of India (1999).
4. Reference Books:
5. Pedrotti, Frank L., Pedrotti, Leno S., and Pedrotti, Leno M., Introduction to Optics, Pearson Prentice HallTM (2008).
6. Wehr, M.R, Richards, J.A., Adair, T.W., Physics of The Atom, Narosa Publishing House (1990).
7. Verma, N.K., Physics for Engineers, Prentice Hall of India (2014)

Evaluation Scheme:

Event	Weightage
Mid-Sem Test	25
Tut/Sessional	7
Lab + Project	25
Quiz	8
End-Sem Test	35
Total	100

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UHU003 **PROFESSIONAL COMMUNICATION**

L	T	P	CR
2	0	2	3.0

Course Objective: To introduce the students to effective professional communication. The student will be exposed to effective communication strategies and different modes of communication. The student will be able to analyze his/ her communication behavior and that of the others. By learning and adopting the right strategies, the student will be able to apply effective communication skills, professionally and socially.

Course Content:

Effective Communication: Meaning, Barriers, Types of communication and Essentials. Interpersonal Communication skills.

Effective Spoken Communication: Understanding essentials of spoken communication, Public speaking, Discussion Techniques, Presentation strategies.

Effective Professional and Technical writing: Paragraph development, Forms of writing, Abstraction and Summarization of a text; Technicalities of letter writing, internal and external organizational communication. Technical reports, proposals and papers.

Effective non-verbal communication: Knowledge and adoption of the right nonverbal cues of body language, interpretation of the body language in professional context. Understanding Proxemics and other forms of nonverbal communication.

Communicating for Employment: Designing Effective Job Application letter and resumes; Success strategies for Group discussions and Interviews.

Communication Networks in Organizations: Types, barriers and overcoming the barriers.

Laboratory Work:
1. Pre -assessment of spoken and written communication and feedback.
2. Training for Group Discussions through simulations and role plays.
3. Training for effective presentations.
4. Project based team presentations.
5. Proposals and papers-review and suggestions.

Minor Project (if any): Team projects on technical report writing and presentations.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Understand and appreciate the need of communication training.
2. Use different strategies of effective communication.
3. Select the most appropriate mode of communication for a given situation.

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4. Speak assertively and effectively.
5. Correspond effectively through different modes of written communication.
6. Write effective reports, proposals and papers.
7. Present himself/herself professionally through effective resumes and interviews.

Text Books:

1. Lesikar R.V and Flately M.E., Basic Business Communication Skills for the Empowering the Internet Generation. Tata Mc Graw Hill. New Delhi (2006).
2. Raman,M & Sharma, S., Technical Communication Principles and Practice, Oxford University Press New Delhi(2011).
3. Mukherjee H.S., Business Communication-Connecting at Work, Oxford University Press New Delhi, (2013).

Reference Books:

1. Butterfield, Jeff., Soft Skills for everyone, Cengage Learning New Delhi,(2013).
2. Robbins, S.P., & Hunsaker, P.L., Training in Interpersonal Skills, Prentice Hall of India New Delhi,(2008).
3. DiSianza, J.J & Legge, N. J., Business and Professional Communication, Pearson Education India New Delhi,(2009).

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	45
3	Sessional (Group Discussions; professional presentations; panel discussions; public speaking; projects, quizzes)	30

UBM001 INTRODUCTION TO BIOENGINEERING APPLICATIONS

L	T	P	CR
3	1	0	3.5

Course objective: The students will learn that engineering principles can be applied to living systems and to demonstrate key principles and engineering concepts taught in various courses throughout the Biomedical Engineering

Course Content:

Basic Concepts: Numbers, Units and Consistency Checks: Introduction, Numbers and significant figures, Scientific Notation, Accuracy and Precision, Dimensions and units, SI Units, Keeping Track of Units in Equations, English and Other Units, Conversion factors, The Use of Weight to Describe Mass, Consistency checks, Reality Check, Units Check, Ranging Check

Darcy's Law: Pressure-Driven Transport through Membranes: Introduction – Biological and Man-Made Membranes, Darcy's Law, Ideal and Non ideal Materials, Mechanical Filtration (Sieving)

Poiseuille's Law: Pressure-Driven Flow Through Tubes: Introduction – Biological Transport, Poiseuille's Law, Simplified Version of Poiseuille's Law, Assumptions for Poiseuille's Law, Power Expended in the Flow, Series and Parallel Combinations of Resistive Elements, Series,
Parallel

Hooke's Law: Elasticity of Tissues and Compliant Vessels: Introduction, The Action of Forces to Deform Tissue, HOOKE'S Law and Elastic Tissues, Compliant Vessels, Incompressible Flow of Compliant Vessels

Starling's Law of the Heart, Windkessel Elements and Conservation of Volume: Introduction – Compliance of the Ventricles, Pressure-Volume Plots: the pv Loop, STARLING'S LAWOF THE HEART, Windkessel Elements, Conservation of Volume in Incompressible Fluids

Euler's Method and First-Order Time Constants: Introduction: Differential Equations, Euler's Method, Waveforms of Pressure and Volume, First-Order Time Constants

Muscle, Leverage, Work, Energy and Power: Introduction: Muscle, Levers and Moments, Work, Energy, Power, Power in Fluid Flow

Ohm's Law: Current, Voltage and Resistance: Introduction, Charge, Electric Field, Current, Voltage, Ohm's Law, Fluid Analogies, Sign Conventions for Voltage and Current, Resistivity of Bulk Materials, Diodes and Other Non-Ohmic Circuit Elements, Power Loss in Resistors

Kirchhoff's Voltage and Current Laws: Circuit Analysis: Introduction, Kirchhoff's Voltage Law (KVL), Kirchhoff's Current Law (KCL), Resistive Circuit Analysis Using the Branch Current Method

Series and Parallel Combinations of Resistors and Capacitors: Introduction, Resistors in Series, Resistors in Parallel, Capacitors in Series, Capacitors in Parallel, Voltage Divider, Current Divider.

Course learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Understand the basic concepts of numbers, units and consistency checks
2. Apply Darcy's Law, Poiseuille's Law, Hooke's Law, Starling's Law and Euler's Method on physiological system
3. Comprehend the Muscle, Leverage, Work, Energy and Power for the system
4. Apply Ohm's Law, Kirchhoff's Voltage and Current Laws, Series and Parallel Combinations of Resistors and Capacitors for solving circuits.

Text Book:

1. Introduction to Biomedical Engineering: Biomechanics and Bioelectricity Part I & II," D.A. Christensen, Synthesis Lectures on Biomedical Engineering, Morgan & Claypool (2009).
2. Introduction to Biomedical Engineering, 2nd Edition, by John Enderle, Joseph Bronzino, Susan M. Blanchard, Elsevier Academic Press (2005)

Evaluation Scheme:

S. No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (Assignments/Quizzes)	25

UBM004 **HUMAN ANATOMY AND PHYSIOLOGY**

L	T	P	CR
3	0	0	3.0

Course Objective: This course will introduce students to central concepts in human anatomy and physiology. This includes the structure, function and homeostatic role of key organs within the body; the engineering principles governing these systems and processes; and designing engineering-based solutions to overcome dysfunction in disease.

Course Content:

Introduction to the Human Body: Eleven systems of the human body, Homeostasis, Human body planes and sections. Polarization & depolarization of cell. Types of tissues & their origins with functions in brief. Membranes Epithelial, Mucous, Serous, Cutaneous and Synovial.

Cardiovascular, Respiratory & Alimentary System: Heart, conductive tissue of heart, cardiac cycle, heart valves, systemic & pulmonary circulation, Transmission of cardiac impulse, blood pressure. Blood: composition of blood-blood cells & their functions, Respiratory system: respiration external (ventilation), Exchange in gases in the alveoli, artificial respiration. Alimentary system: all organs of the digestive system, other secretions & main functions.

Nervous & Excretory System: Different parts, their functions, reflex action & reflex arc. Function of sympathetic nervous system, nervous conduction & action potentials. Excretory system: Structure of Nephron, formation of urine & function of kidneys, urinary bladder, urethra, internal/external sphincters.

Reproductive, Endocrine & Sensory System: (male & female). Endocrine system: all glands, their secretions, control of secretions. Sense organs: Eye, Ear, Integumentary system: structure, type and functions of skin.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Understand the structure of organs and skins
2. Recognize the components of blood and its transfusion
3. Acquire the knowledge of the respiratory and digestive mechanism
4. Realize the brain activity and central nervous system.

Text Book

1. Anatomy and physiology in health and illness by: Ross and Wilson (ELBS Publishers)

2. Human Phiosology by A. Vander, J. Sherman and D. Luciano (Mc Graw Hill Publishers)

Reference Book

1. Manual of Human Dissection by Charles E Tobin (Mc Graw Hill, Edition 4, 1961)
2. Modern Physiology and Anatomy of Nurses by J Gibson (Black Well, 1981)
3. Physiology of human body by Guyton. (Prism books)
4. Principles of Anatomy and Physiology by Tortora and Grabowski. (Haper Collin publishers)
5. Biosimulation: simulation of living systems by Daniel. A. Beard Cambridge texts in Biomedical Engineering, 2012 (Cambridge University Press)

Evaluation Scheme:

S. No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (may include Assignments / Projects / Tutorials / Quiz)	25

UMA016 **CALCULUS II**

L	T	P	CR
4	1	0	4.5

Course Objectives: The objective is to impart students with skills and knowledge of techniques of integration, definite integrals, sequences and series, power series and parametric curves, to be enable them to solve the requisite biological problems.

Course Content:

Definite Integrals: Use antiderivatives to evaluate definite integrals and apply definite integrals in a variety of applications to model physical, biological or economic situations. Whatever applications (e.g. determining area, volume of solids of revolution, arc-length, area of surfaces of revolution, centroids, work, and fluid forces) are chosen, the emphasis should be on setting up an approximating Riemann sum and representing its limit as a definite integral.

Techniques of Integration: Employ a variety of integration techniques to evaluate special types of integrals, including substitution, integration by parts, trigonometric substitution, and partial fraction decomposition.

Improper Integrals: Evaluate improper integrals, including integrals over infinite intervals, as well as integrals in which the integrand becomes infinite on the interval of integration.

Sequences and Series: Determine the existence of and find algebraically the limits of sequences. Determine whether a series converges by using appropriate tests, including the comparison, ratio, root, and integral.

Power Series: Find the nth Taylor polynomial at a specified center for a function and estimate the error term. Use appropriate techniques to differentiate, integrate and find the radius of convergence for the power series of various functions.

Parametric Curves: Analyze curves given parametrically and in polar form and find the areas of regions defined by such curves.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Employ a variety of integration techniques including substitution, integration by parts, trigonometric substitution and partial fraction decomposition, to evaluate special types of integrals.
2. Use antiderivatives to evaluate definite integrals and apply definite integrals in determining area and arc-length.
3. Acquire the knowledge of sequences and series.

4. Acquire the knowledge of power series and parametric curves

Text Books:

1. Thomas' Calculus, George B. Thomas, Pearson Education, 2014, 14th edition.
2. Calculus – Volume II, OpenStax (Print ISBN-13: 978-1-938168-06-2; Digital ISBN-13: 978-1-947172-14-2), Senior Contributing Authors: Edwin "Jed" Herman and Gilbert Strang. The ebook is available for free athttps://openstax.org/details/books/calculus-volume-2;
3. Mathematics, A Text book (Parts I & II), NCERT, New Delhi, 2011.
4. Stewart James, Essential Calculus; Thomson Publishers (2007), 6th ed.

Reference Books:

1. Wider David V, Advanced Calculus: Early Transcendentals, Cengage Learning (2007).
2. Apostol Tom M, Calculus, Vol I and II, John Wiley (2003).

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UEN008 **ENERGY AND ENVIRONMENT**

L	T	P	CR
3	0	0	3.0

Course Objectives: The exposure to this course would facilitate the students in understanding the terms, definitions and scope of environmental and energy issues pertaining to current global scenario; understanding the value of regional and global natural and energy resources; and emphasize on need for conservation of energy and environment.

Course Content:

Introduction: Natural Resources & its types, Concept of sustainability and sustainable use of natural resources, Pollution based environmental issues and case studies

Conventions on Climate Change: Origin of Conference of Parties (COPs), United Nations Framework Convention on Climate Change (UNFCCC) and Intergovernmental Panel on Climate Change (IPCC); Kyoto Protocol, instruments of protocol – CDM, JI and IET; Montreal Action Plan; Paris Agreement and post-Paris scenario.

Air Pollution: Origin, Sources and effects of air pollution; Primary and secondary meteorological parameters; Wind roses; Atmospheric Stability; Inversion; Plume behavior; Management of air pollution: Source reduction and Air Pollution Control Devices for particulates and gaseous pollutants in stationary and mobile sources.

Water Pollution: Origin, Sources of water pollution, Category of water pollutants, Physico-Chemical characteristics, Components of wastewater treatment systems, Advanced treatment technologies.

Solid waste management: Introduction to solid waste management, Sources, characteristics of municipal and industrial solid waste, Solid waste management methods: Incineration, composting, Bio-methanation, landfill, E-waste management, Basal convention.

Energy Resources: Classification of Energy Resources; Conventional energy, Resources-Coal, petroleum and natural gas, nuclear energy, hydroelectric power; Non-conventional energy resources- Biomass energy, Thermo-chemical conversion and biochemical conversion route; Generation of Biogas and biodiesel as fuels; Solar energy-active and passive solar energy absorption systems; Type of collectors; Thermal and photo conversion applications; Wind energy.

Facilitated through Online Platforms

Ecology and Environment: Concept of an ecosystem; structural and functional units of an ecosystem; Food Chain, Food Web, Trophic Structures and Pyramids; Energy flow; Ecological Succession; Types, Characteristics, Biodiversity, Biopiracy.
Human Population and the Environment: Population growth, variation among nations; Population explosion – Family Welfare Programmes; Environment and human health; Human Rights; Value Education; Women and Child Welfare; Role of Information Technology in Environment and Human Health, Environmental Ethics.

Course Learning Outcomes (CLOs): Upon completion of this course, the students will be able to:

1. Comprehend the interdisciplinary context with reference to the environmental issues and case studies
2. Assess the impact of anthropogenic activities on the various elements of environment and apply suitable techniques to mitigate their impact.
3. Conceptualize and explain the structural and functional features of ecological systems
4. Correlate environmental concerns with the conventional energy sources associated and assess the uses and limitations of non-conventional energy technologies

Recommended Books

1. Moaveni, S., Energy, Environment and Sustainability, Cengage (2018)
2. Down to Earth, Environment Reader for Universities, CSE Publication (2018)
3. Chapman, J.L. and Reiss, M.J., Ecology - Principles and Application, Cambridge University Press (LPE) (1999).
4. Eastop, T.P. and Croft, D.R. Energy Efficiency for Engineers and Technologists, Longman and Harow (2006).
5. O'Callagan, P.W., Energy Management, McGraw Hill Book Co. Ltd. (1993).
6. Peavy H.S. and Rowe D.R. Environmental Engineering, McGraw Hill (2013).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UTA013 **COMPUTER PROGRAMMING**

L	T	P	CR
3	0	2	4.0

Course objective: This course is designed to explore computing and to show students the art of computer programming. Students will learn some of the design principles for writing good programs.

Course Content:

Computer Fundamentals: Classification of Computers, Application of Computers, Basic Organisation of Computers, Input and Output Devices, Binary Number System, Computer Memory, Computer Software.

Algorithms and Programming Languages: Algorithm, Flowcharts, Pseudocode, Generation of Programming Languages.

C Language: Structure of C Program, Life Cycle of Program from Source code to Executable, Compiling and Executing C Code, Keywords, Identifiers, Primitive Data types in C, variables, constants, input/output statements in C, operators, type conversion and type casting. Conditional branching statements, iterative statements, nested loops, break and continue statements.

Functions: Declaration, Definition, Call and return, Call by value, Call by reference, showcase stack usage with help of debugger, Scope of variables, Storage classes, Recursive functions, Recursion vs Iteration.

Arrays, Strings and Pointers: One-dimensional, Two-dimensional and Multi-dimensional arrays, operations on array: traversal, insertion, deletion, merging and searching, Inter-function communication via arrays: passing a row, passing the entire array, matrices. Reading, writing and manipulating Strings, understanding computer memory, accessing via pointers, pointers to arrays, dynamic allocation, drawback of pointers.

Linear and Non-Linear Data Structures: Linked lists, stacks and queues.

Laboratory work: To implement Programs for various kinds of programming constructs in C Language.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Comprehend concepts related to computer hardware and software, draw flowcharts and write algorithm/pseudocode.
2. Write, compile and debug programs in C language, use different data types, operators and console I/O function in a computer program.

3. Design programs involving decision control statements, loop control statements, case control structures, arrays, strings, pointers, functions and implement the dynamics of memory by the use of pointers.
4. Comprehend the concepts of linear and Non-Linear data structures by implementing linked lists, stacks and queues.

Evaluation scheme:

Sr. no.	Evaluation Elements	Weights (%)
1.	MST	25
2.	EST	40
3.	Sessional (May include Assignments /Projects /Tutorials /Quiz /Lab evaluations)	35

UCB010 **CHEMISTRY FOR BIOMEDICAL ENGINEERS**

L	T	P	CR
3	1	2	4.5

Course Objectives: This course aims to apply fundamental chemical principles to biomedical devices and diagnostic systems. It focuses on the chemistry underlying implants, medical materials, and material–biological interactions.

Chemistry in Human Physiology: Blood chemistry and physiological balance, pH regulation, electrolyte balance, Acid–base balance and buffer systems in the human body, Introduction to fundamentals of protein structure, hemoglobin chemistry. Chemistry of oxygen transport and storage, Chemical basis of inflammation and oxidative stress, Chemical principles behind diagnostic tests such as glucose, urea, creatinine, and cholesterol estimation.

Biomaterials in Medical Devices: Chemistry of orthopedic implants, including titanium alloys and stainless steel, Corrosion mechanisms in implants and body fluids, Bioactive ceramics (hydroxyapatite, bone substitutes), Polymeric implants (PMMA bone cement, PEG, and PLA), biocompatibility, toxicity, and biodegradation mechanisms, Surface modification strategies for implant integration, Chemistry of dental biomaterials, cardiovascular stent materials and coatings.

Biosensors and Diagnostic Chemistry: Principles of biosensors, Electrochemical glucose biosensor, Enzyme immobilization techniques, immunoassay chemistry (ELISA), Basic chemistry of polymerase chain reaction (PCR, Wearable chemical sensors, Applications of diagnostic chemistry in healthcare systems.

Separation Techniques: Principles of chromatographic techniques (Gas chromatography, High-performance liquid chromatography), fundamentals of spectroscopic techniques (UV-visible and IR spectroscopy), general principles of electrophoretic techniques (Native-PAGE, SDS-PAGE), basic principles of mass spectrometry

Laboratory Experiments

1. Preparation and evaluation of physiological buffer (pH 7.4)
2. Synthesis of silver nanoparticles as antibacterial testing agents
3. Pigment separation using paper chromatography
4. Surface wettability measurement (contact angle demonstration)
5. Preparation of SDS-PAGE gels and protein molecular weight determination
6. Detection and identification of blood groups
7. Demonstration of HR-MS and FE-SEM instruments

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Explain chemical principles behind medical diagnostics.
2. Analyze material–tissue interactions in biomedical systems.
3. Evaluate biomaterial performance in clinical applications.
4. Apply chemical techniques in biosensor design.
5. Interpret experimental data from biomedical laboratory studies.

Recommended Books

1. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2015). Harper's Illustrated Biochemistry (30th ed.). McGraw-Hill Education.
2. Nelson, D. L., & Cox, M. M. (2017). Lehninger Principles of Biochemistry (7th ed.). W. H. Freeman & Company.
3. Ratner, B. D., Hoffman, A. S., Schoen, F. J., & Lemons, J. E. (Eds.). (2012). Biomaterials Science: An Introduction to Materials in Medicine (3rd ed.). Elsevier/Academic Press.
4. Park, J. B., & Lakes, R. S. (2007). Biomaterials: An Introduction (3rd ed.). Springer.
5. Wang, J. (2006). Analytical Electrochemistry (3rd ed.). Wiley-VCH.
6. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of Instrumental Analysis (7th ed.). Cengage Learning.

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM301 **ELECTRICAL CIRCUITS**

L	T	P	CR
3	1	2	4.5

Course Objective: To introduce concepts of DC and AC circuits and electromagnetism.

Course Content:

Elementary Concepts: Concept of Potential difference and EMF. Ohm's law, effect of temperature on resistance, resistance temperature coefficient. SI units of work Power and Energy.

D. C. Circuits (Only Independent sources): Kirchhoff's law, ideal and practical voltage and current sources. Mesh and Nodal analysis (Super node and super Mesh excluded). Source transformation. Star delta transformation. Superposition theorem, Thevenin's theorem Norton's theorem, maximum power transfer theorem.

Steady state analysis of DC Circuits: The ideal capacitor, permittivity, parallel plate capacitor, variable capacitor; charging and discharging characterization, time-constant, rise-time, fall-time; inductor energization and de-energization, inductance current-voltage relationship,time-constant; Transient response of RL, and RC circuits.

A.C. Fundamentals: Sinusoidal voltage and currents, their mathematical and graphical representation, concept of cycle period, frequency, instantaneous, peak, average, r.m.s. values, peak factor, and form factor, phase difference, lagging, leading and in phase quantities and phasor representation. Series and parallel circuits, fundamentals of resonance in AC circuits

Electromagnetism: Electromagnetic induction, Dot convention, Equivalent inductance, Analysis of Magnetic circuits, AC excitation of magnetic circuit, Iron Losses, Fringing and stacking, applications: solenoids and relays.

Laboratory Work:

Verification of KVL and KCL, Superposition, Thevenin and Norton theorems, Measurement of R, L, C parameters, A.C. series and parallel circuits, Computer aided analysis of RL and RC circuits, Magnetic circuits.

Course Learning Outcomes (CLOs): Upon completion of this course, the students will be able to:

7. Apply networks laws and theorems to solve electric circuits.
8. Analyze steady state response of DC circuits.

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

9. Signify AC quantities through phasor and compute AC system behavior during steady state.
10. Apply the concepts of electro magnetism and electrostatics to solve the engineering problems.

Text Books:

1. Hughes, E., Smith, I.M., Hiley, J. and Brown, K., Electrical and Electronic Technology, PHI (2008).
2. Nagrath, I.J. and Kothari, D.P., Basic Electrical Engineering, Tata McGraw Hill (2002).
3. Naidu, M.S. and Kamashaiah, S., Introduction to Electrical Engineering, Tata McGraw Hill (2007).

Reference Books:

1. Chakraborti, A., Basic Electrical Engineering, Tata McGraw-Hill (2008).
2. Del Toro, V., Electrical Engineering Fundamentals, Prentice-Hall of India Private Limited (2004).

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UMA017 **DIFFERENTIAL EQUATIONS**

L	T	P	CR
4	**1**	**0**	**4.5**

Course Objectives: The course is designed to impart students with basic knowledge of sequence, infinite series and their convergence, Taylor series expansion of functions, analysis and solution of ordinary differential equations with emphasis on the fundamental techniques for solving linear differential equations and their applications to practical problems.

Course Content:

Introduction to differential equations: Some Basic Mathematical Models, Standard equations,
Classification of differential equation, solutions to some differential equations.

First order differential equations: Linear Equations; Method of Integrating Factors; Separable Equations; Modeling with First Order Equations; Differences between Linear and Nonlinear equations exact equations and Integrating Factors.

Second order differential equations: Homogeneous Equations with Constant Coefficients, Solutions of Linear Homogeneous Equations, Complex Roots of the Characteristic Equation; Euler Equations, Repeated Roots, Reduction of Order, Nonhomogeneous Equations, Variation of Parameters, Mechanical and Electrical Vibrations.

Higher order differential equations: General Theory of n^{th} order Linear Equations, method of Undetermined Coefficients, method of Variation of Parameters.

Improper Integrals and Laplace transforms: Improper integrals: Introduction and examples, Definition of the Laplace Transform, Solution of Initial Value Problems, Step Functions, Differential Equations with Discontinuous Forcing Functions, Impulse Functions, The Convolution Integral.

Sequence and series: Sequences, Arithmetic progressions, Geometric progressions, Infinite Series; The Integral Test; Comparison Tests, Ratio and Root Tests, Alternating Series, Absolute and Conditional Convergence; Power Series, Taylor and Maclaurin Series, Convergence of Taylor Series; Applications of Taylor Series.

Course Learning Outcomes (CLOs): Upon completion of this course, the students will be able to:

1. Find the nth Taylor polynomial at a specified center for a function and estimate the error term. Use appropriate techniques to differentiate, integrate and find the radius of convergence for the power series of various functions.
2. Solve first-order differential equations that are separable, linear or exact, also solve first-order differential equations by making the appropriate substitutions, including homogeneous equations.
3. Use linear or non-linear first-order differential equations to solve application problems such as exponential growth and decay.
4. Solve higher-order homogeneous and non-homogenous differential equations with constant coefficients.
5. Perform operations with Laplace and inverse Laplace transforms to solve higher-order differential equations.
6. Determine the existence of, and find algebraically, the limits of sequences, determine whether a series converges by using appropriate tests, including the comparison, ratio, root, and integral test.

Text Books:

1. Thomas' Calculus, George B. Thomas, Pearson Education, 2014, 14th edition.
2. Elementary Differential Equations, Boyce and Diprima, 10th edition, Wiley, 2012.
3. Mathematics, A Text book (Parts I & II), NCERT, New Delhi, 2011.

Reference Books:

1. Simmons, G.F., Differential Equations (With Applications and Historical Notes), Tata McGraw Hill (2009).
2. Apostol Tom M, Calculus, Vol I and II, John Wiley (2003).

Evaluation Scheme:

S. No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM032 **ENGINEERING STATICS**

L	T	P	CR
3	1	0	3.5

Course Description: This course covers the topics of the operations with free body concept, equilibrium of coplanar and non-coplanar force systems, analysis of trusses, friction and centroids, center of gravity and moment of inertia.

Course Content:

Introduction to statics: Introduction, Newtonian Mechanics, Fundamental Properties of Vectors, Representation of Vectors Using Rectangular Components, and Vector Multiplication.

Basic Operation with Force Systems: Equivalence of Vectors, Force, Reduction of Concurrent Force Systems, Moment of a Force about a Point, Moment of a Force about an axis, Couples, Change the Line of Action of a Force.

Resultant of Force Systems: Reduction of Force System to a Force and a Couple, Definition of Resultant, Resultant of Coplanar Force Systems, Resultant of Three-Dimensional Systems, Introduction to Distributed Normal Loads.

Coplanar Equilibrium Analysis: Definition of Equilibrium, Free-Body Diagram of a body, Coplanar Equilibrium Equations, Writing and Solving Equilibrium Equations, Equilibrium Analysis for Single-Body Problems, Free-Body Diagrams involving Internal Reactions, Equilibrium Analysis of Composite bodies, Analysis of Trusses, Method of Joints, Method of Sections.

Three-Dimensional Equilibrium: Free-body Diagrams, Independent Equilibrium equations, Improper Constraints, Writing and Solving Equilibrium equations, Equilibrium Analysis.

Friction: Coulomb's theory of Friction, Problem Classification and Analysis, Impending Tipping Angle of Friction: Wedges and Screws, Ropes and Flat belts.

Centroids and Center of Gravity: Centroids of Plane Areas and Curves, Centroids of Curved surfaces, Volumes, and Space curves, Theorem of Pappus- Guldinus.

Moment of Inertia: Moment of Inertia of Areas, Moment of inertia about the centroidal axes

Course Learning Outcomes (CLOs): Upon completion of this course, the students will be able to:

1. To explain and analyze the free body diagram of the mechanical structures.

2. To apply and illustrate the equilibrium equation in case of rigid bodies for 2D and 3D structures.
3. To recognize and analyze the problems related to internal and external forces for trusses.
4. To illustrate the problems of wedge, screw, ropes and flat belts utilizing friction.
5. To identify the centroid and moment of inertia of rigid body structure.

Text Books:

1. Shames, I. H. Engineering Mechanics: Dynamics, Pearson Education India (2006).
2. Beer, Johnston, Clausen and Staab, Vector Mechanics for Engineers, Dynamics, McGraw-Hill Higher Education (2003).

Reference Books:

1. Hibler, T.A., Engineering Mechanics: Statics and Dynamics, Prentice Hall (2012).
2. Timoshenko and Young, Engineering Mechanics, Tata McGraw Hill Education Private Limited, (2006).
3. J. L. Meriam and L. G. Kraige, Engineering Mechanics, Vol I – Statics, Vol II – Dynamics, 6th Ed, John Wiley, 2008.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM007 **ADDITIVE MANUFACTURING IN BIOMEDICAL ENGINEERING**

L	T	P	CR
2	0	2	3.0

Course objectives: This course introduces the fundamentals of rapid prototyping (RP) / additive manufacturing and its application in the biomedical field.

Course Content:

Introduction: Rapid prototyping (RP) / additive manufacturing for Biomedical Engineering: Current Capabilities and Challenges, Basic Principles of RP, Biomodels for Surgical Training, Planning, and Procedures.

Classifications of Different RP Techniques, Process Technology in RP: Based on raw material, Based on layering technique and energy sources. Biocompatible materials.

Design of CAD Models for bioengineering applications: Transformations, Curves, Surface Modeling, Solid modeling for additive manufacturing using solid works. Advances in Biomimetic Computer-Aided Design and Engineering

Process Technology in RP: Stereo-lithography, Laser additive manufacturing LENS, Selective laser sintering (SLS), Selective laser melting (SLM) or direct metal laser sintering (DMLS), Fused deposition modeling (FDM), Laminated object manufacturing, Three-dimensional Bioplotter.

STL files for RP: STL file generation, Defects in STL files and repairing algorithms, other Interface formats.

Laboratory Work:

1. To generate solid models with the given dimensions using SolidWorks.
2. Design and fabricate a physical model for biomedical applications.
3. The students will be doing a project realizing the application of RP technology for 3D scaffold for biomedical applications

Course Learning Outcomes (CLOs): Upon completion of this course, the students will be able to:

1. Develop a solid model applying the concepts of transformations & solid modelling or using MRI/CT scan data.
2. Analyze different rapid prototyping systems based on their principles of operation and materials used for different types of biomedical applications
3. Develop physical prototype applying the fundamental concepts of rapid prototyping for biomedical applications.

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

Text Books:

1. Chua, C.K., Leong, K.F., Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley and Sons Inc., 2000.
2. Pham, D.T., Demov, S.S., Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer-Verlag London Limited, 2001.
3. Noorani, R., Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., New Jersey, 2006.
4. Narayan, Roger, ed. Rapid Prototyping of Biomaterials: Techniques in Additive Manufacturing. Woodhead Publishing, 2019.

Reference Books:

1. Patri, K. V., Weiyin, Ma, Rapid Prototyping - Laser-based and Other Technologies, Kluwer Academic Publishers, U.S.A., 2003.
2. Hague, R.J.M., Reeves, P. E., Rapid Prototyping, Tooling and Manufacturing, iSmithers Rapra Publishing, 2000.
3. Gibson, Ian, David W. Rosen, and Brent Stucker. Additive manufacturing technologies. Vol. 17. New York: Springer, 2014.
4. Hopkinson, N., Hague, R.J.M., Dickens, P.M., Rapid Manufacturing- An Industrial Revolution for the Digital Age, John Wiley & Sons Ltd., U.K., 2006.
5. Zeid, I., Mastering CAD/CAM, Tata McCraw Hil

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weight age (%)
1	MST	25
2	EST	45
3	Sessional (Assignments / Quizzes / Presentations / Lab work / Project)	30

UBM301 **SENSORS AND TRANSDUCERS IN HEALTHCARE**

L	T	P	CR
3	1	2	4.5

Course Objectives: This course aims to make the students familiar with the construction, working principle, signal conditioning and use of different types of sensors and transducers in medical field.

Course Content:

Basics of Sensors and transducers: Definition and classification of sensors and transducers, static and dynamic sensor characteristics, signal conditioning, signal modulation and demodulation, healthcare application of sensors.

Physical Sensors: Resistance, capacitive and inductive sensors, signal conditioning circuit and healthcare applications, Piezoelectric Sensors, Ultrasonic sensors, magnetoelectric sensors, Hall effect Sensors, Photoelectric Sensors, Fiber Optic Sensors, Temperature sensors and their biomedical application, Encoders, MEMS technology and MEMS-based sensor fabrication.

Physiological sensors: Biomedical signals and other physiological and biochemical parameters, basics of ECG, EMG sensor, galvanic skin resistance, oximeter, heart rate sensors.

Chemical Sensors: Basics of electrochemistry, Ion-Selective Electrodes, pH sensors, conductivity sensor, Gas Sensors (Electrochemical, Semiconductor- and Solid Electrolyte-based), Humidity Sensors (Capacitive Humidity Sensors, Resistive Humidity Sensors, Thermal Conductivity Humidity Sensors), Intelligent Chemical Sensor Arrays (e-Nose, e-Tongue).

Biosensors and smart sensors: Definition, components and classification of biosensors, electrochemical, optical and quartz based biosensors, Smart sensors - component and architecture, smart wearable sensors for medical devices.

Laboratory: Experiments based on strain gauge, capacitive transducer, LVDT, photoelectric, piezoelectric, temperature measurement, LDR.

Course Learning Outcomes (CLOs Upon completion of this course, the students will be able to:

1. Classify and analyze the characteristics of sensors and transducers
2. Describe the operation of physical and physiological sensors and their application for measuring biomedical signals.
3. Elucidate the working principle and applications of chemical sensors

4. Classify and analyse the working principles of biosensors and smart sensors

Text Books:

1. Biomedical Sensors and Measurement, Ping Wang Qingjun Liu, 2020, Springer Nature Switzerland AG (Part of Springer Nature)
2. Measurement systems: Application & Design, E. A. Doebelin, 2020, McGraw Hill

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessional (May include assignments/quizzes)	30

UBM505 **INTRODUCTION TO ANALOG CIRCUITS AND DEVICES**

L	T	P	CR
3	1	2	4.5

Course objective: This course will introduce students the basics of design of electronic circuits for Biomedical applications. This course covers basic operational amplifier circuits as well as the operation of semiconductor diodes and transistors. An introduction to digital logic circuits is also included.

Course Content:

Analog electronics: Overview: Passive components, Introduction to Semiconductors. P Type and N type semiconductors, P-N junction, diode characteristics. Zener diode, tunnel diode, LED, photodiodes.

Diodes applications as Rectifiers: Half wave rectifiers, full wave rectifiers, their analysis filter and power supplies, voltage regulators, clippers, clampers, voltage multiplier.

Transistor: Basic mechanism of transistor. Characteristics of CB, CC and CE configuration their analysis and frequency response biasing of transistor. Hybrid model power amplifiers push pull amplifiers in class A, class B, class AB; operation feedback in amplifier frequency response. FET and MOSFET – Basic mechanism structure characteristics and parameters.

Operational amplifiers Characteristics and type of OpAmps, dc and ac analysis, application of opamp as inverting & non inverting amplifier, adder, subtractor, integrator, differentiator, comparator, zero crossing detector, instrumentation amplifiers. s/h circuit. Frequency to voltage & voltage to frequency converter, Oscillator and Wave form generator, Phase-shift, Wein Bridge, and Wheatstone bridge, crystal oscillator. Sine wave, triangular wave, square wave and saw tooth wave generation, 555 Timers.

Filters: Butterworth Filters: Active low pass Filter, High pass filter, Band pass filter, Band elimination filter & Notch filter. Higher order Filters and their Comparison. Design of second, high order filters using op-amps.

Laboratory work: Rectifier, clipper, clamper, Series voltage regulator, RC coupled amplifier in CE mode, Wein bridge oscillator, filter, logic gates, A/D and D/A converters, Computer simulation using EDA tools.

Course Learning Outcomes (CLOs Upon completion of this course, the students will be able to:

1. Apply the knowledge of diodes and transistors to solve the engineering problems.

2. Design different type of circuits such as rectifiers, clippers, clampers, filters etc
3. Design different circuit using op-amp and filter realization
4. Design linear wave shaping circuits and higher order filters.

Text Books:

1. Sedra A. S. and Smith K. C., Microelectronic Circuits, Oxford University Press, 8th Edition (2014)
2. Boylestad R. L., Electronic Devices and Circuit Theory, Pearson Education, 11th Edition (2013).

Reference Books:

1. Malvino, A.P. Electronics principle by TMH 3rd edition

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	45
3.	Sessional (May include Assignments/Projects/Tutorials/Quiz/ Lab evaluations)	30

UCS312 **AI FOR ENGINEERS**

L	T	P	CR
2	0	2	3.0

COURSE OBJECTIVE: Develop foundational AI knowledge while equipping participants with practical problem-solving skills using data relevant to engineering applications.

Course Content:

1. Introduction to AI for Engineers:
- Definitions: Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Reinforcement Learning (RL)
- Understanding AI's role in engineering decision-making
- Illustrative examples from engineering fields (e.g., predictive maintenance, process control)

2. Data and Preprocessing
- Types of data: sensor data, image data, text data, and time-series data
- Techniques for cleaning, normalization, and handling missing values
- Introduction to feature selection methods

3. Supervised Learning
- Core algorithms: Linear Regression, Logistic Regression, Decision Trees, Random Forest
- Applications: Predicting equipment failure or component lifespan

4. Unsupervised Learning
- Clustering techniques: K-Means, DBSCAN
- Dimensionality reduction methods: Principal Component Analysis (PCA), t-SNE
- Applications: Process classification and anomaly detection

5. Neural Networks & Deep Learning (Intro)
- Fundamentals of Neural Networks: Multilayer Perceptron (MLP), Convolutional Neural Networks (CNN)
- Use cases: Image recognition (e.g., detecting cracks in structures)

6. Time-Series Analysis
- Forecasting techniques: ARIMA and introductory Long Short-Term Memory (LSTM) models
- Applications: Load prediction and vibration analysis

7. Toolchain for Engineers
- Programming tools: Python, Jupyter Notebook
- Libraries: pandas, scikit-learn, TensorFlow/Keras
- Version control: Using Git effectively

8. Mini Project
- Choose an engineering-specific dataset
- Apply preprocessing, modeling, and evaluation techniques Practicals

- Build a regression model to predict temperature rise in a motor
- Use K-Means clustering to group materials based on properties
- Create a neural network to detect faulty circuits

9. Case Studies

- Siemens: AI applications in industrial automation
- General Electric (GE): AI-driven turbine health monitoring
- Honeywell: Predictive maintenance in smart factories

Evaluation Criteria

- Quizzes: 20%
- Lab Assignments: 20%
- Mini Project: 40%
- Viva/Presentation: 20%

UTD003 **APTITUDE SKILLS BUILDING**

L	T	P	CR
2	0	0	2.0

Course Objective: This course aims to sensitize students with the gamut of skills which facilitate them to enhance their employability quotient and do well in the professional space. These skills are imperative for students to establish a stronger connect with the environment in which they operate. An understanding of these skills will enable students to manage the placement challenges more effectively.

Course Content:

Emotional Intelligence: Understanding Emotional Intelligence (EI); Daniel Goleman's EI Model: Self Awareness, Self-Regulation, Internal Motivation, Empathy, Social Skills; Application of EI during Group Discussions & Personal Interview; Application of EI in personal life, student life and at the workplace

Team Dynamics & Leadership: Understanding the challenges of working within a team format in today's complex organizational environments; Stages of team formation; Appreciating forces that influence the direction of a team's behaviour and performance; Cross-functional teams; Conflict in Teams- leveraging differences to create opportunity Leadership in the team setting & energizing team efforts; Situational leadership; Application of team dynamics & collaboration in Group Discussions; Application of team dynamics at the workplace

Complex Problem Solving: Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions; Understanding a working model for complex problem solving - framing the problem, diagnosing the problem, identifying solutions & executing the solutions; Appreciation of complex problem solving at the workplace through case studies

Lateral Thinking: Understanding lateral thinking & appreciating the difference between vertical & lateral thinking, and between convergent & divergent thinking; Understanding brain storming & mind-maps; Solving of problems by an indirect and creative approach, typically through viewing the problem in a new and unusual light; Application of lateral thinking during Group Discussions & Personal Interviews; Application of lateral thinking at the workplace

Persuasion: Role of persuasion in communication; Application of ethos-pathos-logos; Using persuasive strategies to connect with individuals & teams to create competitive advantage

Quantitative Reasoning: Thinking critically and applying basic mathematics skills to interpret data, draw conclusions, and solve problems; developing proficiency in numerical reasoning; Application of quantitative reasoning in aptitude tests

Verbal Reasoning: Understanding and reasoning using concepts framed in words; Critical verbal reasoning; Reading Comprehension; Application of verbal reasoning in aptitude tests

Group Discussion (GD): Illustrating the do's and don'ts in Group Discussions; Specific thrust on types of GD topics; GD evaluation parameters; Understanding the challenge in a case discussion; SPACER model

Personal Interview (PI): Interview do's and don'ts; PI evaluation parameters; The art of introduction; Managing bouncer questions; Leading the panel in a PI

Course Learning Outcomes (CLO: Upon completion of this course, the students will be able to

1. appreciate the various skills required for professional & personal success.
2. bridge the gap between current and expected performance benchmarks.
3. competently manage the challenges related to campus placements and perform to their utmost potential.

Recommended Books:

1. Harvard Business Essentials; Creating Teams with an Edge; Harvard Business School Press (2004)
2. Edward de B., Six Thinking Hats; Penguin Life (2016)
3. Daniel, G., Working with Emotional Intelligence; Bantam Books (2000)
4. Aggarwal, R.S., Quantitative Aptitude for Competitive Examinations; S Chand (2017)
5. Agarwal, A., An expert guide to problem solving: with practical examples; CreateSpace Independent Publishing Platform (2016)

William, D., The Logical Thinking process; American Society for Quality (2007)

UBM401 LINEAR ALGEBRA FOR BIOMEDICAL ENGINEERING AND MACHINE LEARNING

L	T	P	CR
3	1	2	4.5

Course Objective: The course aims to impart fundamental knowledge of linear algebra concepts required for biomedical engineering applications. It focuses on vectors, matrices, systems of equations, eigenvalue problems, and matrix decompositions, which form the mathematical foundation for signal processing, medical imaging, data analysis, and machine learning techniques used in advanced biomedical courses.

Course Content:

Vectors, Geometry, and Biomedical Data Representation
Scalars, vectors, and vector spaces. Vector operations including addition, scalar multiplication, dot and cross products. Norms, distance, angle, and orthogonality. Linear combinations and span. Geometric interpretation of biomedical datasets with examples from biosignals such as ECG and EEG feature vectors.

Matrices and Systems of Linear Equations
Matrices and matrix operations. Special matrices including diagonal, symmetric, orthogonal, and identity matrices. Systems of linear equations and augmented matrices. Gaussian elimination and row-reduced echelon form. Rank of a matrix and consistency of systems with applications to biomedical measurement systems and calibration.

Vector Spaces, Linear Transformations, and Subspaces
Definition and properties of vector spaces. Subspaces, column space, row space, and null space. Basis and dimension. Linear transformations and matrix representation. Change of basis and coordinate transformations with relevance to biomedical signal transformations and dimensionality reduction.

Eigenvalues, Eigenvectors, and Biomedical Applications
Eigenvalues and eigenvectors. Characteristic equation and diagonalization. Symmetric matrices and orthogonal diagonalization. Interpretation of eigenmodes in biomedical systems with applications in stability analysis, vibration modeling, and imaging.

Matrix Decompositions and Introduction to Machine Learning
LU, QR, and Singular Value Decomposition. Least-squares approximation and low-rank matrix approximation. Conditioning and numerical stability. Linear algebra foundations of machine learning algorithms with case studies using biomedical datasets and imaging matrices.

Laboratory Work

Vector and matrix operations using MATLAB or Python. Solving systems of linear equations numerically. Eigenvalue analysis of biomedical datasets. PCA implementation on ECG and EEG data. SVD-based noise reduction and image compression. Least-squares fitting for biomedical measurements.

Course Learning Outcomes (CLOs): Upon completion of this course, the students will be able to

1. apply vector and matrix concepts to represent biomedical signals and data.
2. solve systems of linear equations arising in biomedical engineering problems,
3. analyze vector spaces and transformations,
4. interpret eigenvalues and eigenvectors in biomedical and machine learning contexts
5. use matrix decomposition techniques for data analysis and dimensionality reduction.

Text Books

1. G. Strang, Linear Algebra and Its Applications, Cengage Learning, 5th Edition.
2. D.C. Lay, S.R. Lay, and J.J. McDonald, Linear Algebra and Its Applications, Pearson, 5th Edition.

Reference Books

1. G. Golub and C. Van Loan, Matrix Computations, Johns Hopkins University Press.
2. T. Hastie, R. Tibshirani, J. Friedman, The Elements of Statistical Learning, Springer. 3. S. Boyd and L. Vandenberghe, Introduction to Applied Linear Algebra, Cambridge University Press.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments / quizzes / Projects / Laboratory)	25

UBM006 **INTRODUCTION TO BIOMECHANICS**

L	T	P	CR
3	1	2	4.5

Course Objective: The student should gain an understanding of the mechanical and anatomical principles that govern human motion and develop the ability to link the structure of the human body with its function from a mechanical perspective.

Course Content:

Forces and Force Systems: Overview of force, moment, torque, equilibrium, stress and strain diagram, mass moment of inertia, angular acceleration, displacement, load cell, velocity and acceleration graphs with examples in the area of Biomechanics.

Applications of Statics to Biomechanics: Need for Biomechanics to understand muscle actions, skeletal joints, skeletal muscles; basic considerations, assumption and limitations; mechanics of elbow, shoulder, spinal column, hip, knee and ankle; need for Biomechanics to understand muscle actions, sports medicine and rehabilitation applications; forces exerted across articulating joints; three mechanical characteristics of muscle, muscle force production and transmission – functional relations.

Multiaxial Deformations and Stress Analyses: Poisson's ratio, biaxial and triaxial stresses; stress transformation, principal stresses, Mohr's circle and failure theories; allowable stress and factor of safety; fundamental strength of materials in biological tissues: Factors affecting the strength of materials, fatigue and endurance; stress concentration, bending and torsional stress; combined loading – axial shear, torsional and flexural.

Mechanics of the Musculoskeletal System—Tissues Biomechanics: Visco-elasticity; analogies based on springs and dampers; empirical models of visco-elasticity, time-dependent material response, comparison of elasticity and visco-elasticity; common characteristics of biological tissues, skin tissue, muscle tissue; composition of bone, scalp, skull and brain tissue; mechanical and physical properties of bone, structural integrity of bone, bone fractures; tendons and ligaments, skeletal muscles, articular cartilage, sports medicine and rehabilitation and applications.

Laboratory Work
Experimental work on hydraulic biaxial testing, biaxial mechanical testing, Axial torsion testing machine, knee or shoulder testing, Lab-View data acquisition & thermal imaging camera (hardware and software), force and pressure measurement, GAIT LAB for motion capture and tracking system; measurement's group strain gauge conditioners, Image guided robotic bone drilling with load cell, bench grinder & mini table saw.

Micro Project

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

Students in a group of 4/5 will carry out micro project.

Course Learning Outcomes (CLOs): Upon completion of this course, the students will be able to

1. Identify a given bone, ligament or muscle by name, anatomic location or function.
2. Analyze the stresses and strains in biological tissues with the given loading conditions and material properties.
3. Identify the appropriate viscoelasticity model for the mechanical behaviour of a given biological tissue.
4. Identify relationships between structure and function in tissues and the implications of these relationships.
5. Identify, analyze, and solve various biomechanical problems.

Text Books:

1. Ozkaya N, Nordin M, Goldsheyder D, Leger D. Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, USA: Springer; 2012.
2. Huston R. Principles of biomechanics. CRC press; 2008
3. Knudson D. Fundamentals of biomechanics. Springer Science & Business Media; 2007

Reference Books:

1. Bartlett R. Introduction to sports biomechanics: Analysing human movement patterns. Routledge; 2007
2. Mow VC, Huiskes R, editors. Basic orthopaedic biomechanics & mechano-biology. Lippincott Williams & Wilkins; 2005.
3. Nordin M, Frankel VH, editors. Basic biomechanics of the musculoskeletal system. Lippincott Williams & Wilkins; 2001.
4. Fung YC. Biomechanics: mechanical properties of living tissues. Springer Science & Business Media; 2013

Evaluation Scheme:

S. No.	**Evaluation elements**	**Weightage (%)**
1	MST	30
2	EST	45
3	Sessional: Assignment, Laboratory, Quizzes/Tests, Project etc.	25

UBM602 **INTRODUCTION TO DIGITAL ELECTRONICS**

L	T	P	CR
3	1	2	4.5

Course Objectives:

This course facilitates the students to study the properties for Boolean algebra and simplification of Boolean equations using K-maps. The digital circuits' classification is studied and the main elements of this classification are studied. Application of these circuits to build a basic computer is discussed. The students also learn about different types of memories and how they are programmed. The course also discusses about the basic applications of digital electronics like digital clock, frequency counter.

Course Content:

Codes: BCD, ASCII code, Excess-3 code, Gray code. Error detecting and error correcting codes. Combinational Logic Design: Boolean laws & theorems. Karnaugh Map- simplification of Boolean expressions- Sum of Products (SOP) form, Product of Sums (POS) form. Logic Gates, Implementations of Logic Functions using gates, Realization of Boolean Expressions using universal gates.

Arithmetic Circuits: Half adder, Full adder, Half subtractors, Full subtractors, Parallel binary adder, parallel binary Subtractor. Code-converters Data processing circuits: Multiplexers, De-Multiplexers, Encoders-Priority Encoder, Decoders. Digital Circuit Testing tools: Logic pulser, Logic probe, Current Tracer.

Sequential circuits: Flip-flops-RS, D, JK and JK Master slave. Realizations of one flip flop using other flip
flops. Registers: Serial-in parallel-out, Serial-in Serial-out, parallel-in-serial-out parallel-in-parallel-out.
Counters: Asynchronous and synchronous counters, decade counters, ring counters. Design of synchronous counters using excitation tables, Synchronous Up/Down counters.

Classification of memories: ROM – ROM organization – PROM – EPROM – EEPROM – EAPROM, RAM –RAM organization – Write operation – Read operation – Memory cycle – Timing wave forms , RAM Cell , Programmable Logic Devices – Programmable Logic Array (PLA) – Programmable Array Logic (PAL) – Field Programmable Gate Arrays (FPGA) – Implementation of combinational logic circuits using ROM, PLA, PAL. Applications: Digital Clock, Frequency counter, Time measurement, Displays.

Introduction to DAC and ADC: Sampling, Quantization, quantization noise, aliasing and reconstruction filtering, Specifications, DAC Conversion, Binary weighted Resistor DAC, R-2R Ladder DAC, Inverted (or) Current mode DAC, Sample and hold circuits, ADC conversion, Types of ADCs: Direct Conversion ADC/Flash type ADC, Successive approximation ADC, Integrating ADCs, Sigma-Delta ADCs, Analog Multiplexers.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to

1. Apply the concept of K-map for the minimization of Boolean expression.
2. Design basic data processing circuits
3. Applications of flip-flops
4. To build a basic computer architecture and memories
5. Build ADCs and DACs

Recommended Books:

1. M. Morris Mano, "Digital Design", 4th Edition, Prentice Hall of India Pvt. Ltd., 2008 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003.
2. Donald P. Leach & Albert Paul Malvino, Digital Principles and electronic, 5 th Ed., Tata Mc. Graw Hill Publishing Co. Ltd., New Delhi, 2003
3. R. P. Jain, Modern Digital Electronics, 3rd Ed., Tata Mc Graw Hill Publishing Co. Ltd., New Delhi, 2003.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM008 **BIOMATERIALS**

L	T	P	CR
3	0	0	3.0

Course Objective: To provide basic understanding of Biomaterials viz-a-viz their structural, physical and mechanical properties, processing techniques and response in biological systems.

Course Content:

Introduction to Biomaterials: Biological response to biomaterials, types of biomaterials, properties of biomaterials.

Chemical structure of Biomaterials: Structure of metals, ceramics and polymers, techniques for biomaterial characterization: X-ray diffraction, UV-VIS spectroscopy, Infrared spectroscopy and HPLC.

Physical and Mechanical Properties of Biomaterials: Crystallinity and defects: linear, planar and volume defects, defects in polymers, introduction to thermal analysis techniques, thermal transitions in crystalline and non-crystalline materials. Tensile and shear properties, creep, fracture and failure, fatigue testing, methods to improve mechanical properties of Biomaterials.

Biomaterial Degradation: Corrosion of metals and ceramics, degradation of polymers, biodegradable ceramics and polymers, Assays for measurement of extent of degradation.

Biomaterial Processing and Surface Properties: Processing of metals, ceramics and polymers to improve bulk properties, processing techniques for improving biocompatibility. Chemical, biological and physical modifications of biomaterial surfaces, contact angle analysis, surface characterization techniques: light and electron microscopy.

Interaction of Biomaterials with protein and cells: Thermodynamics of protein adsorption, protein structure, protein transport and adsorption kinetics, Techniques for protein estimation: affinity chromatography, colorimetric assays. Cellular structure and extracellular environment, cell-environment interactions, estimation of cell – material interactions: cytotoxicity assays, DNA and RNA assays.

Biological response to Biomaterials: Overview of innate and acquired immunity, *In-vitro* assays for inflammatory response, wound healing: repair vs regeneration, *In-vivo* assays for inflammatory response, overview of acquired immunity, B cells and antibodies, T cells, assays for immune response, overview of haemostasis, role of platelets, coagulation, tests for hemocompatibility, overview of infection, tumorigenesis and pathological calcification.

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Investigate the physical, chemical, mechanical, surface, and degradation properties of biomaterials.
2. Apply the characterization methods for applications of biomaterials in the medical field.
3. Utilize knowledge of processing of biomaterials for their modifications.
4. 4. Investigate how the human body responds to biomaterials by analyzing their interactions with proteins, cells, innate immune system, acquired immune system, wound healing, thrombosis, infection, tumorigenesis, and pathologic calcification.

Text Book:

1. J.S. Temenoff& A.G. Mikos, Biomaterials: The Intersection of Biology and Materials Science, Prentice Hall, 2009.

Reference Books:

1. Ratner, Buddy D., et al. Biomaterials Science: An Introduction to Materials in Medicine. 2nd ed. Burlington, MA: Academic Press 2004
2. Bhat Sujata, Biomaterials, 2nd ed. Narosa Publishing House, New Delhi 2015
3. V Hasirci, N. Hasirci, Fundamentals of Biomaterials, Springer, 2018
4. P Ducheyne (Editor), Comprehensive Biomaterials, 1st Edition, Elsevier, 2011

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UHU050 EVOLUTIONARY BASIS OF HUMAN BEHAVIOUR FOR ENGINEERS
(1 SELF EFFORT HOUR)

L	T	P	CR
1	0	0	1.0

UCS412 **ETHICS AND RISK MITIGATION IN AI**

L	T	P	CR
3	0	0	3.0

Course Objective: Empowering engineers to navigate ethical and societal implications of AI in safety-critical domains

Course Content:

1. Introduction to AI Ethics
Understanding the distinction between ethics and compliance is foundational for AI engineers. While compliance ensures adherence to regulations and standards, ethics delves deeper into principles guiding the responsible use of AI. Engineers will explore the core principles of fairness, accountability, transparency, and privacy, emphasizing their relevance in decision-making processes.
2. Bias in Engineering AI Models
Bias in engineering applications can manifest in various forms, such as calibration bias in sensors or the use of biased datasets during model training. Engineers will study real-world examples to understand how biases can lead to safety system failures or discrimination in access to services. This module equips participants to recognize, mitigate, and manage biases effectively.
3. Data Privacy & Governance
With the increasing integration of AI into sensitive domains like smart grids and health sensors, data privacy and governance are crucial. Participants will examine the Indian DPDP Act and GDPR, focusing on their relevance to engineering IoT systems. The goal is to understand how to handle sensitive data responsibly while maintaining compliance with global standards.
4. Explainable AI (XAI)
Explainable AI bridges the gap between black-box models and interpretable systems. Engineers will learn about tools such as SHAP and LIME, which provide insights into AI decision-making processes. Practical applications will include explaining AI-based decisions in process control systems, ensuring transparency and trust in high-stakes engineering environments.
5. AI in Critical Systems
Critical systems such as autonomous vehicles, robotics, and power grids demand rigorous risk management. Engineers will explore risk categories specific to these applications, emphasizing redundancy and fallback mechanisms. The module highlights the necessity of robust systems capable of mitigating risks and maintaining operational safety.
6. Safety-by-Design
Safety-by-design principles entail proactive measures to ensure the reliability of AI systems. Engineers will investigate fail-safe models and strategies to combat adversarial attacks on control systems. Furthermore, the module will underscore the importance of engineering responsibility in deploying AI, ensuring that safety remains the highest priority.

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

7. Governance and Standards
AI governance frameworks, such as IEEE AI ethics and NIST standards, provide a structured approach to ethical deployment. Engineers will study these frameworks and learn how to create AI audit templates tailored to engineering applications. This module fosters a systematic approach to maintaining accountability and compliance.
8. AI Policy & Case Resolution
Real-world simulations will challenge participants to create AI policies for smart plant operations, addressing ethical dilemmas and practical constraints. Engineers will evaluate case studies of ethical failures to understand lessons learned and apply them to future engineering scenarios.

Practicals
Hands-on exercises are integral to this course, enabling engineers to apply theoretical knowledge in practical settings:
• Bias detection using SHAP: Participants will analyze sensor data to identify and mitigate biases effectively.
• Privacy impact assessment: Engineers will use templates to evaluate privacy implications in smart home data.
• AI audit checklist creation: Developing comprehensive checklists for AI-driven drone navigation to ensure safety and compliance.

Case Studies
The course incorporates comprehensive case studies to illustrate the real-world implications of ethics and risk mitigation in AI:
- Boeing 737 MAX: Analyzing software bias and identifying gaps in risk mitigation strategies.
- Tesla autopilot: Exploring failures in AI systems and the importance of robust data governance.
- AI in nuclear reactor control: Insights from IAEA on the role of ethical AI in maintaining safety in critical applications.

Evaluation
The assessment framework is designed to evaluate both theoretical understanding and practical application:
- Scenario-based short answers: Accounting for 30%, this segment tests engineers' ability to respond to ethical dilemmas in AI contexts.
- Ethics audit: Another 30% focuses on evaluating engineers' capacity to critically assess and audit AI systems.
- Final case report and group discussion: Constituting 40%, this segment promotes collaborative learning and comprehensive evaluation of case studies.

By the end of this course, engineers will be equipped with the knowledge and tools necessary to implement AI systems that prioritize ethics, mitigate risks, and uphold societal trust in safety-critical applications.

UBM504 **FUNDAMENTALS OF SIGNAL AND SYSTEMS**

L	T	P	CR
3	1	2	4.5

Course Objective: To familiarize with techniques suitable for analysing and synthesizing both continuous-time and discrete time signals & systems.

Course Content:

Classification of signals and systems: Representation of discrete time signals, Elementary discrete time signal, Basic operation on signals, classification of Signals-Deterministic and random signal, periodic and Non-periodic, Energy and power signal, causal and Non-causal signal, Even and Odd signal. Classification of systems- static and dynamic system, casual and non-causal system, linear and non-linear system, time variant and time invariant system, stable and unstable system.

Analysis of continuous time signals: Fourier series Analysis-Trigonometric Fourier series, Cosine Fourier series, Exponential Fourier series, Fourier Spectrum of continuous time signals, Fourier transform analysis, Laplace transform, Analysis of electrical network using Laplace transform.

Continuous time systems: Analysis of differential Equation-Transfer Function-Impulse Response-Frequency Response-Convolution integral- Fourier Methods-Laplace transforms Analysis-Block diagram representation

Analysis of discrete time signals: Spectrum of DT Signals-Discrete Time Fourier Transform (DTFT)-Properties of discrete time Fourier Transform-Discrete Fourier Transform (DFT)-Properties of DFTZ-transform in signal Analysis-Properties of Z- Transform-Inverse Z-transform.

LTI – discrete time systems: Analysis of differential Equation-Transfer Function-Impulse Response-Frequency Response-Convolution SUM –Fast Fourier transform- Block diagram representation.

Random signals: Introduction, Probability, Random variables, Gaussian distribution, Transformation of random variables, random processes, stationary processes, Correlation and Covariance Functions, Regularity and Ergodicity, Gaussian Process.

Course learning outcomes (CLOs): Upon completion of this course, the students will be able to

1. Classify continuous-time and discrete-time signals and systems based on their properties.

1. Apply Fourier and Laplace transforms to analyze continuous-time signals and systems.
2. Analyze continuous-time LTI systems using transfer functions and convolution.
3. Compute discrete-time signal and system responses using DTFT, DFT, FFT, and Z-transform.
4. Interpret statistical characteristics of random signals and processes.

Text Book

1. Oppenheim, A.V. and Willsky, A.S., Signals and Systems, Prentice Hall of India (1997) 2 nd ed.
2. Proakis, J.G. and Manolakis, D.G., Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall (2007) 4th ed

Reference Book

1. Lathi, B.P., Signal Processing and Linear System, Oxford University Press (2008).
2. Roberts, M.J., Fundamentals of Signals and Systems, McGraw Hill (2007)

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM507 **INTRODUCTION TO EMBEDDED SYSTEMS**

L	T	P	CR
3	1	2	4.5

Course Objective: To introduce fundamental concepts of microprocessors, microcontrollers, and embedded platforms, and develop basic programming and interfacing skills for biomedical applications.

Course Content:

Fundamentals of Embedded Systems and Microprocessors: Embedded systems overview, characteristics of embedded systems, biomedical embedded applications, real-time requirements in embedded systems, CPU architecture, ALU, registers, buses, memory organization, instruction cycle and machine cycle, microprocessor versus microcontroller, evolution of microprocessors, introduction to ARM-based systems, overview of embedded programming languages.

ARM Cortex-M Microcontrollers: ARM Cortex-M architecture overview, functional units, registers and flags, stack pointer and program counter, pin configuration, timing and interrupts, instruction set, addressing modes, assembly language programming, simple programs.

Arduino Programming and Interfacing: Introduction to Arduino UNO, ESP32 overview, ESP8266 overview, Arduino hardware architecture, Arduino IDE, LCD interfacing, biomedical sensor interfacing, simple embedded applications.

Introduction to ZynQ and Embedded SoC Platforms: Embedded SoC concept, need for high-performance embedded systems, ZynQ architecture overview, ARM processor in ZynQ, programmable logic concept, Arduino versus ZynQ comparison, biomedical signal processing applications.

Introduction to ZynQ and Embedded SoC Platforms: Embedded SoC concept, need for high-performance embedded systems, FPGA basics, ZynQ architecture overview, ARM processor in ZynQ, programmable logic concept, Arduino vs ZynQ comparison, biomedical signal processing applications.

Laboratory Work: Assembly language programming on ARM Cortex-M, Arduino digital and analog I/O experiments, sensor-based Arduino/ESP32/ ESP8266 experiments

Course learning outcomes (CLOs): Upon completion of this course, the students will be able to

1. Explain the architecture and operation of ARM Cortex-M microcontrollers, Arduino, ESP platforms, and ZynQ embedded SoC systems.
2. Develop basic assembly programs for ARM Cortex-M /Arduino/ ESP32/ESP8266.
3. Interface sensors and peripherals with Arduino and ESP platforms for biomedical applications.
4. Compare microprocessors, microcontrollers, and embedded SoC platforms in the context of modern embedded biomedical system design.

Books:

1. Sloss, Andrew, Dominic Symes, and Chris Wright. *ARM system developer's guide: designing and optimizing system software*. Elsevier, 2004.
2. Shibu K. V. — *Introduction to Embedded Systems*, 1st Edition, McGraw-Hill Education
3. Simon Monk — *Programming Arduino: Getting Started with Sketches*, 1st Edition, McGraw-Hill Education, 2016.
4. Xilinx (Digilent Authors) — *The Zynq Book: Embedded Processing with the ARM Cortex-A9 on the Zynq All Programmable SoC*, 1st Edition, Digilent Inc / MGSuperLabs, 2017.

Reference Books:

1. Frank Vahid and Tony Givargis — Embedded System Design: A Unified Hardware/Software Introduction, 1st Edition, Wiley, 2002.
2. Zhu, Yifeng. Embedded Systems with ARM Cortex-M Microcontrollers in Assembly. E-Man Press Llc, 2023.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM605 **DATA STRUCTURES AND ALGORITHMS**

L	T	P	CR
3	0	2	4.0

Course Objectives: To become familiar with different types of data structures and their applications and learn different types of algorithmic techniques and strategies.

Course Content:

Introduction and Overview: Basic Terminology, Elementary Data Organization, Data Structures, Control Structures, Asymptotic Notations for Algorithms, Big O notation: formal definition and use, Little o, big omega and big theta notation, Arithmetic Expressions, Polish Notations, Arrays, Records, Pointers, Storing Strings, String Operations, Pattern Matching Algorithms, Stacks, Queues, Recursion, Towers of Hanoi.

Searching and Sorting: Linear Arrays, Traversing and Searching in Linear Arrays, Inserting and Deleting, Bubble Sort, Linear Search, Binary Search, Insertion Sort, Merge Sort, Quick Sort, Radix Sort and Selection Sort.

Non-Linear Data Structures: Trees, Binary Trees, Traversing Binary Trees, Binary Search Trees, Searching and Inserting in Binary Search Trees, Deleting in a Binary Search Tree, Preorder, Postorder and Inorder Traversal, Heaps, Graph, Graph Algorithms, Breadth First Search, Depth First Search.

Linked List: Introduction, Insertion into a linked list, Deletion into a linked list. Stack, Queues, trees using linked list, Hashing, Hash Functions.

Laboratory work: Implementation of Arrays, Recursion, Stacks, Queues, Lists, Binary trees, Sorting techniques, Searching techniques. Implementation of all the algorithmic techniques.

Course learning outcomes (CLOs): Upon completion of this course, the students will be able to

1. Implement the basic data structures and solve problems using fundamental algorithms
2. Implement various search and sorting techniques
3. Analyze the complexity of algorithms, to provide justification for that selection, and to implement the algorithm in a particular context
4. Analyze, evaluate and choose appropriate data structure and algorithmic technique to solve real-world problems

Text Books:

1. 1. Seymour Lipschutz Data Structures, TATA McGraw Hill (2016).
2. 2. Corman, Leiserson & Rivest, Introduction to Algorithms, MIT Press (2009).
3. 3. Narasimha Karumanchi, Data Structures and Algorithms Made Easy (2014).

Reference Books:

1. 1. Sahni, Sartaj, Data Structures, Algorithms and Applications in C++, Universities Press (2005).

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	25
2	EST	45
3	Sessional (Assignments / Projects / Tutorials / Quizzes / Lab Evaluations)	30

UBM508 **MEDICAL INSTRUMENTS**

L	T	P	CR
3	1	2	4.5

Course Objectives: The course aims to impart knowledge about different biological signals, their acquisition, measuring instruments and related constraints. In addition, the course will also provide understanding of cardiovascular, respiratory and neuromuscular measurements, along with clinical laboratory equipment and patient safety.

Course Content:

Measurements in Cardiovascular System: Electrocardiograph, ECG machines and instrumentation, measurement of blood pressure, blood flow, cardiac output, cardiac rate, plethysmograph, pacemakers, defibrillators, heart sound measurement, echo-cardiograph.

Measurements in Respiratory System: Measurement of gas volume, respiratory transducers and instruments, respiratory therapy equipment, artificial mechanical ventilation.

Measurements in Neuromuscular and Sensory systems: EEG and EMG measurement and recording, Block diagram of EEG machine, evoked potentials, nerve conduction studies (NCS), galvanic skin response (GSR) measurements.

Clinical laboratory instrumentation: Blood cell counter and associated hematology system, oximeters, audiometer, ultrasound imaging system, medical X-Ray equipment - nature of X-rays, X-Ray absorption, tissue contrast, X- Ray Equipment (components, block diagram and working principle), causes of x-ray tube failure, Principles of tomography, Computed tomography (CT) components and functioning, advantages of CT over film screen radiography, Differences between conventional imaging equipment and digital imaging equipment, Fundamentals of magnetic resonance, block diagram approach of magnetic resonance imaging (MRI) system, components and working principle, fMRI, causes of failure and troubleshooting of different instruments.

Laboratory work: Study the variance in pulse rate of subject in a batch, use Spiro meter on the subject, auditory system check-up using audiometer, measurement of heart rate using stethoscope, blood pressure measurement using sphygmomanometer, pulse rate and SpO_2 measurement using pulse oximeter, ECG measurement, pulse rate and respiration rate measurement using Polyrite machine. Electromyogram test using EMG biofeedback trainer.

Course learning outcome (CLO): Upon completion of this course, the students will be able to:

1. Exhibit the knowledge of working principle and applications of the cardiovascular, respiratory measurements

2. Interpret and apply biological signals for assessment of neuromuscular and sensory system function.
3. Measure the physiological parameters using non-invasive diagnostic tools.
4. Comprehend the working and troubleshooting of various imaging instruments.

Text Books:

1. L. Cromwell, F.J. Weibell, and E.A. Pfeiffer, Biomedical Instrumentation and Measurement, Dorling Kingsley (2006) 2nd ed.
2. J.J. Carr, and J.M. Brown, Introduction to Biomedical Equipment Technology, Prentice Hall (2000) 4th ed.
3. S. Webb, The Physics of Medical Imaging, Adam Hilger, Bristol and Philadelpia, 1988.

Reference Books:

1. L.A. Geddes, and L.E. Baker, Principles of Applied Biomedical Instrumentation, Wiley InterScience (1989) 3rd ed.
2. J.G. Webster, Medical Instrumentation Application and Design, John Wiley (2007) 3rd ed.
3. Gopal B. Saha, Physics and Radiobiology of Nuclear Medicine, Third edition Springer, 2006.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessional (May include assignments/quizzes)	30

UTA025 **INNOVATION AND ENTREPRENEURSHIP with 1 self-effort hour**

L	T	P	CR
1	0	2	3.0

Course Objective: This course aims to provide the students with a basic understanding in the field of entrepreneurship, entrepreneurial perspectives, concepts and frameworks useful for analyzing entrepreneurial opportunities, understanding eco-system stakeholders and comprehending entrepreneurial decision making. It also intends to build competence with respect business model canvas and build understanding with respect to the domain of startup venture finance.

Course Content:

Introduction to Entrepreneurship: Entrepreneurs; entrepreneurial personality and intentions - characteristics, traits and behavioral; entrepreneurial challenges.

Entrepreneurial Opportunities: Opportunities- discovery/ creation, Pattern identification and recognition for venture creation: prototype and exemplar model, reverse engineering.

Entrepreneurial Process and Decision Making: Entrepreneurial ecosystem, Ideation, development and exploitation of opportunities; Negotiation, decision making process and approaches, - Effectuation and Causation.

Crafting business models and Lean Start-ups: Introduction to business models; Creating value propositions - conventional industry logic, value innovation logic; customer focused innovation; building and analyzing business models; Business model canvas, Introduction to lean startups, Business Pitching.

Organizing Business and Entrepreneurial Finance: Forms of business organizations; organizational structures; Evolution of organization, sources and selection of venture finance options and its managerial implications. Policy Initiatives and focus; role of institutions in promoting entrepreneurship.

Course learning outcome (CLO): Upon completion of this course, the students will be able to:

1. Explain the fundamentals behind the entrepreneurial personality and their intentions
2. Discover/create and evaluate opportunities.
3. Identify various stakeholders for the idea and develop value proposition for the same.
4. Describe various Business Models and design a business model canvas.
5. Analyse and select suitable finance and revenue models for start-up venture.

Text Books

1. Ries, Eric (2011), The lean Start-up: How constant innovation creates radically successful businesses, Penguin Books Limited.
2. Blank, Steve (2013), The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company, K&S Ranch.
3. S.Carter and D.Jones-Evans, Enterprise and small business-Principal Practice and Policy, Pearson Education (2006)

Reference Books

1. T. H. Byers, R. C. Dorf, A. Nelson, Technology Ventures: From Idea to Enterprise, McGraw Hill (2013)
2. Osterwalder, Alex and Pigneur, Yves (2010) Business Model Generation.
3. Kachru, Upendra, India Land of a Billion Entrepreneurs, Pearson

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessional (May include project / assignments / quizzes / tutorials / lab evalaution)	30

UBM509 APPLICATIONS OF AI FOR BIOMEDICAL ENGINEERING

L	T	P	CR
2	0	2	3.0

Course Objective: To introduce fundamental concepts of Artificial Intelligence and enable students to apply AI techniques for analysis, diagnosis, and decision-making in biomedical engineering applications, including medical imaging, biosignal processing, and healthcare systems.

Course Content:

Fundamentals of AI in Healthcare: Role of AI in Healthcare, Data acquisition concepts: Sampling, quantization and interpolation, Data filtering: Image filtering techniques, Data analysis: Time-domain, frequency-domain and time-frequency-domain analysis.

Machine Learning Fundamentals: Introduction to Machine Learning, Supervised, Unsupervised, and Reinforcement Learning, Regression and Classification techniques, k-Nearest Neighbours, Decision Trees, Support Vector Machines, HMM, Performance metrics: Accuracy, Sensitivity, Specificity, ROC curve, Handling missing values in clinical trials, noise filtering in biosignals, and class imbalance in rare disease datasets.

Deep neural networks: Convolutional neural network, Recurrent neural networks (RNN), long-short term memory (LSTM), language models, machine translation, image captioning, video processing, visual question answering, video processing, learning from descriptions, and attention, object detection.

Machine Learning for Clinical Decision Support: Supervised Learning: Regression: Predicting Continuous Glucose Monitoring (CGM) levels. Classification: Decision Trees, Random Forests, and SVMs for early cancer detection. Unsupervised Learning: Clustering for patient stratification and identifying "Disease Phenotypes." Feature Engineering: Extracting HRV (Heart Rate Variability) from raw ECG for stress or cardiac health analysis.

Deep Learning in Medical Imaging: Artificial Neural Networks (ANN): Multi-layer perceptrons for multi-variate diagnostic classification. Convolutional Neural Networks (CNN): Automated analysis of X-rays, MRI, and Histopathology. Image Segmentation: Architectures like U-Net for precise tumor contouring and organ segmentation. Transfer Learning: Utilizing pre-trained models (ResNet, Inception) on limited clinical datasets.

Laboratory Work:

1. Biomedical Signal and Medical Image Filtering
2. Time, Frequency, and Time–Frequency Analysis of Biosignals
3. Support Vector Machine and HMM for Healthcare Data
4. Feature Engineering from ECG Signals
5. Convolutional Neural Networks for Medical Imaging

Course learning outcome (CLO): Upon completion of this course, the students will be able to

1. Explain AI and ML concepts used in biomedical engineering.
2. Implement basic AI models for biomedical datasets.
3. Analyze medical images and biosignals using AI techniques.
4. Apply deep learning models for disease diagnosis.

Textbook

1. Ian Goodfellow, Yoshua Bengio & Aaron Courville – Deep Learning, MIT Press, 2016.
2. Kevin P. Murphy – Machine Learning: A Probabilistic Perspective, The MIT Press, 2012
3. S. Kevin Zhou, Hayit Greenspan & Dinggang Shen (Editors) – Deep Learning for Medical Image Analysis, Academic Press/Elsevier, 2017 (1st Edition).

Reference Book

1. Tom M. Mitchell – Machine Learning, McGraw-Hill, 1997
2. R. O. Duda, P. E. Hart & D. G. Stork – Pattern Classification, 2nd Edition, John Wiley & Sons, 2000

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessional (May include assignments/quizzes)	30

UBM005 **BIOMEDICAL QUALITY CONTROL**

L	T	P	CR
3	1	0	3.5

Course Objective: To apply statistical analysis to biological data; to investigate experiment design involving biological systems; to formulate and solve problems in statistics; to use computational tools to analyze and model biological data; to analyze and interpret data from biological system.

Course Contents:

Introduction to statistics and quality control: Statistical Inference, Samples, Populations, and the Role of Probability, Discrete and Continuous Data.
Random variables and Probability distribution: Concept of a Random Variable, Discrete Probability Distributions, Continuous Probability Distributions and Joint Probability Distributions
Discrete and Continuous Probability Distributions: Binomial and Multinomial Distributions, Hypergeometric Distribution, Negative Binomial and Geometric Distributions, Poisson distribution and the Poisson Process, Continuous Uniform Distribution, normal distribution and its Applications, specifications and quality control
Fundamental Sampling Distributions: Random sampling, Sampling distributions, t-Distribution and F-Distribution
One- and Two-Sample Test of Hypothesis: Statistical Hypothesis testing, P-values for Decision making, Analysis of variance, Goodness-of Fit Test, Confidence interval for the parameters of various distributions
Linear Regression: Simple Linear Regression Model, Least Square and the Fitted Model, Regression Model
Non-parametric Statistic: Non-parametric tests, Signed-Rank Test and Wilcoxon Rank-Sum Test, Runs Test and Tolerance Limits

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to

1. Apply the basic principles of Probability and sample spaces for solving the engineering problems.
2. Comprehend the concept of Discrete and Continuous distribution
3. Perform hypothesis test.
4. Develop and analyze linear regression models.

Textbook:

1. Probability & Statistics for Engineers & Scientists, MyLab Statistics Update 9th Edition, by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, and Keying E. Ye.

Reference Book:

1. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.

2. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
3. Mood A.M, Graybill F.A. and Boes D.C, Introduction to the Theory of Statistics, McGraw Hill.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UCS312 **DATABASE MANAGEMENT SYSTEM**

L	T	P	CR
2	0	2	3.0

Course Objectives: Emphasis is on the need of database systems. Main focus is on E-R diagrams, relational database, concepts of normalization and de-normalization and SQL commands.

Course Content:

Introduction: Data, data processing requirement, desirable characteristics of an ideal data processing system, traditional file-based system, its drawback, concept of data dependency, Definition of database, database management system, 3-schema architecture, database terminology, benefits of DBMS.
Relational Database: Relational data model: Introduction to relational database theory: definition of relation, keys, relational model integrity rules.
Database Analysis: Conceptual data modeling using E-R data model -entities, attributes, relationships, generalization, specialization, specifying constraints, Conversion of ER Models to Tables, Practical problems based on E-R data model.
Relational Database Design: Normalization- 1NF, 2NF, 3NF, BCNF, 4NF and 5NF. Concept of Denormalization and practical problems based on these forms.
Transaction Management and Concurrency control: Concept of Transaction, States of Transaction and its properties, Need of Concurrency control, concept of Lock, two-phase locking protocol.
Recovery Management: Need of Recovery Management, Concept of Stable Storage, Log Based Recovery Mechanism, Checkpoint.
Database Implementation: Introduction to SQL, DDL aspect of SQL, DML aspect of SQL – update, insert, delete & various form of SELECT- simple, using special operators, aggregate functions, group by clause, sub query, joins, co-related sub query, union clause, exist operator. PL/SQL - cursor, stored function, stored procedure, triggers, error handling, and package.

Laboratory work: Students will perform SQL commands to demonstrate the usage of DDL and DML, joining of tables, grouping of data and will implement PL/SQL constructs. They will also implement one project.

Project: It will contain database designing & implementation, should be given to group of 2-4 students. While doing projects emphasis should be more on back-end programming like use of SQL, concept of stored procedure, function, triggers, cursors, package etc. Project should have continuous evaluation and should be spread over different components.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to

1. Analyze the Information Systems as socio-technical systems, its need and advantages as compared to traditional file-based systems.
2. Analyze and design database using E-R data model by identifying entities, attributes and relationships.
3. Apply and create Relational Database Design process with Normalization and De-normalization of data.
4. Comprehend the concepts of transaction management, concurrence control and recovery management.
5. Demonstrate use of SQL and PL/SQL to implementation database applications.

Text Books:

1. Silverschatz A., Korth F. H. and Sudarshan S., Database System Concepts, Tata McGraw Hill (2010) 6th ed.
2. 2. Elmasri R. and Navathe B. S., Fundamentals of Database Systems, Pearson (2016) 7th ed.

Reference Books:

1. Bayross I., SQL, PL/SQL the Programming Language of Oracle, BPB Publications (2009) 4th ed.
2. 2. Hoffer J., Venkataraman, R. and Topi, H., Modern Database Management, Pearson (2016) 12th ed.

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weights (%)**
1.	MST	25
2.	EST	45
3.	Sessional (may include Assignments/Projects/Tutorials/Quiz)	30

UBM701 **MEDICAL IMAGE PROCESSING**

L	T	P	CR
3	0	2	4.0

Course Objectives: To introduce the concepts of image processing and basic analytical methods to be used in biomedical image processing. To familiarize students with image enhancement and restoration techniques, To explain different image compression techniques and segmentation techniques.

Course Content:

Introduction: Fundamentals of Image formation, components of image processing system, image sampling and quantization, Nature of Biomedical images, Objectives of biomedical image analysis, Difficulties in biomedical image acquisition and analysis.

Image Enhancement: Basic gray-level transformation, histogram processing, arithmetic and logic operators, basic spatial filtering, smoothing and sharpening spatial filters, image enhancement in frequency domain, biomedical applications.

Image restoration: A model of the image degradation/restoration process, noise models, restoration in the presence of noise–only spatial filtering, Weiner filtering, constrained least squares filtering, geometric transforms, biomedical applications.

Image Segmentation: Detection of discontinuous, edge linking and boundary detection, thresholding, Hough Transform Line Detection and Linking, region–based segmentation.

Image Reconstruction: Image reconstruction from projections, Radon transform, Methods for generating projection data, Transmission tomography, Reflection tomography, Emission tomography, Magnetic resonance imaging, Fourier slice theorem, Back-projection theorem. Image Coding and Compression: Lossy verses lossless compression, Fundamental concepts of coding, Image coding and compression standards, biomedical applications.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Explain the fundamentals of digital image and its processing
2. Perform image enhancement techniques in spatial and frequency domain.
3. Elucidate the mathematical modelling of image restoration.
4. Apply the concept of image segmentation for biomedical applications.
5. Elucidate the mathematical modelling of image reconstruction.

Text Books:

1. Digital Image Processing, Rafeal C. Gonzalez, Richard E. Woods, Second Edition, Pearson Education/PHI.

2. Biomedical Image Processing, Thomas M Deserno, ISBN 978-3-642-15816-2, 2011, Springer.
3. Biomedical Image Analysis, RangRaj M Rangyyan, ISBN-13: 978-0849396953, CRC Press 2004.

Reference Books

1. Image Processing, Analysis, and Machine Vision, Milan Sonka, Vaclav Hlavac and Roger Boyle, Second Edition, Thomson Learning.
2. Introduction to Digital Image Processing with Matlab, Alasdair McAndrew, Thomson Course Technology
3. Computer Vision and Image Processing, Adrian Low, Second Edition, B. S. Publications
4. Digital Image Processing using Matlab, Rafeal C. Gonzalez, Richard E. Woods, Steven L. Eddins, Pearson

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UHU005 **HUMANITIES FOR ENGINEERS**

L	T	P	CR
2	0	2	3.0

Course Objectives (COs): The objective of this course is to introduce values and ethical principles that will serve as a guide to behavior on a personal level and in professional life. The course is designed to help the students to theorize about how leaders and managers should behave to motivate and manage employees; to help conceptualize conflict management strategies that managers can use to resolve organizational conflict effectively. It also provides background of demand and elasticity of demand to help in devising pricing strategy; to make strategic decisions using game theory and to apply techniques of project evaluation.

Course Content:

Unit 1: Human Values and Ethics

Values: Introduction to Values, Allport-Vernon-Lindzey Study of Values, Rokeach Value Survey, Instrumental and Terminal Values.

Moral and Ethical Values: Types of Morality, Kant's Principles of Morality, Factors for taking ethical decisions, Kohlberg's Theory of Moral Development; Professional Ethics: Profession: Attributes and Ethos, Whistle-blowing.

Unit 2: Organizational Behavior

Introduction to the Field of Organizational Behaviour; Individual Behaviour, Personality, and Values

Perceiving Ourselves and Others in Organizations; Workplace Emotions, Attitudes, and Stress

Foundations of Employee Motivation and Leadership; Performance Appraisal; Conflict and Negotiation in the Workplace

Unit 3: Economics

Demand, Supply & Elasticity **–** Introduction to Economics, Demand & its Determinants, Elasticity and its types; Production & Cost Analysis – Short run & Long Run Production Functions, Short run & Long run cost functions, Economies & Diseconomies of Scale

Competitive Analysis & Profit Maximization **–** Perfect competition, Monopoly, Monopolistic & Oligopoly Markets

Strategy & Game Theory **–** Pure Strategy & Mixed Strategy Games, Dominance, Nash Equilibrium, & Prisoner's Dilemma

Capital Budgeting – Capital Projects, Net Present Value (NPV) & IRR techniques.

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

Practical:

1. Practical application of these concepts by means of Discussions, Role-plays and Presentations,
2. Analysis of Case Studies on ethics in business and whistle-blowing, leadership, managerial decision- making.
3. Survey Analysis
4. Capital Budgeting assignment

Course learning Outcomes (CLOs): Upon completion of this course, the students will be able to:

1. Comprehend ethical principles and values and apply them as a guide to behavior in personal and professional life.
2. Apply tools and techniques to manage and motivate employees.
3. Analyze and apply conflict management strategies that managers can use to resolve organizational conflict effectively.
4. Devise pricing strategy for decision-making.
5. Apply techniques for project evaluation.

Text Books

1. A. N. Tripathi, Human Values, New Age International (P) Ltd. (2009).
2. Robbins, S. P/ Judge, T. A/ Sanghi, S Organizational Behavior Pearson, New Delhi, (2009).
3. Petersen, H.C., Lewis, W.C. and Jain, S.K., Managerial Economics, Pearson (2006).

Reference Books

1. McKenna E. F. Business psychology and organisational behaviour. Psychology Press, New York (2006).
2. Furnham A. The Psychology of Behaviour at Work: The Individual in the organization. Psychology Press, UK (2003).
3. Salvatore, D and Srivastava, R., Managerial Economics, Oxford University Press (2010).
4. Pindyck, R and Rubinfiled, D., Microeconomics, Pearson (2017).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM694 **CAPSTONE PROJECT (START)**

L	T	P	CR
0	0	2	8.0

Course Objective: To facilitate the students learn and apply an engineering design process in electrical engineering, including project resource management. As a part of a team, the students will make a project, that emphasizes, hands-on experience, and integrates analytical and design skills. The idea is to provide an opportunity to the students to apply what they have learned throughout the course of graduate program by undertaking a specific problem.

Course Description: Capstone Project is increasingly interdisciplinary, and requires students to function on multidisciplinary teams. It is the process of devising a system, component or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs. It typically includes both analysis and synthesis performed in an iterative cycle. Thus, students should experience some iterative design in the curriculum. As part of their design experience, students have an opportunity to define a problem, determine the problem scope and to list design objectives. The project must also demonstrate that students have adequate exposure to design, as defined, in engineering contexts. Engineering standards and realistic constraints are critical in engineering design. The program must clearly demonstrate where standards and constraints are taught and how they are integrated into the design component of the project. Each group will have 4-5 students. Each group should select their team leader and maintain daily diary. Each Group will work under mentorship of a Faculty supervisor. Each group must meet the assigned supervisor (2hrs slot/week) till the end of the semester (record of attendance will be maintained), as per the time slot which will be provided to them by the respective supervisor. This is mandatory requirement for the fulfilment of the attendance as well as the successful completion of the project. The faculty supervisor of the project will continuously assess the progress of the works of the assigned groups. Some part of the analysis and design of the system will be done in the first section of project in semester VI. The second section would comprise of completion of the project in semester VII in which each team will have to submit a detailed report of the project along with a poster.

Specific goals for the course: After the completion of the course, the students will be able:

1. To identify design goals and analyze possible approaches to meet given specifications with realistic engineering constraints.

2. To design a biomedical engineering project implementing an integrated design approach
3. applying knowledge accrued in various professional courses.
4. To perform simulations and incorporate appropriate adaptations using iterative synthesis.
5. To use modern engineering hardware and software tools.
6. To work amicably as a member of an engineering design team.
7. To improve technical documentation and presentation skills.

UBM706 **ROBOTICS IN HEALTHCARE**

L	T	P	CR
2	0	2	3.0

Course objective: This course is designed to understand the basics concepts of robotics and to introduce the various applications of robots in medicine and healthcare sector.

Course Content:

Introduction Automation and Robots, Classification, Application, Specification, Notations.

Direct Kinematics Dot and cross products, Coordinate frames, Rotations, Homogeneous coordinates Link coordination arm equation, (Five- axis robot, Four axis robot, Six-axis robot) Controller PID control, lead-lag compensation, and other controllers.

Inverse Kinematics General properties of solutions tool configuration Five axis robots, Three-Four axis, Six axis robot (Inverse Kinematics). Workspace analysis and trajectory planning work envelope and examples, workspace fixtures, Pick and place operations, Continuous path motion, Interpolated motion, Straight-line motion.

Task Planning Task level programming, Uncertainty, Configuration, Space, Gross motion, Planning, Grasp Planning, Fine-motion planning, Simulation of planar motion, Source and Goal scenes, Task Planner simulation.

Applications in Biomedical Engineering Application in rehabilitation, Clinical and Surgery

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Learn the basics of Robotics
2. Understand the kinematics and inverse Kinematics
3. Develop motion planning solution
4. Recognize the various applications of Robots in Medicine

Text Books:

1. Fundamentals of Robotics-Analysis and control, Robert Schilling, Prentice Hall of India.

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

2. Robotics, Fu, Gonzales and Lee, McGraw Hill
3. Introduction to Robotics, J. J, Craig, Pearson Education

Reference Books:

1. Robotics and AI, Staughard, Prentice Hall of India.
2. Industrial Robotics - Grover, Wiess, Nagel, Oderey, McGraw Hill.
3. Robotics and Mechatronics. Walfram Stdder,
4. Introduction to Robotics, Niku, Pearson Education.
5. Robot Engineering, Klafter, Chmielewski, Negin, Prentice Hall Of India.
6. Robotics and Control, Mittal, Nagrath, Tata McGraw Hill publications.

Evaluation scheme:

S. No	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include Assignments/Projects/Tutorials/Quiz/ Lab evaluations)	25

UBM608 PHYSIOLOGICAL MODELING AND CONTROL

L	T	P	CR
3	**1**	**2**	**4.5**

Course Objective: This course is designed to understand the concept of mathematical modelling, analysis and control designs of physiological systems in terms of dynamic modelling and linear feedback control systems. The student should be made to explain and formulate the physiological models and vital organs and learn some of the applications of biomedical control systems to achieve desired performance.

Course Content:

Introduction to Modeling: Approaches to modeling: The technique of mathematical modeling, classification of models (static and dynamic), time invariant and time varying systems, first-order and second order model and their response to various inputs, the Laplace transform, transfer functions and block diagram analysis, state space approach, general structure of control systems (open and closed-loop feedback).

Modeling of Dynamic Physiological System: Pharmacokinetic model, ADME principle, the pupil control systems (human eye), Windkessel circulatory model, swinging limb, compartmental modelling, Electrical analogy, homeostasis, neuromuscular reflex model.

Stability: Open-loop, closed-loop stability, pole, zero, Routh-Hurwitz criterion, root locus.

Frequency response: Bode plot, Nyquist plot, gain margin, phase margin.

Control Design: Lag, lead compensators, PID controller, controllability, observability, state feedback control, drug delivery system.

Course Learning Outcome: Upon completion of this course, the students will be able to:

1. Use mathematical models to describe biological dynamic processes
2. Develop differential equations to describe the compartmental physiological model
3. Identify the stability and frequency response analysis of physiological systems.
4. Design controllers for the biomedical applications.
5. Illustrate the Simulation of physiological systems

Text Books:

1. Michel C Khoo, ―Physiological Control Systems -Analysis, simulation and estimation‖, Prentice Hall of India, 2001.
2. Nise, Norman S., Control Systems Engineering, 8th Edition Wiley.

References:

1. Benjamin C Kuo—Automatic control systems‖, Tenth Edition, McGraw-Hill Education, 2017.
2. David T Westwick, Robert E. Kearney, Identification of Nonlinear Physiological Systems, Wiley IEEE Press, 2003.
3. Ogata, K., Modern Control Engineering, 5th Edition, Pearson.
4. L Stark, Neurological Control System, Plenum Press‖,1968.
5. John H Milsum—Biological control systems, McGraw Hill 1966

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM707 **COMPUTATIONAL NEUROSCIENCE**

L	T	P	CR
3	1	2	4.5

Course Objectives

The course aims to provide an understanding of how the nervous system processes information through mathematical, computational, and algorithmic models. It introduces students to neuron and network modeling, neural coding, learning mechanisms, and data-driven analysis of neural signals. The course builds foundations required for advanced studies in biomedical signal processing, neural engineering, brain–machine interfaces, and machine learning.

Course Content:

Introduction to Computational Neuroscience and Neurobiology: Overview of the nervous system and levels of neural organization. Basic neuroanatomy and neurophysiology. Electrical properties of neurons. Ion channels, membrane potentials, and action potentials. Motivation for computational modeling in neuroscience and its applications in biomedical engineering.

Single Neuron Models: Biophysical neuron models including the Hodgkin–Huxley model and its assumptions. Simplified neuron models such as leaky integrate-and-fire and exponential integrate-and-fire models. Spike generation, refractory mechanisms, and numerical simulation of neuron models.

Synapses, Neural Coding, and Spike Trains: Chemical and electrical synapses. Synaptic dynamics and plasticity. Excitatory and inhibitory synapses. Rate coding, temporal coding, and population coding. Spike train analysis and representation of information in neural systems.

Neural Networks and Learning Mechanisms: Networks of spiking neurons including feedforward and recurrent architectures. Stability and dynamics of neural circuits. Hebbian learning and spike-timing-dependent plasticity. Relationship between biological neural networks and artificial neural networks.

Computational Analysis of Neural Data and Applications: Neural data acquisition methods such as EEG, MEG, and single-unit recordings. Preprocessing and feature extraction of neural signals. Dimensionality reduction and decoding approaches. Applications in brain–machine interfaces, neuroprosthetics, and neurological disorder modeling.

Laboratory Work

Simulation of neuron models using MATLAB or Python. Implementation of integrate-and-fire and Hodgkin–Huxley models. Spike train generation and analysis. Synaptic plasticity simulations. Basic neural network modeling and analysis of EEG or neural time-series datasets.

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to

1. explain the biological and computational principles of neural systems
2. model and simulate single neuron and network dynamics
3. analyze neural coding mechanisms, apply learning rules and plasticity concepts
4. use computational tools to analyze neural data for biomedical applications

Text Books

1. P. Dayan and L.F. Abbott, Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, MIT Press.
2. E. Izhikevich, Dynamical Systems in Neuroscience, MIT Press.

Reference Books

1. W. Gerstner et al., Neuronal Dynamics, Cambridge University Press.
2. C. Koch, Biophysics of Computation, Oxford University Press.
3. S. Haykin, Neural Networks and Learning Machines, Pearson.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM708 **REGULATORY PROCESSES AND BIOETHICS**

L	T	P	CR
3	0	0	3.0

The course aims to provide undergraduate biomedical engineering students with an understanding of regulatory frameworks governing medical devices, diagnostics, drugs, and clinical research. It also introduces ethical principles and bioethical challenges associated with healthcare technologies, human and animal research, data privacy, and emerging biomedical innovations. The course prepares students to design, develop, and deploy biomedical technologies in compliance with regulatory standards and ethical norms.

Course Content:

Introduction to Regulatory Processes in Biomedical Engineering: Overview of regulation in healthcare and biomedical engineering. Role of regulatory bodies and standards organizations. Need for regulation in medical devices and healthcare technologies. Product life cycle of biomedical devices from concept to market. Classification of medical devices based on risk. Overview of regulatory approval pathways and compliance requirements.

Medical Device Regulations and Quality Systems: Medical device regulations and standards. Quality management systems and good manufacturing practices. Risk management and hazard analysis. Design controls and documentation. Verification and validation processes. Clinical evaluation and post-market surveillance. Case studies of regulated biomedical products.

Ethics in Biomedical Research and Healthcare: Introduction to ethics and moral reasoning. Principles of bioethics including autonomy, beneficence, non-maleficence, and justice. Ethics in human subject research. Informed consent and confidentiality. Ethics in animal experimentation. Institutional ethics committees and regulatory oversight in research.

Bioethics in Emerging Biomedical Technologies: Ethical challenges in genetic engineering, stem cell research, and assisted reproductive technologies. Ethics of artificial intelligence and machine learning in healthcare. Brain–machine interfaces, neurotechnology, and cognitive privacy. Ethical concerns in digital health, wearable devices, and telemedicine. Equity and accessibility in healthcare technologies.

Legal, Social, and Professional Responsibilities: Legal aspects of biomedical engineering practice. Intellectual property rights and patents in biomedical innovation. Data protection, cybersecurity, and patient privacy. Professional codes of conduct and responsibilities of biomedical engineers. Social implications of biomedical technologies and responsible innovation.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Explain the need for regulatory processes in biomedical engineering
2. Identify regulatory requirements for medical devices and healthcare technologies
3. Apply ethical principles to biomedical research and clinical practice
4. Analyze ethical challenges associated with emerging biomedical technologies
5. Demonstrate professional and social responsibility as biomedical engineers

Text Books

1. J. Merrill, Biomedical Ethics for Engineers, CRC Press
2. A. Sharpe, Medical Device Regulations: Global Overview and Guiding Principles, Springe

Reference Books

1. T. Beauchamp and J. Childress, Principles of Biomedical Ethics, Oxford University Press
2. World Health Organization, Medical Device Regulations: Global Framework and Practices
3. FDA, Design Control Guidance for Medical Device Manufacturers

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weights (%)**
1.	MST	25
2.	EST	45
3.	Sessional (may include Assignments/Projects/Tutorials/Quiz	30

UEI613 **BIOMETRICS**

L	T	P	CR
2	0	2	3.0

Course Objectives: To understand the concepts of Biometrics and to design biometric system

Course Content:

Introduction: Overview of Biometrics, Biometric Identification, Biometric Verification, Biometric Enrollment, Biometric, System Security, Introduction of biometric traits and its aim, image processing basics, basic image operations, filtering, enhancement, sharpening, edge detection, smoothening, enhancement, thresholding, localization. Fourier Series, DFT, inverse of DFT

Authentication and Biometrics: Secure Authentication Protocols, Authentication Protocols, Biometric system, identification and verification. FAR/FRR, system design issues. Positive/negative identification. Biometric system security, authentication protocols, matching score distribution, ROC curve, DET curve, FAR/FRR curve. Expected overall error, EER, biometric myths and misrepresentations.

Common biometrics: Finger Print Recognition, Face Recognition, Speaker Recognition, Iris Recognition, Hand Geometry, Signature Verification, Positive and Negative of Biometrics.

Selection of suitable biometric: Biometric attributes, Zephyr charts, types of multi biometrics. Verification on multimodel system, normalization strategy, Fusion methods, Multimodel identification.

Course Learning Outcomes (CLO): Upon completion of this course, the students will be able to:

1. Elucidate the basics of Biometric Identification
2. Analyse different error measures used in biometric identification and verification
3. Apply various biometrics for identification
4. Exhibit the knowledge of multimodel biometric identification system.

Text Books:

1. Digital Image Processing using MATLAB, By: Rafael C. Gonzalez, Richard Eugene Woods, 2nd Edition, Tata McGraw-Hill Education 2010
2. Guide to Biometrics, By: Ruud M. Bolle, Sharath Pankanti, Nalini K. Ratha,Andrew W. Senior, Jonathan H. Connell, Springer 2009
3. Pattern Classification, By: Richard O. Duda, David G.Stork, Peter E. Hart, Wiley 2007

Reference Books:

1. Bolle, Connell et. al., "Guide to Biometrics", Springer.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM632 **ARTIFICIAL ORGANS AND LIMBS**

L	T	P	CR
3	0	2	4.0

Course Objective: To provide students with fundamental knowledge of the design, materials, working principles, and clinical applications of artificial organs and prosthetic limbs used to replace or support damaged biological systems.

Course Content:

Introduction to Artificial Organs: Need and scope of artificial organs, Classification: Implantable and external artificial organs, Physiological considerations in artificial organ design, Biocompatibility and bioethics, Regulatory standards for medical devices.

Artificial Heart and Circulatory Support Devices: Structure and function of the natural heart, Artificial heart: Design and working principles, Ventricular Assist Devices (VADs), Artificial heart valves: Mechanical and biological valves, Blood compatibility and thrombosis issues.

Artificial Kidneys and Dialysis Systems: Physiology of kidneys, Hemodialysis and peritoneal dialysis, Components and working of artificial kidney, Dialysis membranes and materials, Recent advances in renal replacement therapy.

Artificial Lungs, Pancreas, and Sensory Organs: Artificial lungs and oxygenators, Artificial pancreas and insulin pumps, Artificial cochlea (cochlear implants), Artificial retina and vision prosthesis, Challenges in sensory organ replacement.

Prosthetic Limbs and Orthotic Devices: Anatomy and biomechanics of human limbs, Upper and lower limb prostheses, Conventional vs myoelectric prosthetic limbs, Control systems in prosthetics, Orthotic devices and rehabilitation engineering.

Laboratory Work

1. Simulation of Human Cardiovascular System
2. Artificial Heart Pump Modeling and Simulation
3. Dialysis Membrane Transport Simulation
4. Artificial Lung (Membrane Oxygenator) Simulation
5. Cochlear Implant Signal Processing Simulation.

Course Learning Outcome (CLO): Upon completion of this course, the students will be able to:

1. Understand physiological requirements of artificial organs
2. Explain design principles of prosthetic and implantable devices
3. Analyze materials and biocompatibility issues
4. Apply engineering concepts to rehabilitation devices

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

5. Compare conventional and advanced prosthetic systems including myoelectric and bionic limbs.

Textbooks

1. D. A. Winter, Biomechanics and Motor Control of Human Movement, Wiley, 2009
2. John Enderle & Joseph Bronzino, Introduction to Biomedical Engineering, Academic Press, 2000
3. Donald L. Wise, Biomaterials Engineering and Devices, Humana Press, 2000

Reference Books

1. S. K. Basu, Biomedical Engineering, McGraw-Hill
2. R. S. Khandpur, Handbook of Biomedical Instrumentation, McGraw-Hill
3. IEEE & Elsevier journals on prosthetics and artificial organs

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessional (May include assignments/quizzes)	30

UBM522 **LASER OPTICS AND ULTRASOUND**

L	T	P	CR
3	1	0	3.5

Course Objectives: To Study about optical properties of the tissues and the interactions of light with tissues, medical optics and ultrasound based diagnostic system.

Course Content:

Optical Properties of the Tissues: Fundamental Properties of light - Refraction, Reflection, Laws (Snell's law and Fresnel law) Scattering, Absorption, Light transport inside the tissue, Tissue properties, Laser Characteristics as applied to medicine and biology, Laser tissue Interactions – Photo chemical, Photo thermal and Photo mechanical interactions, Fluorescence, Speckles, Photo ablative processes

Instrumentation in Photonics: Instrumentation for absorption, Scattering and emission measurements, Excitation light sources – high pressure arc lamps, LEDs, Lasers, Optical filters – Prism and Monochromators, Polarizers, Optical detectors – Single Channel and Multichannel detectors, Time resolved and phase resolved detection methods, Optical fibres – Total Internal Reflection.

Surgical Therapeutic Applications of Lasers: Lasers in ophthalmology, Dermatology, Dentistry, Urology, Otolaryngology, Tissue welding and Soldering.

Non-Thermal Diagnostic Applications: Optical coherence tomography, Elastography, Laser Induced Fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM – Holographic and Speckle applications of lasers in biology and medicine

Diagnostic and Therapeutic Techniques: Near field imaging of biological structures, In vitro clinical diagnostics, Phototherapy, Photodynamic therapy (PDT) - Principles and mechanisms - Oncological and non-oncological applications of PDT - Biostimulation effect – applications - Laser Safety Procedures

Ultrasound: Physics of ultrasound and Production of ultrasound, Medical ultrasound, acoustic impedance, absorption and attenuation of ultrasound energy, pulse geometry, ultrasonic field, ultrasonic transducers and probe design, Principles of image formation, capture and display - Principles of A Mode, B Mode and M Mode. Real-time ultrasonic imaging systems, electronic scanners, image artifacts, Doppler ultra sound and Colour velocity mapping, duplex ultrasound, bio-effects and safety levels. Scan converters, Frame grabbers, Single line and multiline monitoring of ultrasound displays - US artifacts

Course Learning Outcome (CLO): Upon completion of this course, the students will be able to:

1. Demonstrate knowledge of the fundamentals of optical properties of tissues
2. Analyze the components of instrumentation in Medical Photonics and Configurations
3. Describe surgical applications of lasers.
4. Describe photonics and its diagnostic applications.
5. Investigate emerging techniques in medical optics
6. differentiate biosensors, optical and ultrasonic sensors
7. Demonstrate knowledge of the fundamentals of ultrasound

TEXT BOOKS:

1. Tuan Vo Dirh, ―Biomedical Photonics – Handbook‖, CRC Press, Bocaraton, 2014.
2. Paras N. Prasad, ―Introduction to Biophotonics‖, A. John Wiley and Sons, Inc. Publications, 2003

REFERENCES:

3. Markolf H. Niemz, ―Laser-Tissue Interaction Fundamentals and Applications‖, Springer, 2007
4. G. David Baxter ―Therapeutic Lasers – Theory and practice‖, Churchill Livingstone publications Edition- 2001.
5. Leon Goldman, M.D., & R. James Rockwell, Jr., ―Lasers in Medicine‖, Gordon and Breach, Science Publishers Inc., 1975

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weights (%)
1.	MST	30
2.	EST	45
3.	Sessional (may include Assignments/Projects/Tutorials/Quiz)	25

UBM521 **APPLIED BIOTRANSPORT**

L	T	P	CR
3	1	0	3.5

Course Objectives: To describe the fundamental concepts of momentum, heat and mass transfer and understand the roles of transport processes in the cells, tissues and organ systems of the human boddy. Formulate problems in chemical and biological systems, identifying fundamental transport processes and the equations that describe these systems.

Course Content:

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

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

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

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

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

Course Learning Outcome (CLO): Upon completion of this course, the students will be able to:

1. Mathematically define and describe general bio transport
2. Study the various models of heat transfer to achieve homeostasis
3. Comprehend mass transfer in Kidneys and lungs
4. Apply mass transfer principles in designing dialyzers and oxygenators
5. Construct compartmental models to analyse drug delivery and blood flow

Text books:

1. Biomedical Engineering Principles, An Introduction to fluid, heat and mass transfer process, Cooney D. O., Marcel Dekker Inc, (1976).

2. Transport Phenomena is living systems- Biomedical Aspects of Momentum and Man Transport, Lightfoot E. N., John Wiley (1974).
3. Basic transport phenomena in biomedical engineering, Fournier, Ronald L., Taylor & Francis, 1998.

Reference books:

1. G.A. Truskey, F. Yuan, D. F. Katz: "Transport phenomena in biological systems." 2 nd Edition.

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weights (%)**
1.	MST	30
2.	EST	45
3.	Sessional (may include Assignments/Projects/Tutorials/Quiz	25

UBM522 **TELEMEDCINE IN HEALTH CARE**

L	T	P	CR
3	1	0	3.5

Course Objective: This course will present the advantages and challenges of telehealth services to close these gaps. Special focus is placed on how communication, innovative technology, safety and efficiency are addressed through telehealth.

Course Content:

Introduction to Telemedicine: Historical perspective and Evolution of telemedicine, Tele health, Tele care, Components of telemedicine system, Global and Indian scenario, Ethical and legal aspects of Telemedicine – Confidentiality, Social and legal issues, Safety and regulatory issues, Law governing telemedicine.

Telemedicine Systems: Telemedicine System, Essential Parameters for Telemedicine, Components of Telemedicine, Trends in Telemedicine System, Delivery modes in Telemedicine,

Telecommunication Technologies for Telemedicine: Principles of Multimedia – Text, Audio, Video, data, Data communications and networks, PSTN, POTS, ANT, ISDN, Internet, Air/ wireless communications: GSM satellite, and Micro wave, Modulation techniques, Integration and operational issues, Communication infrastructure for telemedicine – LAN and WAN technology, Satellite communication.

Ethical and Legal Aspects of Telemedicine: Confidentiality, patient rights and consent: confidentiality and the law, the patient-doctor relationship, access to medical records, consent treatment - data protection & security, jurisdictional issues, intellectual property rights**.**

Telemedical Applications: Telemedicine access to health care services – health education and self-care. Introduction to robotics surgery, tele-surgery. Tele-cardiology, Telemedicine in neurosciences, Electronic Documentation, e-health services security and interoperability., Telemedicine access to health care services – health education and self-care, Business aspects – Project planning, Usage of telemedicine.

Course learning outcome: Upon completion of this course, the students will be able to:

1. Understand the regulatory, legislative and political considerations that affect the implementation of telehealth
2. Understand the telecommunication technologies for telemedicine.
3. Explain protocols behind encryption techniques for secure transmission of data
4. Understand the Ethical and Legal Aspects of Telemedicine
5. Identify the various applications of the telehealth technology

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

Text Books:

1. Norris, A.C. "Essentials of Telemedicine and Telecare", Wiley (ISBN 0-471-53151-0), First edition, 2002.
2. Shashi Gogia, "Fundamentals of Telemedcine and Telehealth", Elsevier (ISBN 9780128143094), First edition, 2019.
3. R. S. Khandpur, "Telemedicine Technology and Applications", PHI Learning Pvt. Ltd., May 1, 2017.
4. O'Carroll, P. W, Yasnoff W.A., Ward E.Ripp, L.H., Martin, E.L., "Public Health Informatics and Information Systems", Springer (ISBN 0-387-95474-0), 1st Edition, 2003.

Reference Books:

1. Simpson, W. "Video over IP- A practical guide to technology and applications", Focal Press (Elsevier). ISBN-10: 0-240-80557-7, 2006.
2. Wootton R. Craig, J., Patterson V. "Introduction to Telemedicine", Royal Society of Medicine Press Ltd (ISBN 1853156779), 2nd Edition, 2006.
3. Ferrer-Roca, O., Sosa-Iudicissa, M, "Handbook of Telemedicine", IOS Press (Studies in Health Technology and Informatics, Volume 54). (ISBN 90-5199-413-3), 3rd Edition, 2002.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM523 **BIOGENERATIVE ENGINEERING**

L	T	P	CR
3	1	0	3.5

Course Objectives: To understand the principles of developmental biology, stem cell biology, and somatic regeneration and integrate engineering principles and technologies into regenerative medicine.

Introduction to regenerative engineering: Basic concepts**,** Rationale for regenerative engineering, Molecular regenerative engineering, Cellular regenerative engineering, Tissue regenerative engineering.

Biological basis of regenerative engineering: Regenerative machineries: Molecules, Cells, Systems, Cell generation during embryonic development: Embryonic processes, Mechanisms of cell generation. Embryonic stem cells: Stem cell identification, Stem cell characterization, Stem cell function. Somatic resident stem cells: Bone marrow stem cells, Other resident stem cells. Somatic organ regeneration: Liver regeneration, Regeneration of other organs. Cytokines in regeneration, Growth factors in regeneration, Extracellular matrix in regeneration

Principles and technologies of regenerative engineering: Gene-based regenerative engineering**:** Identification of pathogenic and regenerative genes, Gene recombination and manipulations, Biological mediations of gene transfer, Chemical and physical mediations of gene transfer, Small interfering RNAs for mRNA modulations, Epigenetic modulations, MicroRNA modulations, Gene editing. Cell-level regenerative engineering, Tissue-level regenerative engineering.

Course Learning Outcome (CLO): Upon completion of this course, the students will be able to:

1. Assess the mechanisms of naturally occurring developmental and regenerative processes
2. Acquire knowledge about the principles and technologies of molecular, cellular, and tissue regenerative engineering.
3. Establish hypotheses for regenerative engineering research.
4. Design engineering strategies for regenerative medicine.

Recommended Books:

1. Shu Q. Liu, Bioregenerative Engineering: Principles and Applications. Wiley Interscience, New York, 2007*.
2. Shu Q. Liu. Cardiovascular Engineering: A Protective Approach. McGraw-Hill, New York, 2020

Evaluation Scheme:

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	45
3	Sessional (May include Assignments//Quizzes/Lab Evaluations)	30

UEI718 **VIRTUAL INSTRUMENTATION**

L	T	P	CR
3	1	0	3.5

Course Objective: The objective of this course is to introduce the concept of virtual instrumentation and to develop basic VI programs using loops, case structures etc. including its applications in image, signal processing and motion control.

Course Content:

Review of Virtual Instrumentation: Historical perspective, Block diagram and Architecture of Virtual Instruments
Data-flow Techniques: Graphical programming in data flow, Comparison with conventional programming.
VI Programming Techniques: VIs and sub-VIs, Loops and Charts, Arrays, Clusters and graphs, Case and sequence structures, Formula nodes, Local and global variables, Strings and file I/O.

Data Acquisition Basics: ADC, DAC, DIO, Counters and timers.

Common Instrumentation Interfaces: RS232C/ RS485, GPIB, PC Hardware structure, DMA software and hardware installation.

Use of Analysis Tools: Advanced analysis tools such as Fourier transforms, Power spectrum, Correlation methods, Windowing and filtering and their applications in signal and image processing, Motion Control.

Additional Topics: System buses, Interface buses: PCMCIA, VXI, SCXl, PXI, etc.

Laboratory Work: Components of Lab VIEW, Celsius to Fahrenheit conversion, Debugging, Sub-VI, Multiplot charts, Case structures, ASCII files, Function Generator, Property Node, Formula node, Shift registers, Array, Strings, Clusters, DC voltage measurement using DAQ

Course Learning Outcome (CLO): Upon completion of this course, the students will be able to:

1. Demonstrate the working of LabVIEW
2. Exhibit the knowledge of the various types of structures used in LabVIEW
3. Analyze and design different type of programs based on data acquisition
4. Demonstrate the use of LabVIEW for signal processing, image processing etc.
5. Use different analysis tools

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

Text Books:

1. Johnson, G., LabVIEW Graphical Programming, McGraw–Hill (2006).
2. Sokoloft, L., Basic Concepts of LabVIEW 4, Prentice Hall Inc. (2004).
3. Wells, L.K. and Travis, J., LabVIEW for Everyone, Prentice Hall Inc. (1996).

Reference Book:

1. Gupta, S. and Gupta, J.P., PC Interfacing for Data Acquisition and Process Control, Instrument Society of America (1988).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (May include Assignments//Quizzes/Lab Evaluations)	40

UBM604 **BIOSIGNAL PROCEESING**

L	T	P	CR
3	**1**	**0**	**3.5**

Course Objective: The student should be made to understand characteristics of some of the most commonly used biomedical signals, including ECG, EEG, EOG, and EMG.

Course Content:

Introduction to Biomedical Signals: Bio signal Characteristics of Electro Cardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG), Electroretinogram (ERG), Electrogastrogram (EGG), Electroneurogram (ENG), Event related potentials (ERPs), Phonocardiogram (PCG), Speech signal, Objectives of Biomedical signal analysis, Difficulties in Biomedical signal analysis, Computer-aided diagnosis.

Filtering for Removal of Artifacts: Time-domain Filters – synchronized averaging, Moving Average Filters, Derivative-based operators to remove low-frequency artifacts. Frequency-domain filters – Removal of High Frequency noise, Removal of low frequency noise, Removal of periodic artifacts, optimal filter- Wiener filter, Adaptive filters for removal of interference, Removal of biological artifacts using independent component analysis. Evoked potentials- noise characteristics.

Cardiovascular Applications, QRS Detection Algorithm, ECG compression techniques (Direct Time Domain (TP, AZTECH, CORTES, SAPA, Entropy Coding), Frequency Domain (DFT, DCT, DWT, KLT, Walsh Transform), Parameter Extraction: Heart rate variability, acquisition and RR Interval conditioning, Spectral analysis of heart rate variability

Neurological Applications: Modeling EEG- linear, stochastic models - Nonlinear modeling of EEG, – Nonparametric spectral analysis, Model based spectral analysis -EEG segmentation - Joint Time-Frequency analysis - correlation analysis of EEG channels - coherence analysis of EEG channels~~.~~ EEG applications- Epilepsy, sleep disorders, brain computer interface. Analysis of ERP effect.

Analysis on Wave shape, Signal Classification and Recognition: Modeling intramuscular EMG-Intramuscular signal Decomposition-Fractal analysis of EMG signals. Statistical analysis of VAG signals. Analysis on amplitude and latency of MEG signals~~.~~ Signal classification and recognition – Statistical signal classification, direct feature selection and ordering.

Course Learning Outcome (CLO): Upon completion of this course, the students will be able to:

1. Analyze different types of biomedical signals and identify their spectral components.
2. Identify physiological interferences and artifacts affecting biomedical signals and selection of different filters and judge filter performance.

3. Extract features from various Biomedical signal.
4. Develop an algorithm to classify biomedical signals.

Text Books:

1. Rangayyan, Biomedical Signal Analysis, Wiley 2002.
2. Semmlow, Biosignal and Biomedical Image Processing, Marcel Dekker, 2004

References:

1. Arnon Cohen, Bio-Medical Signal Processing Vol I and Vol II, CRC Press Inc., Boca Rato, Florida 1999.
2. D. C. Reddy, Biomedical Signal Processing: Principles and techniques, Tata McGraw Hill, New Delhi, 2005
3. Willis J Tompkins, Biomedical Digital Signal Processing, Prentice Hall, 1993
4. Bruce, Biomedical Signal Processing and Signal Modeling, Wiley, 2001
5. Sornmo, Bioelectrical Signal Processing in Cardiac and Neurological Applications, Elsevier 2005.

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weights (%)**
1.	MST	30
2.	EST	45
3.	Sessional (may include Assignments/Projects/Tutorials/Quiz	25

UBM633 HOSPITAL WASTE MANAGEMENT

L	T	P	CR
3	1	0	3.5

Course Objectives: The student should be made to understand the hazardous materials used in hospital and its impact on health and various waste disposal procedures and management.

Course Content:

Healthcare hazard control and understanding accidents: Healthcare Hazard Control: Introduction, Hazard Control, Hazard Control Management, Hazard Control Responsibilities, Addressing Behaviors, Hazard Control Practice, Understanding Hazards, Hazard Analysis, Hazard Control and Correction, Personal Protective Equipment, Hazard Control Committees, Hazard Control Evaluation, Hazards, System Safety, Ergonomics. Understanding Accidents: Accident Causation Theories, Human Factors, Accident Deviation Models, Accident Reporting, Accident Investigations, Accident Analysis, Organizational Functions That Support Accident Prevention, Workers' Compensation, Orientation, Education, and Training.

Biomedical waste management: Biomedical Waste Management: Types of wastes, major and minor sources of biomedical waste, Categories and classification of biomedical waste, hazard of biomedical waste, need for disposal of biomedical waste, waste minimization, waste segregation and labelling, waste handling, collection, storage and transportation, treatment and disposal.

Hazardous materials: Hazardous Substance Safety, OSHA Hazard Communication Standard, DOT Hazardous Material Regulations, Healthcare Hazardous Materials, Medical Gas Systems, Hazardous Waste Operations and Emergency Response Standard, Respiratory Protection.

Facility safety : Introduction, Facility Guidelines Institute, Administrative Area Safety, Slip, Trip, and Fall Prevention, Safety Signs, Colors, and Marking Requirements, Scaffolding, Fall Protection, Tool Safety, Machine Guarding, Compressed Air Safety, Electrical Safety, Control of Hazardous Energy, Permit Confined Spaces, OSHA Hearing Conservation Standard, Heating, Ventilating, and Air-Conditioning Systems, Assessing IAQ, Landscape and Grounds Maintenance, Fleet and Vehicle Safety.

Infection control, prevention and patient safety: Healthcare Immunizations, Centers for Disease Control and Prevention, Disinfectants, Sterilants, and Antiseptics, OSHA Bloodborne Pathogens Standard, Tuberculosis, Healthcare Opportunistic Infections, Medical Waste. Patient Safety: An Organizational Function, Errors and Adverse Events, Safety Cultures, Patient-Centered Healthcare, Quality Improvement Tools and Strategies, Healthcare-Associated Infections, Medication Safety.

Approved in 3rd meeting of the Academic Council held on 18th March, 2026

Course Learning Outcome (CLO): Upon completion of this course, the students will be able to:

1. Analyse various hazards, accidents and its control
2. Design waste disposal procedures for different biowastes
3. Categorise different biowastes based on its properties
4. Design different safety facility in hospitals
5. Propose various regulations and safety norms

Text Books:

1. Tweedy, James T., Healthcare hazard control and safety management-CRC Press_Taylor and Francis (2014).
2. Anantpreet Singh, Sukhjit Kaur, Biomedical Waste Disposal, Jaypee Brothers Medical Publishers (P) Ltd (2012).

Reference:

1. R.C.Goyal, ―Hospital Administration and Human Resource Management‖, PHI – Fourth Edition, 2006
2. V.J. Landrum, ―Medical Waste Management and disposal‖, Elsevier, 1991.

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (Assignments/Quizzes)	25

UBM633 **TISSUE ENGINEERING**

L	T	P	CR
3	1	0	3.5

Course Objectives: This course will enable Students to understand thoroughly the key concepts of tissue organization, remodeling and strategies for restoration of tissue function. This will enable them to design tissue regeneration and tissue injury repair strategies.

Introduction: Basic definition, Introduction to tissue engineering, Cells as therapeutic agents with examples. Cellular fate processes, Cell differentiation, Cell migration - underlying biochemical process.

Structural and organization of tissues: Tissue organization, Tissue Components, Tissue types, Functional subunits. Tissue Dynamics, Homeostasis in highly prolific tissues and Tissue repair. Angiogenesis. Epithelial, connective; vascularity and angiogenesis, basic wound healing, cell migration, current scope of development and use in therapeutic and in-vitro testing, Stem Cells

Molecular & Cellular aspects: Cell-extracellular matrix interactions - Binding to the ECM, Modifying the ECM, Malfunctions in ECM signaling. Cell signaling molecules, growth factors, hormone and growth factor signaling, growth factor delivery in tissue engineering, cell attachment: differential cell adhesion, receptor-ligand binding, and Cell surface markers.

Biomaterials & Scaffold: Engineering biomaterials for tissue engineering, Degradable materials (collagen, silk and polylactic acid), porosity, mechanical strength, 3-D architecture and cell incorporation. Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver, Bioreactors for Tissue Engineering. Smart Biomaterials, Organoids and Spheroids, Organ-on-chip

Case study and regulatory issues: Case study of multiple approaches: cell transplantation and engineering for liver, musculoskeletal, cardiovascular, neural, visceral tissue engineering. Ethical, FDA and regulatory issues of tissue engineering.

Course learning outcome (CLO): Upon completion of this course, the students will be able to:

1. Comprehend the structural organization of cells and tissues, the role of cell interaction, cell migration, wound healing and cellular processes
2. To illustrate different cellular and molecular signaling pathways.
3. Describe the different biomaterials and its properties, design, fabrication and biomaterials selection criteria for tissue engineering scaffolds
4. Comprehend applications of tissue engineering

Text books:

1. 1. Principles of tissue engineering, Robert. P.Lanza, Robert Langer & William L. Chick, Academic press.
2. 2. The Biomedical Engineering –Handbook, Joseph D. Bronzino, CRC press.
3. 3. Introduction to Biomedical Engg., Endarle, Blanchard & Bronzino, Academic press.

Reference books:

1. Tissue Engineering, B. Palsson, J.A. Hubbell, R.Plonsey & J.D. Bronzino, CRC-Taylor & Francis
2. Nanotechnology and Tissue engineering - The Scaffold", Cato T. Laurencin, Lakshmi S. Nair, CRC Press 2005.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25