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

CURRICULUM & SCHEME OF COURSES

(w.e.f. 2024)

B. Tech. Biomedical Engineering

Electrical and Instrumentation Engineering Department

Curriculum Development – Guiding Principles

The statutory bodies of the University, the Senate or the Planning and Monitoring Board oversee the design and development process so that the activity is carried out in a planned manner. The detailed planning for this activity is the responsibility of the Department Head. The systematic process of design and development includes the activities & sub activities including techniques & organizational interfaces and the time frame for completion of various activities. The plans are updated, as the instructional design evolves.

The design and development process generally begins with a need analysis report which comprises of (i) Stated needs (ii) Implied needs (iii) Overall goals of Instructions (iv) Relevant standards i.e. AICTE and UGC guidelines and Curricula of Entrance Tests like Graduate Aptitude Test for Engineers (GATE), etc. and (v) General characteristics of target population.

Organizational and Technical interfaces between different faculty and external expert groups providing input to the instructional design are defined, committees are constituted and their reports are documented. Faculty members from different disciplines connected with the design & development activity are associated with the process. The updation/restructuring is carried out as the design process progresses. Clear responsibilities are assigned and effective communication is ensured.

The requirements of instructional design are determined and recorded. For instructional design, the input is taken from various sources. Input requirements are clearly understood and reconciled. The design input may come from:

1. Need analysis & Reviews.
2. Recommendations from
    a. Faculty & senior management
    b. Employers and industry
    c. Alumni
    d. Regulatory Bodies
3. Success/failure reports of similar courses & programs.
4. Published literature relevant to programs.
5. Boundary condition w.r.t GATE, curricula etc.

The general steps followed in curriculum development are as under:

- The need for starting a new programme or course(s) may arise from interaction with Industry, Faculty, Students, Alumni or PMB/Senate/BOG, UGC/AICTE etc.
- The idea of proposed programme is discussed in the HODs' meeting and if found appropriate, the Head of concerned department is asked to put up a proper proposal. A sub-committee of internal/external member(s) may sometimes be formed for making the feasibility and viability analysis.
- The DAAC (on the basis of recommendations of sub-committee, wherever required) does the need analysis and prepares the proposal for approval from Board of Studies (BOS).

- The BOS after deliberating on the proposal may make the desired modifications and then send the proposal to DOAA for consideration in SUGC/SPGC, along with the duly filled checklists.
- The proposal is put up for consideration to SUGC/SPGC and upon its approval the recommendations may be sent to the Senate and PMB.
- After the Senate approval, the proposal may be sent to concern Department/School through academic section for allocation of appropriate course codes OR if required it is sent to AICTE/UGC for approval and the status is put up in the forthcoming meeting of BOG.
- Once approved, it is implemented by the concerned Department/School after allocation of proper course code by the academic section.

The employability, innovation and research in curriculum design and development is ensured by:

- Involvement of industry professionals in curriculum development
- Benchmarking exercises to extract customers (employer's) requirements
- Mandatory project semester in Industry for all UG and some PG students
- Synergizing curriculum with industry practices and needs

The curriculum design and development for all programs is done at least once every four years to ensure continuing suitability, adequacy and effectiveness in satisfying the requirements and the vision, mission and quality policy of the University. The design process includes assessing opportunities for improvement and the need for ensuring suitable employability, innovation and research (more applicable to postgraduate programs). The process invites formal inputs from all stake holders and generally includes the following sources:

- Action taken report on the previous reviews and external accreditation reports (NAAC, NBA-AICTE)
- Results of student's performance in various examinations
- Result of Students Reaction Survey
- Feedback from
    - Industry,
    - Alumni,
    - participating organizations in campus placement and other concerned sources
- Details of corrective/preventive actions
- Improvement programs suggested/recommended
- Training programs launched
- Review of mission and quality policy

The process of determining solutions to satisfy the identified needs is laid down and documented. Instructions are designed by incorporating these solutions. The analysis and mappings are recorded. The design output at this stage is taken as the initial design for subsequent reviews. The output of instructional design & development is documented in the form of a report named “Curriculum and Scheme of Courses”. Through various reviews and verifications, it is ensured that the design output meets the design input requirements.

The design output report includes:

- The types and levels of skill and knowledge to be imparted
- Program Educational Objectives; Student Outcomes
- Course Learning Outcomes
- Scheme of courses and the detailed syllabi
- Assessment and evaluation.

The output documents like curriculum and instructional strategies are reviewed and approved before release at various levels and stages.

Reviews are conducted at defined stages of the curriculum Design, in which faculty members from the concerned area as well as experts from amongst the peer group from within and/or outside the University are associated. Records of the reviews are maintained. Based on the reviews, the curriculum is updated.

New/revised curriculum and instructional design is made applicable to the prospective students. The curriculum is validated in the initial stages of its introduction by taking a feedback from students and faculty members regarding the effectiveness and applicability of the curriculum, with regard to the documented needs. Necessary changes, if required, are made to ensure that the design conforms to defined needs of the students. Wherever required, additional instructional sessions and allied inputs are arranged for students/participants.

Some Broad Guidelines

Undergraduate Programs

Undergraduate engineering students are taught a series of courses in basic sciences to develop understanding of scientific principles and methods, analytical ability and rigor. These courses are followed by courses in engineering sciences to provide a smooth transition from basic sciences to professional engineering courses. A series of courses in technical arts are designed to develop engineering skills through training in engineering drawing, measurements, computing skills, manufacturing technology and effective communication. The professional courses in the chosen field of specialization are meant to develop creative abilities for the application of basic and engineering sciences to engineering problems involving planning, design, manufacturing, maintenance and research and development. In addition, courses in humanities and social sciences are incorporated to develop appreciation of the impact of science and technology on society. The undergraduate curriculum consists of two main components i.e. core courses and professional courses. The core courses lay emphasis on concepts and principles. It involves teaching of subjects in Basic Sciences, Humanities and Social Sciences and Engineering Science. Attention is also paid to develop communication skills in English language - the medium of instructions. The Professional courses lay emphasis on system analysis, design, manufacturing and professional practice. There is an in-built flexibility to encourage students to specialize in streams of their choice through a system of professional and free electives. The University strives to foster among its students a strong desire and capacity for continuous learning as well as self-appraisal to develop sterling human & professional qualities and a strong sense of service to society through designed, curricular, co-curricular activities and congenial campus environment.

B. Tech. BIOMEDICAL ENGINEERING

Following is the proposed course scheme for the students during the session 2024-25 and onwards. In the tables below:

SEMESTER-I

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UMA015	CALCULUS-I	4	1	0	4.5
2	UTA003	COMPUTER PROGRAMMING	3	0	2	4.0
3	UCB028	GENERAL CHEMISTRY-I	3	1	2	4.5
4	UPH010	PHYSICS WITH CALCULUS-I	3	1	2	4.5
5	UHU003	PROFESSIONAL COMMUNICATION	2	0	2	3.0
6	UBM001	INTRODUCTION TO BIOENGINEERING APPLICATIONS	3	1	0	3.5
		TOTAL	**18**	**4**	**8**	**24.0**

SEMESTER-II

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UMA016	CALCULUS-II	4	1	0	4.5
2	UCB029	GENERAL CHEMISTRY-II	3	1	2	4.5
3	UPH011	PHYSICS WITH CALCULUS-II	3	1	2	4.5
4	UBM032	ENGINEERING STATICS	3	1	0	3.5
5	UEN002	ENERGY AND ENVIRONMENT	3	0	0	3.0
6	UBM002	ORIENTATION AND INTRODUCTION TO BIOENGINEERING COMPUTING	2	0	4	4.0
		TOTAL	**18**	**4**	**8**	**24.0**

SEMESTER-III

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UBM009	BIOENGINEERING THERMODYNAMICS	3	1	0	3.5
2	UMA017	DIFFERENTIAL EQUATIONS	4	1	0	4.5
3	UBM031	ELECTRICAL CIRCUITS	3	1	2	4.5
4	UBM003	FUNDAMENTAL OF LIFE SCIENCES	3	0	2	4.0
5	UBM024	FRESHMAN DESIGN INNOVATION-I	1	0	4	3.0
6	UBM008	BIOMATERIALS	3	0	0	3.0
		TOTAL	**17**	**3**	**8**	**22.5**

SEMESTER-IV

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UMA018	CALCULUS-III	4	1	0	4.5
2	UBM007	ADDITIVE MANUFACTURING IN BIOMEDICAL ENGINEERING	2	0	2	3.0
3	UBM025	FRESHMAN DESIGN INNOVATION-II (2 SELF EFFORT HOURS)	1	0	2	3.0
4	UBM006	INTRODUCTION TO BIOMECHANICS	3	1	2	4.5
5	UHU005	HUMANITIES FOR ENGINEERS	2	0	2	3.0
6	UBM005	BIOMEDICAL QUALITY CONTROL	3	1	0	3.5
		TOTAL	**15**	**3**	**8**	**21.5**

SUMMER: For all those students who want to go to the University of Toledo for further studies, it is mandatory to complete an online ***ENGLISH LANGUAGE*** course.

SEMESTER-V

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UEI614	BIOMEDICAL SENSORS AND MEASUREMENT	3	1	2	4.5
2	UBM605	DATA STRUCTURE AND ALGORITHMS	3	0	2	4.0
3	UBM503	FOUNDATIONS OF ARTIFICIAL INTELLIGENCE	3	0	2	4.0
4		ELECTIVE-I	3	1	0	3.5
5	UBM504	FUNDAMENTALS OF SIGNALS AND SYSTEM	3	1	0	3.5
6	UBM505	INTRODUCTION TO ANALOG CIRCUITS AND DEVICES	3	1	2	4.5
		TOTAL	**18**	**4**	**8**	**24.0**

SEMESTER-VI

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UBM608	PHYSIOLOGICAL MODELLING AND CONTROL	3	1	2	4.5
2	UBM694	CAPSTONE PROJECT –I (START)	1	0	2	0
3	UBM602	INTRODUCTION TO DIGITAL ELECTRONICS	3	1	2	4.5
4	UBM607	MACHINE LEARNING	3	0	2	4.0
5		ELECTIVE-II	3	1	0	3.5
6	UBM609	BASIC-MEDICAL INSTRUMENTS	3	0	2	4.0
7	UBM604	BIOSIGNAL PROCESSING	3	1	0	3.5
8	UCS312	DATABASE MANAGEMENT SYSTEM	2	0	2	3.0
		TOTAL	**21**	**4**	**12**	**27.0**

SEMESTER-VII

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UBM701	MEDICAL IMAGE PROCESSING	3	0	2	4.0
2	UBM702	HOSPITAL ENGINEERING AND MANAGEMENT (2 Hrs. SELF EFFORT)	2	0	0	3.0
3	UBM706	ROBOTICS IN HEALTHCARE	2	0	2	3.0
4	UBM603	ADVANCED MEDICAL INSTRUMENTS	3	0	0	3.0
5	UBM694	CAPSTONE PROJECT-II	-	-	-	8.0
		TOTAL	**10**	**0**	**2**	**21.0**

SEMESTER-VIII

S. No.	COURSE NO.	TITLE	L	T	P	CR
1	UBM891	PROJECT SEMESTER	-	-	-	**15.0**
		OR				
1	UEI610	FUNDAMENTALS OF MICROPROCESSORS AND MICROCONTROLLERS	3	0	2	4.0
2	UBM892	DESIGN PROJECT	-	-	-	8.0
3	UEI613	BIOMETRICS	2	0	2	3.0
		Total	**5**	**0**	**4**	**15.0**
		OR				
1	UBM893	START- UP SEMESTER	-	-	-	**15.0**

Total Credit= 179

ELECTIVE-I

S.NO.	COURSE NO.	COURSE NAME	L	T	P	CR
1	UBM521	APPLIED BIOTRANSPORT	3	1	0	3.5
2	UBM522	LASER OPTICS AND ULTRSOUND	3	1	0	3.5
3	UBM523	BIOREGENRATIVE ENGINEERING	3	1	0	3.5
4	UEI831	BIOSENSORS AND MEMS	3	1	0	3.5
5	UBM524	TISSUE ENGINEERING	3	1	0	3.5

ELECTIVE-II

S.NO.	COURSE NO.	COURSE NAME	L	T	P	CR
1	UBM631	TELEMEDCINE IN HEALTH CARE	3	1	0	3.5
2	UBM632	ARTIFICIAL ORGANS AND LIMBS	3	1	0	3.5
3	UEI718	VIRTUAL INSTRUMENTATION	2	0	3	3.5
4	UBM633	HOSPITAL WASTE MANAGEMENT	3	1	0	3.5
5	UBMXXX	BIOPHOTONICS	3	1	0	3.5

Semester	EL Activity**
I	Arduino Based Embedded System
II	IOT Based Home Automation
III	Development of Electromyogram (EMG) system using Arduino
IV	Robotics ARM Control
V	Brain Tumor Segmentation using UNET

**These EL activities can be changed in subsequent years, if required.

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 behavior.

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: 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' HoSpital's Rule.
5) Determine the definite and indefinite integrals of functions.

Text Books:

Thomas' Calculus, George B. Thomas, Pearson Education, 2014, 14th edition.

1) 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.
2) Mathematics, A Text book (Parts I & II), NCERT, New Delhi, 2011.
3) 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	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UTA003: 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.

Computers Fundamentals: Classification of Computers, Application of Computers, Basic organization of computer, 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)/Course Objectives (CO):
On 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

UCB028: GENERAL CHEMISTRY-I

L	T	P	Cr
3	1	2	4.5

Course Objective: The course aims at understanding the physical and chemical properties of atoms, molecules and ions.

Detail Contents:

Chemical Tools: Experimentation and Measurements: Significant figures, Rounding Numbers, Accuracy and precision, Mean and median, Average deviation, Standard deviation, Relative standard deviation, Sample mean and population mean, Q-test, F-test, T-test.

Atoms, Molecules and Ions: Recapitulation of basic concepts, an introduction to atomic and molecular spectroscopy, Beer-Lambert's Law.

Mass Relationships in Chemical Reactions: Representation of chemical reactions, Balancing chemical equations: Oxidation number and ion electron methods, Stoichiometric calculations: Amounts of reactants and products.

Reactions in Aqueous Solution: Recapitulation of basic concepts, Measuring the concentration in solutions: Volumetric titration (acid-base, redox and complexometric), Instrument based titrations (conductometry, potentiometry and pH-metry).

Periodicity and Electronic Structure of Atoms: Electromagnetic radiations, Particle like behavior, Photoelectric effect, Black-body radiation, Plank's Postulate, Wave-particle duality, de Broglie's hypothesis, Heisenberg uncertainty principle, Quantum mechanical model of atom, Concepts of orbital and quantum numbers, Pauli's exclusion principle, Periodic trends: Electronic configuration, Atomic radii.

Ionic Compounds: Periodic Trends and Bonding Theory: Electronic configuration of ions, Periodic trends: Electronegativity and Electron affinity, Ionization energy, Formation of ionic bonds, Lattice energy of solids.

Covalent Bonding and Electron-Dot structures: Covalent bonding, Formation of covalent bond, Electron-dot structure, Concept of polarity and dipole moment.

Covalent Bonding: Bonding Theories and Molecular Structure: VSEPR model, Valence bond theory, Concept of hybridization, Molecular Orbital Theory, MO diagrams of diatomic molecules, MO diagrams of π-bonded systems, Conjugated systems, Huckel's rule.

Thermochemistry: Changes in internal energy, enthalpy in chemical reactions, Exothermic and Endothermic reactions, Concept of heat capacity, Kirchhoff's Equation, Hess's Law.

Gases: Their Properties and Behavior: Kinetic theory of gas, Collision and Mean free path, Maxwell-Boltzmann Distribution Law of Molecular Velocities, Concept of ideal and real gases, Behavior of real gases: van der Waal's equation.

Course Learning Outcomes: The students will be able to reflect on:

1. Concepts of analytical tools of experimentation and measurements; atoms, molecules and ions.
2. Periodicity, electronic structure and behavior of atoms.
3. Mass relationships and chemical reactions in aqueous solution.

4. Concepts of ionic and covalent bondings, VSEPR Model, valence bond theory and molecular orbital theory.
5. Thermochemistry, properties of gases and their behavior.
6. Laboratory techniques like pH metry, potentiometry, colourimetry, conductometry and volumetry .

Recommended Books

1. Lee, J.D., Concise Inorganic Chemistry, ELBS, (2008) 5th ed.
2. Sharpe, E., Inorganic Chemistry, Pearson Education (2003) 3rd ed.
3. Skoog, D.A., West, D.M., Holler, F.J., and Crouch, S.R., Fundamentals of Analytical Chemistry, Brooks/Cole (2003) 8th ed.
4. Atkins, P.W., Physical Chemistry, W.H. Freeman (2018) 11th ed.
5. Castellan, G. W., Physical Chemistry, Narosa (2004) 4th ed.
6. Zumdahl, S. S.; Chemistry Concepts and Applications, Cengage Learning, (2009),1st ed.

List of Experiments

1. To determine the amount of NaOH and Na_2CO_3 present in the same solution.
2. To find the temporary and permanent hardness of water sample by complexometric titration using standard EDTA solution.
3. To determine the copper content of a given sample solution of copper ore using 0.1 N sodium thiosulphate solution iodometrically.
4. To estimate the available chlorine in bleaching powder.
5. To determine the amount of Fe^{+2} and Fe^{+3} ions by permanganometry.
6. To find out the total alkalinity and sulphate content in a water sample.
7. To determine the strength of given sodium hydroxide solution by titration with standard hydrochloric acid conductometrically.
8. Determine pKa value of acetic acid by pH-metric titration.
9. Spectrophotometric determination of Fe^{2+} with 1,10-phenanthroline.
10. To titrate potentiometrically FAS solution against potassium permanganate and to determine the standard electrode potential of Fe^{2+} / Fe^{3+} system.

Evaluated Scheme

MST	EST	Sessional (May include Quizzes/Assignments/Lab Evaluation)
25	40	35

UPH010: PHYSICS WITH CALCULUS-I

L	T	P	Cr
3	1	2	4.5

Course Objectives: Introduce the laws of oscillators, acoustics of buildings, ultrasonics, electromagnetic waves, wave optics, lasers, and quantum mechanics and demonstrate their applications in technology. Student will learn measurement principles and their applications in investigating physical phenomenon.

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, dispersion of fog, 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 – Anti-glare automobile headlights, Adjustable tint windows. ***Lasers:*** Basic concepts, Laser properties, Ruby, HeNe, Biomedical LASERs (excimer, CO_2, 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): On 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).*

Reference Books:

1. *Pedrotti, Frank L., Pedrotti, Leno S., and Pedrotti, Leno M., Introduction to Optics, Pearson Prentice Hall^{TM} (2008).*
2. *Wehr, M.R, Richards, J.A., Adair, T.W., Physics of The Atom, Narosa Publishing House (1990).*
3. *Verma, N.K., Physics for Engineers, Prentice Hall of India (2014)*

Scheme of evaluation

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

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.

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):

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.
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

Detail contents:

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)

Student 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

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 Contents:

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: 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

UCB029: GENERAL CHEMISTRY-II

L	T	P	Cr
3	1	2	4.5

Course Objective: The student will get an introduction to phase transformation, kinetics, chemical equilibrium, thermodynamics and structure-property relationship.

Liquids, Solids and Phase Changes: States of matter, Phase, Component and Degree of freedom, Physical properties of liquids, Surface tension, Viscosity, Crystal, Lattice, Unit cell, Miller indices, Diffraction of X-rays, Bragg's law.

Solutions and their properties: Raoult's law, Vapor pressure of ideal and non-ideal solutions, Colligative properties.

Chemical Kinetics: Introduction, Rate laws of chemical reactions, Order and molecularity, Rate constantans and half-life time, Arrhenius equation.

Chemical Equilibrium: Equilibrium constant, Temperature dependence of equilibrium constant:van't Hoff reaction isotherm, Relations between K_p, K_c and K_x.

Aqueous Equilibria of Acid-Base and Applications: Concepts of acids and bases, Dissociation of acids and bases, pH scale, Henderson-Hasselbalch equation, Buffer solutions.

Thermodynamics: Laws of thermodynamics, Spontaneous and non-spontaneous process, Partial molar quantities, Chemical Potential.

Electrochemistry: Specific, equivalent and molar conductivity of electrolytic solutions, Migration of ions, Electrochemical cell, Concentration cells, Liquid junction potential.

Nuclear Chemistry: Nuclear Reactions, Mass defect and binding energy, Nuclear fission and fusion, Radioisotopes and its applications.

Transition Elements and Coordination Chemistry: Recapitulation of basic concepts, General properties and electronic configurations of d-block elements, Crystal field theory, Crystal field splitting in octahedral, tetrahedral and square planar complexes, Spectrochemical series, Jahn-Teller distortion.

Metals and Solid-State Materials: Dislocations in solids, Band theory of solids, Semiconductors and classifications.

Main Group Elements: General trends in main group elements (Group IA-VIIIA).

Organic and Biological Chemistry: Structural and stereo isomerism, Optical rotation, Chiralilty, R-S nomenclature, Interconversion of Fischer, Newman and Sawhorse projections, Role of metal ions in biological systems, Metalloprotein.

List of Experiments

1. To determine the strength of calcium/magnesium ions in a given solution by complexometric titrations.
2. To determine the amount of HCl and CH_3COOH in a given mixture conductometrically.
3. To determine the pK_{in} value of phenolphthalein indicator in aqueous solution.
4. To determine the relative and absolute viscosities of a given liquid.
5. To determine the surface tension of a given liquid.
6. To determine the rate constant of oxidation of iodide with hydrogen peroxide.
7. To determine the solubility and solubility product of spairingly soluble salt by conductance measurement in aqueous solution.
8. To determination the isoelectric point of an amino acid.
9. To determine the optical rotation of cane sugar.
10. Preparation and determination of pH values of buffer solutions.
11. To determine the melting point of organic molecules (demonstration only).

Course Learning Outcomes: The students will be able to reflect on:

1. Comprehend the fundamental idea of phase changes of liquids and solids and their different aspects like colligative properties, X-ray diffraction.
2. Describe different methods to determine rate law of kinetics, concept of chemical equilibrium, applications of acid-base equilibrium in aqueous solution. and thermodynamics.
3. Explain the concepts of thermodynamics, electrochemistry, nuclear chemistry and solid-state materials.
4. Comprehend the general trends of main group elements and concepts of crystal field theory in coordination chemistry.
5. Describe the basic idea of chirality, stereoisomerism in organic reactions and explain the role of metal ions in biological systems.
6. Laboratory techniques like volumetry, conductometry, pH-metry, potentiometry, kinetics, optical rotation, viscosity and surface tension measurement.

Recommended Books

1. Atkins, P.W., Physical Chemistry, W.H. Freeman (1990).
2. Castellan, G. W., Physical Chemistry, Narosa (2004) 4thed.
3. Sharpe, E., Inorganic Chemistry, Pearson Education (2003) 3rded.
4. Huheey, J.E., Keiter, E.A. and Keiter, R.L., Inorganic Chemistry, Pearson Education, (2002) 4th ed.
5. Lee, J.D., Concise Inorganic Chemistry, ELBS, (2008) 5thed.
6. Eliel, E. L., Wilen, S. H.; New York John Wiley and Sons (2004).

Evaluated Scheme

MST	EST	Sessional (May include Quizzes/Assignments/Lab Evaluation)
25	40	35

UPH011 PHYSICS WITH CALCULUS-II

L	T	P	Cr
3	1	2	4.5

Course objective: The students will become aware of planer motion and kinematics of particles, Newton's Law and conservation principles, vibrational and rotational motions.

Kinematics: Motion in One Dimension, Acceleration, Motion with Constant Acceleration, Motion in Two and Three Dimensions, Circular Motion: Geometrical and Analytic Methods, Motion of A Freely Falling Body.

Newton's laws: ***Statics of Particles*****:** Newton's First Law; Forces, Inertial and non-inertial Frames, Quantitative Definition of Force; Statics of Particles, Examples of Static Equilibrium of Particles, Newton's Third Law, Tension, Friction, Kinetic Friction. *Dynamics of Particles:* Dynamics of Particles, Motion of Planets and Satellites, Newton's Law of Gravitation, Newton's 2nd Law of Motion, Applications of Newton's laws of motion

Work, Energy and Momentum: Work-Energy Theorem, Potential and Kinetic Energy, Principle of Conservation of Momentum and energy, Elastic and Inelastic Collisions, Relative Velocity in One-Dimensional Elastic Collisions, Two Dimensional Elastic Collisions, Center of Mass, Time-Averaged Force.

Simple Harmonic Motion: Hooke's Law, Differential Equation for Simple Harmonic Motion and its solutions, Geometrical representation of Simple Harmonic Motion, Energy Conservation in Simple Harmonic Motion, Static Equilibrium of rigid bodies and extended bodies, Small Oscillations of a Pendulum

Central forces and Rigid Body dynamics: Angular Momentum and Central Forces, One and Many Body Problems, Kepler's Law of Planetary Motion, Simple Rotational Motion, Rolling Motion, Conservation of angular momentum, Work-Energy for Rigid Body Dynamics.

List of Experiments:

1. To study linear motion under low friction and plot distance, velocity, momentum, energy (kinetic, potential and total) and acceleration as a function of time.
2. To study dependence of kinetic energy on mass and velocity.
3. To study elastic/inelastic collisions: conservation of momentum.
4. To compare static and dynamic friction, dependence of dynamic friction on area in contact and perpendicular force between two surfaces.
5. To find the moment of inertia of wheel.
6. To find the moment of inertia of irregular body about its center of gravity with a torsion pendulum.
7. (a) To find the angular acceleration of flywheel.
   (b) To find the torque and hence, to find the moment of inertia of a flywheel.
8. To compare the moment of inertia of a solid sphere and a hollow sphere (or solid disc) of same mass using torsion pendulum and hence to show that moment of inertia depends on distribution of mass.
9. To determine value of 'g' at a place using Kater's pendulum.
10. To plot a graph between the distance of knife-edges from center of gravity and time of a compound pendulum. From graph, find
    (a) Acceleration due to gravity 'g'.

(b) Radius of gyration and moment of inertia of the bar about an axis through the center of gravity.

Course learning outcomes: The course learning outcomes are as follows:

1. Demonstrate the ability to use appropriate mathematical techniques to address physics problems
2. Demonstrate the concepts of kinematics of particle in various dimensions.
3. To understand and analyze static and dynamic features of particles.
4. Explain and apply the concept of energy, momentum and related conservation laws.
5. Enhance to ability of students to interpret the vibrational, rotational motion of particle and dynamics of rigid body.
6. Perform experiments related to Kinematics, Newton's Laws, Energy/momentum conservation, simple harmonic motion and rigid body dynamics

Recommended Books:

1. *Resnick& Halliday, Physics Vol.1 & 2, Publisher Willey.*
2. *John D. Cutnell& D. Yang, Introduction to Physics, Publisher Willey.*
3. *R. Serway and J. Jewett, Physics for Scientist & Engineers, CENGAGE publications.*
4. *Upadhyay J.C., Fundamental of Mechanics, Himalaya Publishing House.*

Evaluation Scheme:

Sr.No.	Evaluation Elements	Weight age (%)
1.	MST	25
2.	Tutorial	15
3.	Lab & Project	25
4.	EST	35

UBM032: ENGINEERING STATICS

L	T	P	Cr
3	1	0	3.5

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.

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 (CLO): 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:

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

UEN002: 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.

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):

On the completion of course, 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	50
3.	Sessional /Quizzes Evaluations	20

UBM002 ORIENTATION AND INTRODUCTION TO BIOENGINEERING COMPUTING

L	T	P	Cr
2	0	4	4.0

Course Objectives: The students will understand the basic principles of programming and of implementing mathematical concepts in MATLAB. Specifically, they will be able to write numerical algorithms and evaluate the computational results using graphical representations

Detail contents:

SOLIDWORKS

Basics and User interface: File Handling, User Interface, Pull Down Menus, Command Manager, Mouse Buttons, Keyboard Shortcuts

Sketching: 2D Sketching, Sketching Planes, Entities, Relations, Dimensioning

Part Modeling: Extrusion Boss, Cut, Revolve, Hole, Fillet, Round, Chamfers, Sweep, Loft, Patterns- Linear & Circular, Shelling and Ribs, Draft Standard views, Base Feature, Editing Tools.

Bottom Up Assembly Modeling: Adding & Manipulating Components, Assembly constraints, Sub-assemblies, Mass Properties, Interference Check, Exploded Assemblies, Bill of Materials, Adding Balloons,

Creating Drawings: Drawing views, Driving and Driven Dimensions, Associativity, Creating section views, Annotations.

MATLAB Fundamentals: Variables, The workspace, Arrays: Vectors and matrices, Vertical motion under gravity, Operators, expressions, and statements, Output, Repeating with for Decisions, Complex numbers

Program Design and Algorithm Development: The program design process, Programming MATLAB functions

MATLAB Functions and Data Import-Export Utilities: Common functions, Importing and exporting data

Logical Vectors: Logical operators, Subscripting with logical vectors, Logical functions, Logical vectors instead of elseif ladders

Matrices and Arrays: Matrices, Matrix operations, other matrix functions, Population growth: Leslie matrices, Markov processes, Linear equations, Sparse matrices

Function M-files: Newton's method again, Basic rules, Function handles, Command/function duality, Function name resolution, Debugging M-files, Recursion

MATLAB Graphics: Basic 2-D graphs, 3-D plots, Handle graphics, editing plots, Animation, Color etc., Lighting and camera, Saving, printing and exporting graphs

Vectors as Arrays and Other Data Structures: Update processes, Frequencies, bar charts and histograms, Sorting, Structures, Cell arrays, Classes and objects

Errors and Pitfalls: Syntax errors, Logic errors, rounding error

Course Learning Outcomes (CLO):

Students will be able to

1. Creatively comprehend geometrical details of common engineering objects and assemblies
2. Use parametric 3D CAD software tools for creating their geometric part models, assemblies and automated drawings.
3. Translate mathematical methods to MATLAB code
4. Break a complex task up into smaller, simpler tasks
5. Represent mathematical objects as data structures
6. Tabulate results and represent data visually

Text Books:

1. Tickoo Sham, SOLIDWORKS 2018 for Designers, 16th Edition, CADCIM Technologies (2018)
2. Ronald E. Barr, Davor Juricic, Thomas J. Krueger, Engineering & Computer Graphics Workbook Using SOLIDWORKS 2019, SDC Publications, ISBN: 978-1-63057-219-8
3. MATLAB: An Introduction with Applications, by Amos Gilat, 2nd edition, Wiley, 2004, ISBN-13 978-0471694205.
4. Essential MATLAB for Engineers and Scientists, 5th Edition by B. Hahn and D. Valentine, Academic Press, (2013).

Evaluation Scheme:

S. No.	Evaluation Elements	Weight age (%)
1.	MST	25 (Lab based exam)
2.	EST	35 (Lab based exam)
3.	Sessional (May include Quizzes/Assignments/Lab Evaluation)	40

UBM009: BIOENGINEERING THERMODYNAMICS

L	T	P	Cr
3	1	0	3.5

Course Objective: Understand and apply the laws of thermodynamics to biological systems, comprehend principles of chemical and physical equilibria, chemical, enzyme kinematics, and their application.

First law of thermodynamics: Properties of pure substances, equations of state, Mollier diagram, closed system, open system, reversible processes, internal energy and enthalpy steady-flow engineering devices and transient flow analysis.

Second Law of Thermodynamics: Statements of the second law, heat engines, reversible versus irreversible processes, the Carnot cycle, refrigeration devices, entropy and entropy change, third law, exergy analysis.

Free Energy and Chemical Equilibria: Gibbs free energy, Helmholtz free energy, physical significance of free energy, Gibbs- Helmholtz equation, application of free energy to gases, concept of spontaneity, partial molar Gibbs energy, chemical potential of multicomponent system, reactions of ideal gases, non-ideal systems, equilibrium and standard Gibbs free energy and Biochemical applications of thermodynamics. Law of mass action, The Le-Chatelier principle, Van't Hoff reaction isotherm and equations.

Free Energy and Physical Equilibria: Concepts and applications, phase equilibria for single and multicomponent systems, membranes colligative properties and application of thermodynamics to phase transition

Chemical Kinetics: Concepts and applications, rate of reaction, measurement of rate of reaction, factors influencing rate of reaction, rate laws order and molecularity, integrated rate equations and half-lives, zero order reactions, first order reactions, second order reaction, third order reaction, higher nth order reactions, pseudo–order reactions, temperature dependence of rate of reactions, temperature coefficient , activation energy, Arrhenius equation, rate calculation, collision theory transition state theory.

Enzyme Kinetics: Concept of Enzyme as a biocatalyst, Classification of Enzymes, Activation energy, Reaction velocity, Specific velocity, Turnover number, Michealis-Menten Equation, Derivation of Michealis-Mentain equation, Types of enzyme inhibition, Competitive inhibition, Uncompetitive inhibition, Noncompetitive inhibition, Feedback Inhibition, Significance of K_m and $V_{max,}$ ES complex, Steady state kinetics, Lineweaver-Burk Plot, Eadie-Hofstee Plot, Reaction rate constant, Effect of pH, Temperature, ionic concentration of Enzyme kinetics, Active site, Allosteric site, Coenzyme, Cofactors, Isozyme.

Course Learning Outcomes: The students will be able to reflect on:

1. Analyze and solve problems related to closed systems and steady-flow devices by applying the conservation of energy principle.
2. Analyze the second law of thermodynamics for various systems and to evaluate the performance of heat engines, refrigerators and heat pumps.
3. Analyze principles of chemical and physical equilibrium.
4. Interpret salient features of chemical and enzyme catalyzed reaction and will be able to determine kinetic parameters.

Text Books:

1) Cengel and Boles, Thermodynamics: An Engineering Approach, McGraw-Hill (2011
2) Tinoco, Sauer, Wang, and Puglisi, Physical Chemistry: Principles and Applications in Biological Sciences, 5th Edition, Prentice Hall, 2014.
3) Laidler, K.J., Chemical Kinetics, Dorling Kingsley (2003) 3rd ed.
4) Voet, D., Voet, J.G., ad Pratt, C.W., Principles of Biochemistry, 4th Ed., John Wiley & Sons, Inc. (2013).
5) Atkins, P.W., Physical Chemistry, W.H. Freeman (1990).
6) Castellan, G. W., Physical Chemistry, Narosa (2004) 4th ed.

Evaluated Scheme

Sr. No.	Evaluation Elements	Weight age (%)
1.	Mid semester test	30
2.	End semester test	45
3.	Sessional (May include Quizzes/Assignments)	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: Upon completion of this course, the students will be able to

1) Find the n^{th} 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

UBM031: ELECTRICAL CIRCUITS

L	T	P	Cr
3	1	2	4.5

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

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.

AC. 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 (CLO):

After the completion of the course, the students will be able to:

1. Apply networks laws and theorems to solve electric circuits.
2. Analyze steady state response of DC circuits.
3. Signify AC quantities through phasor and compute AC system behavior during steady state.
4. 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	25
2.	EST	45
3.	Sessional (Assignments/Projects/Tutorials/Quizzes/Lab Evaluations)	30

UBM003: FUNDAMENTALS OF LIFE SCIENCES

L	T	P	Cr
3	0	2	4.0

Course objective: Apart from the structural and coordinated functional aspects of various life forms, the students will know how the collection of thousands inanimate molecules that constitute living organisms and interact to maintain and perpetuate the living systems. Moreover, they will be able to assess the importance of genetic materials in a cell.

Biological chemistry: Chemistry of life, Building blocks of biomolecules, Water and various weak interactions in aqueous systems; pH and biological buffers, Structural and functional attributes of proteins, carbohydrates, lipids

Genetic foundation of life: DNA as genetic material, Structural attributes of DNA and RNA, An overview of replication, transcription, translation, and protein structures

Cellular and subcellular features: Organization of cells and organelles; Membrane transport, diffusion, osmosis; Cell to cell communication; Cytoskeletal networks, Cell junctions, Extracellular matrix (ECM)

Bioenergetics and metabolism: Basic principles of thermodynamics, biochemical processes and bioenergetics, energy-rich compounds, ATP as energy currency, Enzymes-nomenclature and salient attributes, Basic enzyme kinetics, Anaerobic and aerobic metabolism, Cellular Respiration-Electron transport and oxidative phosphorylation, Underlying principle of photosynthesis

Cell division: An overview of cell division in prokaryotes and eukaryotes; Different phases of mitosis and meiosis, Cell cycle and its regulation

Molecular genetics and gene expression: Central dogma of molecular genetics; Chromosomal structure and organization, Genetic codons, DNA mutations and genetic variation, Mendelian genetics-dominance, epistasis and sex chromosomes, Transcription and RNA processing, Regulation of gene expression in prokaryotes and eukaryotes

Laboratory Work: Standard operating procedure (SOP) and Lab Safety**,** Qualitative and quantitative analyses of carbohydrates, lipids, amino acids, proteins and nucleic acids, Microscopic observations of prokaryotic and eukaryotic cells, Animation of cell division: mitosis and meiosis, Demonstration of photosynthesis, Isolation and purification of enzyme, Mutagenesis of bacterial cultures and mutant isolation, DNA and Protein databases along with bioinformatics tools

Course Learning Outcomes (CLO's): Students will be able to

1. Know the chemical constituents of cells, the basic units of living organisms.
2. Know how the simple precursors i.e., building blocks give rise to large biomolecules such as proteins, carbohydrates, lipids, nucleic acids.
3. Analyze the structure-function relationship in various biomolecules.
4. Correlate how the free energy is released during catabolic breakdown and gets utilized during anabolic pathways.
5. Comprehend the role of enzymes as biocatalysts and mechanisms of enzyme catalysis.
6. Analyze the molecular architecture of genomes, genes, and the flow of genetic information through replication, transcription, translation

Text Books

1. *Nelson, DL and Cox MM., Lehninger: Principles of Biochemistry, WH Freeman (2008) 5th ed.*
2. *David E Metzler: Biochemistry, The Chemical reactions of Living Cells Vol. 1. 2nd Edition, Elsevier Academic Press (2003),*
3. *Berg JM, Tymoczko JL and Stryer L: Biochemistry, 5th Edition, WH Freeman and Company, (2005)*

Reference Books

1. *Koolman J and Roehm K H Color Atlas of Biochemistry, 2nd Edition, Georg Thieme Verlag Publishers (2005)*
2. *Jain, J.L., Jain, S. and Jain, N., Fundamentals of Biochemistry, S. Chand and Company Ltd. (2005).*
3. *Plummer DT. An Introduction to Practical Biochemistry, Tata McGraw-Hill Publishing Company Limited (1988)*

Evaluation Scheme:

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

UBM024: FRESHMAN DESIGN INNOVATION-I

(2Hrs SELF EFFORT)

L	T	P	Cr
1	0	2	3.0

Course objective: Basic concepts for biomedical device design and development and incorporating entrepreneurial mindset in freshman bioengineering students using team- and project-based learning experiences.

Course description

- Problem definition
- Concept generalization and evaluation
- Intellectual property
- Standards and engineering ethics
- Detailed design
- Testing and validation
- Prototyping

Few Sample Projects:

- Upright wheel chair for prolonged bed ridden patient
- Portable refrigerator working with solar energy for carrying Vaccine or temperature sensitive medicines, etc.
- Opening the door of public restaurant or restroom without using hand
- Posture correction smart health chair.
- Helmet that helps in social distancing
- Surgery assistant robot
- Extending heel under shoe which can be stretched when you want to pick up something lying on the top.
- Heat sensor as well as motion sensor to detect if there is child in the car.

Course learning outcomes (CLO):

Upon successful completion of the course, the students should be able to:

1. Identify, formulate and solve complex biomedical engineering problems
2. Apply engineering design to produce solutions that meets specific needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. Function effectively on a team, meet collaborative and inclusive environment, establish goals, plan tasks and meet objectives
4. Design and develop final product.
5. Understand the intellectual property rights and get the real-world design experiences as is possible in academic settings
6. Improve technical documentation and presentation skills.

Evaluation Scheme

Evaluation Elements	**Weight age (%)**
Participation, Engineering notebook	25
Review Presentation and Paper Design Review Presentation	25
Final Design Review (Poster Presentation & Demo, Written Report, User Manual, Prototype & Design History File)	50

UBM008: BIOMATERIALS

L	T	P	CR
3	0	0	3

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

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.

Course learning Outcomes:

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. 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:

2. *Ratner, Buddy D., et al. Biomaterials Science: An Introduction to Materials in Medicine. 2nd ed. Burlington, MA: Academic Press 2004*
3. *Bhat Sujata, Biomaterials, 2nd ed. Narosa Publishing House, New Delhi 2015*
4. *V Hasirci, N. Hasirci, Fundamentals of Biomaterials, Springer, 2018*
5. *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

UMA018: CALCULUS-III

L	T	P	Cr
4	1	0	4.5

Course Objectives: The objective of the course is to facilitate student with basic knowledge of, vector valued functions and motion in space, derivatives of several variables, multiple integrals, integration of vector fields, and to handle the real-life problems involving differential and integral calculus.

Course Content:

Vector valued functions and motion in space: Curves in space and their tangents, Integral of vector functions, Arc length in space, Curvature and normal vectors of a curve, Tangential and normal components of acceleration, Velocity and acceleration in polar coordinates

Partial Derivatives: Functions of Several Variables, Limits and continuity in higher dimensions, Partial Derivatives, The Chain rule, Directional derivatives and gradient vectors, Tangent planes and differentials, Extreme values and saddle points, Lagrange multipliers, Taylor formula for two variables, Partial derivatives with constrained variables

Multiple Integrals: Double and iterated integrals over rectangles, Double integrals over general regions, Area by double integration, Double integrals in polar form, Triple integrals in rectangular coordinates, Moments and centers of mass, Triple integrals in cylindrical and spherical coordinates, Substitutions in multiple integrals

Integration in vector fields: Line integrals, Vector fields and line integrals: work, circulation and flux, Path independence, conservative fields, and potential functions, Green's theorem in the plane, Surfaces and area, Surface integrals, Stokes' theorem, The divergence theorem and a unified theory

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

1) Differentiate and integrate vector-valued functions, for position vector (function of time), interpret these as velocity and acceleration.
2) Determine absolute extrema on a closed interval for continuous functions and use the first and second derivatives to analyze and sketch the graph of a function, including determining intervals on which the graph is increasing, decreasing, constant, and concave up or concave down.
3) Evaluate partial derivatives, directional derivatives, gradients and use them to solve applied problems, also use the chain rule for functions of several variables.
4) Evaluate multiple integrals in appropriate coordinate systems and apply them to solve problems involving volume, surface area, density, moments and centroids.
5) Find the curl and divergence of a vector field, the work done on an object moving in a vector field, and the flux of a field through a surface.
6) Apply the ideas of curl and divergence to solve applied problems and identify conservative fields.

Text Books:

1. Thomas' Calculus, George B. Thomas, Pearson Education, 2014, 14th edition.
2. Mathematics, A Text book (Parts I & II), NCERT, New Delhi, 2011.
3. 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:

S. No.	Evaluation Elements	Weight age (%)
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	3	3.5

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

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 outcome (CLO): On completion of this course the student 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.

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

UBM025: FRESHMAN DESIGN INNOVATION-II

L	T	P	Cr.
1	0	2	3.0

(Including 2 self-effort hours)

Course Objectives: This course aims to provide the students with a basic understanding about the process of nature inspired creativity, design thinking, innovation that leads to entrepreneurship. Students understand entrepreneurial perspectives, concepts for analyzing entrepreneurial opportunities and understanding eco-system. It also intends to build competence with respect Business Model Canvas and build understanding with respect to the start-ups and ventures from Bio-medical engineering domain.

Nature inspired Innovations: Entrepreneurs; entrepreneurial personality and intentions -characteristics, traits and behavioral; entrepreneurial challenges. See few links for reference. [https://www.bbc.com/news/business-34676930,https://www.youtube.com/watch?v=uEuFekSgwP4, https://www.richardvanhooijdonk.com/blog/en/six-incredible-innovations-inspired-by-nature/ , https://blogs.sierraclub.org/explore/2013/02/top-5-nature-inspired-innovations.html and similar]

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 analysing business models; Business model canvas, Introduction to lean start-ups, Business Pitching.

Organizing Business and Entrepreneurial Finance: Forms of business organizations; organizational structures; Venture growth, sources and selection of venture finance options and its managerial implications.

Case study of few startups in Biomedical Engineering domain.

Course learning outcomes (CLO):

Upon successful completion of the course, the students should 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. Analyze and select suitable finance and revenue models for start-up venture.

Text Books:

1. Byers T. H., Dorf R. C., Nelson A., *Technology Ventures: From Idea to Enterprise*, McGraw Hill (2013).

2. Blank, Steve, *The Startup Owner's Manual: The Step by Step Guide for Building a Great Company*, K&S Ranch, (2013).

3. S. Carter and D. Jones-Evans, *Enterprise and small business- Principal Practice and Policy*, Pearson Education (2006).

Reference Books:

1. Ries, Eric (2011), The lean Start-up: How constant innovation creates radically successful businesses, Penguin Books Limited.
2. Osterwalder, Alex and Pigneur, Yves (2010) Business Model Generation.
3. Kachru, Upendra, India Land of a Billion Entrepreneurs, Pearson

Evaluation Scheme

10%	marks for lecture QUIZ evaluation.
25%	marks for lab evaluation.
15%	marks for BMC evaluation.
25%	marks for Test at the end of semester*.
25%	marks for evaluation of the report.

*The Test at the end of semester will be of 2-hour duration.

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.

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

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

Course Learning Outcomes (CLOs):

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

UHU005: HUMANITIES FOR ENGINEERS

L	T	P	Cr
2	0	2	3

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.

Detailed 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.

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): The student after completing the course 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:

Mid Semester Exam	**25**
End Semester Exam	**45**
Sessional	**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: The students will 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.

Evaluated Scheme

Sr.No.	Evaluation Elements	Weight age (%)
1.	Mid semester test	30
2.	End semester test	45
3.	Sessional (May include Quizzes/Assignments)	25

UEI614 BIOMEDICAL SENSORS AND MEASUREMENT

L	T	P	Cr
3	1	2	4.5

Course Objectives:

- To make students familiar with the constructions and working principle of different types of sensors and transducers
- To make students aware about the use of different transducers in medical field

Introduction: Definition and Classification of Biomedical Sensors, Basic Concept of Sensors, Classification of Biomedical Sensors, Biomedical Measurement Technology, Bioelectrical Signal Detection, Other Physiological and Biochemical Parameter Detection, Characteristics of Biomedical Sensors and Measurement, Features of Biomedical Sensors and Measurement, Special Requirement of Biomedical Sensors and Measurement, Development of Biomedical Sensors and Measurement, Invasive and Non-invasive Detection, Multi-parameters Detection, In vitro and in vivo Detection

Basics of Sensors and Measurement: Sensor Characteristics and Terminology, Static Characteristics, Dynamic Characteristics, Sensor Measurement Technology, Sensor Measurement Methods/System, Signal Modulation and Demodulation, Improvement of Sensor Measurement System, Biocompatibility Design of Sensors, Concept and Principle of Biocompatibility, Biocompatibility for Implantable Biomedical Sensors, Biocompatibility for in vitro Biomedical Sensors and Design of the Biomedical Sensors

Physical Sensors and Measurement: Resistance Sensors and Measurement, Resistance Strain Sensors, Piezoresistive Sensors, Inductive Sensors and Measurement, Applications in Biomedicine, Capacitive Sensors and Measurement, Principle and Configuration, Biomedical Applications, Piezoelectric Sensors and Measurement, Piezoelectric Effect and Piezoelectric Materials, Ultrasonic, Biomedical Applications, Magnetoelectric Sensors and Measurement, Magnetoelectric Induction Sensors, Applications in Biomedcine, Hall Magnetic Sensors, Photoelectric Sensors, Photoelectric Element Fiber Optic Sensors, Applications of Photoelectric Sensors, Thermoelectric Sensors and Measurement, Thermosensitive Elements, Thermocouple Sensors, Integrated Temperature Sensors, Applications in Biomedicine, Encoders, MEMS - Material for manufacturing MEMS, Patterning and Lithography.

Chemical Sensors and Measurement: Definition and Principle, Classification and Characteristics, Ion Sensors, Ion-Selective Electrodes, Ion-Selective Field-Effect Transistors, Microelectrode Array, Gas Sensors, Electrochemical Gas Sensors, Semiconductor Gas Sensors, Solid Electrolyte Gas Sensors, Surface Acoustic Wave Sensors, Humidity Sensors (Capacitive Humidity Sensors, Resistive Humidity Sensors, Thermal Conductivity Humidity Sensors), Intelligent Chemical Sensor Arrays, e-Nose, e-Tongue, Sensor Networks, History of Sensor Networks, Essential Factors of Sensor Networks, Buses of Sensor Networks and Wireless Sensor Network

Biosensors and Measurement: History and Concept of Biosensors, Components of a Biosensor, Properties of Biosensors, Common Bioreceptor Components, Catalytic Biosensors, Affinity Biosensors, Cell and Tissue Biosensors, Biochips and Nano-biosensors

Smart Sensor: Component of smart sensor, General Architecture of Smart Sensor, Bio-Multifunctional Smart Wearable Sensors for Medical Devices

Laboratory: Experiments based on strain gauge, capacitance, LVDT, photoelectric, piezoelectric and temperature. Also, experiments for digital sensor, LDR, resistivity measurement.

Course Outcomes:

At the end of the course, a student will be able to:

- Classify and explain the characteristics of biomedical sensors with features
- Use concepts for construction and working principle of physical sensors
- Elucidate construction and working principle of chemical & biosensors
- Identify proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, *etc*

Recommended 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 Mc Graw Hill

Evaluation Scheme:

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

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.

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):

On 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. Seymour Lipschutz Data Structures, TATA McGraw Hill (2016).

2. Corman, Leiserson & Rivest, Introduction to Algorithms, MIT Press (2009).

3. Narasimha Karumanchi, Data Structures and Algorithms Made Easy (2014).

Reference Books:

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

UBM503: FOUNDATIONS OF ARTIFICIAL INTELLIGENCE

L	T	P	Cr
3	0	2	4.0

Course Objectives: The student should study the concepts of artificial intelligence and learn the methods of solving problems using artificial intelligence.

Overview: Definition, scope, foundations, approaches, and applications of AI; AI: past, present, and future.

Agents and Environments: agents; rationality; types of agents; properties of environments.

State Space Representation: State and operators; state space; representation real world problems as state space, problem characteristics.

Searching Strategies: uninformed searching methods (DFS, BFS, DFS-ID); informed searching methods such as best first search, hill climbing, A*, iterative deepening A*; problem reduction; constraint satisfaction problems; neural, stochastic, and evolutionary algorithms, local search and optimization problems in different environment.

Game Playing: Game theory and optimal decisions; Turn-taking games; Adversarial search; Minimax principle; Monte-Carlo tree search; Alpha-Beta pruning.

Reasoning: Representation, Inference, Propositional Logic, predicate logic (first order logic), syntax and semantics, logical reasoning, forward chaining, backward chaining.

Dealing with uncertainty: probability, connection to logic, independence, Bayes rule, Bayesian networks, probabilistic inference; time and uncertainty, hidden Markov model; Decision making- Utility theory, utility functions, Decision theoretic expert systems

Fuzzy Systems: Fuzzy sets, Operation on fuzzy sets, Fuzzy relations, Fuzzy measures, Fuzzy reasoning, Fuzzy controller,

Neural Network as Learning Machine: Mathematical model of neuron, activation functions, types of learning, learning methods, classification of neural networks, perceptron and multilayer perceptron, gradient and error back-propagation learning algorithms, typical applications of feedforward neural network, recurrent and temporal neural network, recurrent network use for optimization, Neuro-Fuzzy hybrid system; Engineering Applications

Course Learning Outcomes (CLO): At the end of the course, the student should be able to:

1. Identify appropriate AI methods to solve a given problem that are amenable to solution by AI.
2. Formalize a given problem in the language/framework of different AI methods.
3. Implement basic Fuzzy operations for engineering applications.
4. Implement neural network as learning machine for engineering applications.

Text Books:

1. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE)", Mc Graw Hill- 2008. (Units-I, II,VI & V).
2. Dan W. Patterson, "Introduction to AI and ES", Pearson Education, 2007. (Unit-III).
3. *Ross, J. T., Fuzzy Logic with Engineering Applications, McGraw–Hill (1995).*
4. *S. Haykin, Neural Network: A Comprehensive Foundation, Pearson Education (2003).*

References Books

1. Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007.
2. Stuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson Education 2007.
3. Deepak Khemani "Artificial Intelligence", Tata Mc Graw Hill Education 2013.

Evaluation Scheme:

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

UBM504 FUNDAMENTALS OF SIGNALS AND SYSTEM

L	T	P	Cr
3	1	0	3.5

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

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 (CLO):

1. To analyze the continuous and discrete-time signals and systems, their properties and representations.
2. To have Knowledge of time-domain representation and analysis concepts as they relate to difference equations, impulse response and convolution, etc.
3. To familiarize the concepts of frequency-domain representation and analysis using Fourier Analysis tools, Z-transform.
4. To apply the concepts of the sampling theorem and to solve engineering problems
5. To analyze the systems by examining their input and output signals.
6. Apply the concept of random signals.

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:

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

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.

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 (CLO):

On completion of the course, the students would 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

UBM608: PHYSIOLOGICAL MODELLING 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.

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:

At the end of the course student should 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:

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

UBM694: CAPSTONE PROJECT (Start)

(L: T: P :: 1 : 0 : 2)

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

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.

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: On 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:

Sr. No.	Evaluation Elements	Weight age (%)
1.	MST	25
2.	EST	45
3.	Assignment, Quizzes, and Lab	30

UBM607: MACHINE LEARNING

L	T	P	Cr.
3	0	2	4.0

Course Objective: This course aims to not only cover the fundamentals of machine learning but also give exposure to research in Biomedical Engineering.

Introduction to Machine Learning: Overview of machine learning, Supervised and Unsupervised Classifier, Artificial Neural Networks, Fuzzy classifier, Support vector machine classifier, clustering algorithm (K Nearest Neighbour Classifier, fuzzy c means, PCA, LDA), Decision tree learning, regression analysis, efficiency evaluation of the model.

Bayesian Learning: Probability and Bayes rule, Naive Bayes learning algorithm, Parameter smoothing, Generative vs. discriminative training, Bayes nets and Markov nets for representing dependencies

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

Deep generative models: Auto-encoders, variational auto-encoders, generative adversarial networks, autoregressive models, generative image models, unsupervised and self-supervised representation learning.

Applications in Biomedical Engineering: Unique characteristics and challenges in medicine and healthcare; History and status quo of intelligent and expert systems in medicine, Clinical decision-making, and intelligent systems to support evidence-based medicine, Application of model for disease prediction.

Laboratory work: The laboratory work includes supervised learning algorithms, linear regression, logistic regression, decision trees, k-nearest neighbor, Bayesian learning and the naïve Bayes algorithm, support vector machines and kernels and neural networks, CNN, RNN, LSTM, Autoencoders

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

1. Analyse the complexity of machine learning algorithms and their limitations
2. Demonstrate the ability to evaluate and compare learning models and learning algorithms
3. Apply and interpret the convolutional neural network and autoencoders for the medical image analysis.
4. Apply RNN, LSTM for medical data analysis.
5. Realize algorithms on Biomedical Engineering problems.

Text books:

1. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2016. http://www. deeplearningbook.org.
2. K. P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
3. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
4. Alpaydin E., Introduction to Machine Learning, MIT Press (2010).

Evaluation Scheme

SL.NO	Evaluation Element	Weightage
1	MST	40
2	EST	30
3	Sessional (Quiz, Assignment, Lab)	30

UBM609: BASIC-MEDICAL INSTRUMENTS

L	T	P	Cr
3	0	2	4.0

Course Objective: The course aims to impart knowledge about different biological signals, their acquisition, measurements and related constraints. In addition, the course will also provide understanding of cardiovascular, respiratory system and neuromuscular measurements.

Bio-medical Instrumentation, **Sources of Bioelectric Potentials and Electrodes:** Introduction to man-instrument system, components of the man-instrument system, Physiological system of the body, Problems encountered in measuring a living system. Resting and action potentials, Propagation of action potentials, bioelectric potentials, Bio potential electrodes, Biochemical transducers. Review of transducers.

Measurements in Cardiovascular System: Electrocardiograph, ECG machines, vector cardiography (VCG), ballisto-cardiography (BCG), measurement of blood pressure, blood flow, cardiac output, cardiac rate, plethysmograph, pacemakers, defibrillators, Heart sounds, Phonocardiograph, Echo-cardiograph.

Measurements in Respiratory System: Measurement of gas volume, respiratory transducers and instruments, respiratory therapy equipment, intermittent positive pressure breathing (IPPB) therapy, artificial mechanical ventilation, accessory devices used in respiratory therapy apparatus.

Measurements in Neuromuscular and Sensory systems: Description of Human Brain, Electroencephalogram (EEG) and Electromyogram (EMG) measurement and recording, Block diagram description, evoked potentials, nerve conduction studies (NCS), biofeedback
instrumentation, galvanic skin response (GSR) measurements.

Clinical laboratory instrumentation: Emerging trends in medical diagnostics and therapy, Clinical laboratory instrumentation, Blood cell counter and associated hematology system, Oximeters, Endoscopic diagnosis and foreign body removal, blood gas analyzers, Design of haemodialysis Machine, Design of Electro Surgical Generator or Cautery

Patient Care, Monitoring and Safety Measures: Elements of intensive care monitoring; Basic hospital systems and components Thermography, ultrasound imaging system, Patient safety, classification of medical devices and their safety standards, leakage current, micro, macro shock, different types of safety circuits for medical equipment's, measures to reduce shock hazards.

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 using Sphygmomanometer, Pulse Rate and SpO_2 using Pulse Oximeter, Skin Conductance and Skin Potential using Galvanic Skin Response Module, Pulse Rate using Polyrite machine, Respiration Rate using Polyrite. Electromyogram test using EMG biofeedback Trainer.

Course learning outcomes (CLO):
Students will be able to:
1. Differentiate and analyse the biomedical signal sources

2. Exhibit the knowledge of working principle and applications of the cardiovascular, respiratory and nervous related measurements
3. Measure the parameters non-invasive diagnostic
4. Comprehend patient monitoring and electrical safety in medical equipment's.

Text books

1. Carr, J.J. and Brown, J.M., Introduction to Biomedical Equipment Technology, Prentice Hall (2000) 4th ed.
2. Cromwell, L. and Weibell, F.J. and Pfeiffer, E.A., Biomedical Instrumentation and Measurement, Dorling Kingsley (2006) 2nd ed.
3. Khandpur, R.S., Handbook of Biomedical Instrumentation, McGraw Hill (2003) 2nd ed.

Reference Books

1. Geddes, L.A., and Baker, L.E., Principles of Applied Biomedical Instrumentation, Wiley InterScience (1989) 3rd ed.
2. Medical Instrumentation Haughton by John C. Webster (Mifflis Co. Boston USA).
3. Webster, J.G., Medical Instrumentation Application and Design, John Wiley (2007) 3rd ed.

Evaluation Scheme:

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

UBM604 BIOSIGNAL PROCESSING

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.

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:

At the end of the course student should 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

UCS312: DATABASE MANAGEMENT SYSTEMS

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.

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): On 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.
2. Comprehend the concepts of transaction management, concurrence control and recovery management.
3. 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. 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. 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.

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): After the successful completion of the 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	Weight age (%)
1.	MST	25
2.	EST	45
3.	Sessional (May include assignments/quizzes)	30

UBM702 HOSPITAL ENGINEERING AND MANAGMENT

(2 Hrs Self Effort)

L	T	P	Cr
2	0	0	3.0

Course Objective: To provide the knowledge of planning, designing and safety management in hospital services.

PLANNING AND ORGANIZATION OF THE HOSPITALS: Roles of hospital in healthcare-hospital planning and design-outpatient services nursing unit-intensive care unit-nursing services.

CLINICAL SERVICES: Radiology and imaging services-laboratory services-operation theatre suite pharmacy-central sterile supply department.

DESIGNING OF HOSPITAL SERVICES: Engineering department - maintenance management- clinical engineering- electrical system- air conditioning system- water supply and sanitary system- centralized medical gas system-communication system.

SUPPORT SERVICES AND SAFETY MANAGEMENT: Admitting department- medical records department-food service department- laundry and linen service-housekeeping- safety in hospital-fire safety - disaster management.

INFECTION CONTROL AND WASTE MANAGEMENT: Importance of infection control-hand hygiene-clinical laboratory standards to infection control-health care workers, safety-solid waste management and transportation.

Minor Project: Team projects on Hospital Engineering and Management.

Course Learning Outcomes (CLO): At the end of the course, the student should be able to:

1. Obtain the knowledge about the basic planning and organization of hospitals
2. Study about the clinical services
3. Impart knowledge on designing of hospital services
4. Analyze the infection control and safety management in hospitals

TEXT BOOKS

1. Kunders G.D, “Biomechanics: Hospitals, facilities planning and management”, Tata Mcgraw Hill, 16th edition, 2004.
2. Sakharkar B.M, “Principles of hospital administration and planning”, Jaypee Brothers Medical Publishers Pvt Limited, 2nd edition, 2009

REFERENCES

1. Sanjiv Singh, Sakthi kumar Gupta, Sunil Kant, “Hospital infection control guidelines, principles and practice”, Jaypee Brothers Medical Publishers Pvt. Limited, First edition, 2012.

Evaluation scheme:

Sr.No.	Evaluation Elements	Weight age (%)
1.	MST	25
2.	EST	35
3.	Sessional (May include assignments/quizzes and projects)	40

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.

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):
On completion of the Course, the student would be able to:

- Learn the basics of Robotics
- Understand the kinematics and inverse Kinematics
- Develop motion planning solution
- Recognize the various applications of Robots in Medicine

Text Books:

- *Fundamentals of Robotics-Analysis and control, Robert Schilling, Prentice Hall of India.*
- *Robotics, Fu, Gonzales and Lee, McGraw Hill*
- *Introduction to Robotics, J. J, Craig, Pearson Education*

Reference Books:

- *Robotics and AI, Staughard, Prentice Hall of India.*
- *Industrial Robotics - Grover, Wiess, Nagel, Oderey, McGraw Hill.*
- *Robotics and Mechatronics. Walfram Stdder,*

- *Introduction to Robotics, Niku, Pearson Education.*
- *Robot Engineering, Klafter, Chmielewski, Negin, Prentice Hall Of India.*
- *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

UBM603 ADVANCED MEDICAL INSTRUMENTS

L	T	P	Cr
3	0	0	3.0

Course Objectives: The student should be made

1. To understand the generation of X-ray and its uses in imaging
2. To describe the principle of Computed Tomography.
3. To know the techniques used for visualizing various sections of the body.
4. To learn the principles of different radio diagnostic equipment in Imaging
5. To discuss the radiation therapy techniques and radiation safety.

MEDICAL X-RAY EQUIPMENT: Nature of X-rays- X-Ray absorption – Tissue contrast. X- Ray Equipment (Block Diagram) – X-Ray Tube, the collimator, Bucky Grid, power supply, Cathode and filament currents, focusing cup, Thermionic emission, Electromagnetic induction, Line focus principle and the heel effect, causes of x-ray tube failure: Electron arcing/filament burn out, Failure to warm up tube, High temp due to over exposure, x-ray tube rating charts. X-ray Image Intensifier tubes – Fluoroscopy – Digital Fluoroscopy. Angiography, Cine Angiography, Digital subtraction Angiography. Mammography and Dental x-ray unit.

COMPUTED TOMOGRAPHY: Principles of tomography, CT Generations, X- Ray sources- collimation- X-Ray Detectors-Viewing systems- spiral CT scanning – Ultra fast CT scanners. Advantages of computed radiography over film screen radiography: Time, Image quality, Lower patient dose, Differences between conventional imaging equipment and digital imaging equipment: Image plate, Plate readers, Image characteristics, Image reconstruction techniques- back projection and iterative method. Spiral CT, 3D Imaging and its application.

MAGNETIC RESONANCE IMAGING: Fundamentals of magnetic resonance- Interaction of Nuclei with static magnetic field and Radio frequency wave- rotation and precession – Induction of magnetic resonance signals – bulk magnetization – Relaxation processes T1 and T2. Block Diagram approach of MRI system, system magnet (Permanent, Electromagnet and Super conductors), generations of gradient magnetic fields, Radio Frequency coils (sending and receiving), and shim coils, Electronic components, fMRI.

NUCLEAR MEDICINE TECHNIQUES: Nuclear imaging – Anger scintillation camera –Nuclear tomography – single photon emission computer tomography, positron emission tomography – Recent advances. Radionuclide imaging Bone imaging, dynamic renal function, myocardial perfusion. Non-imaging techniques haematological measurements, Glomerular filtration rate, volume measurements, clearance measurement, whole -body counting, surface counting.

RADIATION THERAPY AND RADIATION SAFETY: Radiation therapy – linear accelerator, Telegamma Machine. SRS –SRT, -Recent Techniques in radiation therapy - 3DCRT – IMRT – IGRT and Cyber knife- radiation

measuring instruments Dosimeter, film badges, Thermo Luminescent dosimeters- electronic dosimeter- Radiation protection in medicine- radiation protection principles.

Course Learning Outcome: At the end of this course, the student should be able to

1. Describe the working principle of X ray machine and its application.
2. Illustrate the principle-computed tomography.
3. Interpret the technique used for visualizing various sections of the body using magnetic
4. resonance imaging
5. Demonstrate the applications of radio nuclide imaging.
6. Outline the methods of radiation safety.

TEXT BOOKS:

1. Steve Webb, ―The Physics of Medical Imaging‖, Adam Hilger, Philadelpia, 1988 (Units I, II, III & IV).

2. R. Hendee and Russell Ritenour ―Medical Imaging Physics‖, Fourth Edition William, Wiley Liss, 2002.

REFERENCES:

1. Gopal B. Saha ―Physics and Radiobiology of Nuclear Medicine‖- Third edition Springer, 2006.

2. B. H. Brown, PV Lawford, R H Small wood, D R Hose, D C Barber, ―Medical physics and Biomedical Engineering‖, - CRC Press, 1999.

3. Myer Kutz, ―Standard handbook of Biomedical Engineering and design‖, McGraw Hill, 2003.

4. P. Ragunathan, ―Magnetic Resonance Imaging and Spectroscopy in Medicine Concepts and Techniques‖, Paperback – Import, 2007

Evaluation Scheme:

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

UEI610: FUNDAMENTALS OF MICROPROCESSORS AND MICROCONTROLLERS

L	T	P	Cr
3	0	2	4.0

Course Objectives: To make the students able to understand microprocessors and microcontroller and their applications.

Introduction to Microprocessor: Evolution of microprocessor, Types of various architectures; Harvard and Von-Neumann, RISC and CISC, Architecture, Addressing Modes.

Introduction to microcontroller: evolution of microcontrollers, comparison of microprocessor and microcontroller.

PIC Microcontrollers: Introduction to 16 and 18F families, Architecture, programming, Instruction set, using assembly and embedded C, introduction to TIMERS and Counters, special operations compare, capture, PWM using timers, analog to digital converters, Interrupts, introduction to communication protocols such as UART, SPI, I2C, CAN, USB I/O programming and interfacing.

Introduction to special features: configuration word, oscillator configuration, power on reset, watch dog timer, brown out reset, in circuit serial programming, in circuit debugger.

Hardware Interfacing: Interfacing with LEDs, Seven Segment, LCD, Relays, D.C. and stepper motors etc., port expansion using SPI and I2C.

Sensor interfacing: Introduction to temperature, pressure and accelerometer sensors (Mems based), interfacing using SPI/I2C/CAN protocol.

Laboratory work: Programming examples of 8085, Programming and Application development around PIC 16FXXX/ 18FXXX microcontroller, interfacing to LED, LCD, Keyboard, ADC, DAC, Stepper Motors and sensors etc.

Course Learning Outcome (CLO):

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

1. Elucidate the 8085 microprocessor architecture, programming and its applications
2. Elucidate the architecture and addressing modes of PIC microcontroller
3. Elucidate the communication protocol of PIC microcontroller
4. Program the microcontrollers for a given application
5. Hardware interfacing of PIC microcontroller and sensor interfacing to develop solutions of real world problems

Text Books:

1. *Peatman J., Design with PIC microcontrollers, Pearson Education, 2006*
2. *Peatman J., Embedded system Design using PIC18Fxxx, Prentice Hall, 2003.*
3. *Mazidi M.A., PIC Microcontroller and Embedded Systems: Using assembly and C for PIC, 2008*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/ Tutorials/ Quizes/ Lab Evaluations)	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

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): Student 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:

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

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.

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 Outcomes (CLO): Successfully the student 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 LASER OPTICS AND ULTRASOUND

L	T	P	Cr
3	0	0	3.0

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

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: At the end of the course student should 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,
3. 2003

REFERENCES:

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

UBM523 BIOREGENRATIVE 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): After the completion of the 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:

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

UEI831: BIOSENSORS AND MEMS

L	T	P	Cr
3	0	0	3.0

Course Objectives: To introduce the concept of biosensors and MEMS, design and fabrication, types and their applications. To explain biosensors and bioelectronics devices. To introduce MEMS technology.

Overview of biosensors and their electrochemistry: Molecular reorganization: Enzymes, Antibodies and DNA, Modification of bio recognition molecules for Selectivity and sensitivity, Fundamentals of surfaces and interfaces

Bioinstrumentation and bioelectronics devices: Principles of potentiometry and potentiometric biosensors, Principles of amperometry and amperometric biosensors, Optical Biosensors based on Fiber optics, FETs and Bio-MEMS, Introduction to Chemometrics, Biosensor arrays; Electronic nose and electronic tongue.

MEMS Technology: Introduction Nanotechnology and MEMS, MEMS design, and fabrication technology – Lithography, Etching, MEMS material, Bulk micromachining, Surface micromachining, Microactuator, electrostatic actuation, Micro-fluidics.

MEMS types and their applications: Mechanical MEMS – Strain and pressure sensors, Accelerometers etc., Electromagnetic MEMS – Micromotors, Wireless and GPS MEMS etc.
Magnetic MEMS – all effect sensors, SQUID magnetometers, Optical MEMS – Micromachinedfiber optic component, Optical sensors, Thermal MEMS – thermo-mechanical and thermo-electrical actuators, Peltier heat pumps.

Course Learning Outcomes (CLO): After the completion of the course student will be able to:

1. Exhibit the knowledge of the concept of molecular reorganization, fundamentals of surfaces and interfaces
2. Elucidate the principles of different types of biosensors
3. Demonstrate the knowledge of the concept of MEMS design, and fabrication technology
4. Exhibit the knowledge of bioinstrumentation and bioelectronics devices
5. Exhibit the understanding of the different types of MEMS and its applications

Text books:

1. *Gardner, J.W., Microsensors, Principles and Applications, John Wiley and Sons (1994).*
2. *Kovacs, G.T.A., Micromachined Transducer Sourcebook, McGraw–Hill (2001).*
3. *Turner, A.P.F., Karube,I., and Wilson G.S., Biosensors–Fundamentals and Applications, Oxford University Press (2008).*

Reference Book:

1. *Trimmer, W., Micromechanics and MEMS, IEEE Press (1990)*

Evaluation Scheme:

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

UBM524: TISSUE ENGINEERING

L	T	P	Cr
3	0	0	3.0

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):
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. Principles of tissue engineering, Robert. P.Lanza, Robert Langer & William L. Chick, Academic press.
2. The Biomedical Engineering –Handbook, Joseph D. Bronzino, CRC press.
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:

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

UBM631 TELEMEDICINE 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.

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

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	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include assignments/quizzes)	25

UBM632 ARTIFICIAL ORGANS AND LIMBS

L	T	P	Cr
3	0	0	3.0

Course Objectives: This course will acquaint the student with modern artificial organs devices and methods used to partially support or completely replace pathological organ, and engineering approaches such as prostheses (limb replacements) and orthoses (limb assists) for human movement.

Artificial kidney: kidney filtration, artificial waste removal methods, haemodialysis, regeneration of dialysate, membrane configuration, wearable artificial kidney machine.

Artificial heart-lung machine: Heart assist devices, principles and functionality, types of ventricular assist devices (VAD), lungs gaseous exchange/ transport, Artificial heart valves.

Other artificial organs: Principles and functionality of Liver support system, Artificial pancreas, Artificial cornea.

Artificial limb: Hand function, musculoskeletal anatomy of the hand and arm, non-hand-like prehensors, myoelectricity, Transradial, transhumeral and shoulder disarticular prostheses, Lower limb anatomy.

Artificial feet: transtibial, transfemoral and hip disarticulation prostheses, Pathological gait and aided walking (crutches, canes and walkers)

Course Learning Outcomes (CLO):

On completion of the Course, the student would be able to:

1. Recognize importance and application of various artificial organs such as artificial kidney, artificial pancreas, liver support system
2. Learn the functionality of heart assist devices
3. Understand the prosthetic devices
4. Acquire the knowledge of musculoskeletal anatomy and muscle mechanic

Text Books:

1. *Gerald Miller, Artificial Organs, Morgan & Claypool, 2006*
2. *Lary Hench, John Jones Biomaterials, Artificial Organs and Tissue Engineering, 2005*

Reference Books:

1. *Joseph D. Bronsino, Tissue Engineering and Artificial Organs. The Biomedical Engineering Handbook, 2006*
2. *Shurr DG and Michael JW. Prosthetics and Orthotics, 2nd Edition, Upper Saddle River, NJ: Prentice-Hall. 2002.*

Evaluation Scheme:

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

UEI 718: VIRTUAL INSTRUMENTATION

L	T	P	Cr
2	0	3	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.

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 Outcomes (CLO): After the completion of the course student 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

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//Quizes/Lab Evaluations)	40

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
- Understand various waste disposal procedures and management.

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.

Course Learning Outcomes (CLO): At the end of the course, the student should 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

UBMXXX BIOPHOTONICS

L	T	P	Cr
3	1	0	3.5

Course Description: This course covers the basic optical principles, techniques and instruments used in biomedical research and clinical medicine. It includes in-depth coverage of optical imaging and spectroscopy systems for biomedical research and clinical diagnosis, details of light interaction with tissue.

Introduction to Optics & Microscopy: Optics and Microscopy, Geometrical optics, Wave optics, Digital imaging, Microscopy (bright field, dark field, DIC, fluorescence)

Introduction to Bio photonics: Photobiology: Light-tissue interactions and light induced effects in biological systems. Optical properties of tissue – absorption, scattering, diffraction, and emission. Spectroscopy: Fluorescence, Raman and diffuse reflectance spectroscopy. Basic principles of optical imaging and spectroscopy systems. Principles of standard optical microscopy/ fluorescence microscopy/ endoscopy and instrumentation.

Optics in Medical Diagnosis: Confocal microscopy: Principles, instrumentation and applications, Light sheet microscopy Two-photon and multi-photon microscopy. Physics of optical tweezers and it's applications in biology. Bio-medical applications of lasers: Laser scissors, Photo-dynamic therapy. Optical coherence tomography (OCT): Physics, Imaging concepts and applications. Photo-acoustic tomography (PAT): Physics, Imaging concepts and applications. Quantitative phase microscopy; Principles and imaging concepts, Imaging beyond diffraction limit; SIM, STED, NSOM, STORM.

Course Learning Outcomes: Upon completion of this course students will be able to

1. Utilize the concepts of geometrical optics, wave optics, digital imaging to relevant bio-photonics applications.
2. To illustrate the knowledge of the light - tissue interaction for biomedical applications.
3. Apply the concepts of the spectroscopy and optical imaging in biological systems.
4. Identify biomedical applications, specify the performance requirements, and find adequate optics solutions.

Text Books

1. Optical System Design (Robert E. Fischer).
   Optics (Hecht)
   Fourier optics (Goodman)
2. Introduction to Bio-photonics (Paras N. Prasad)
3. Biophotonics: Optical Science and Engineering for the 21st Century (Xun Shen, Roel van Wijk)
4. A Laboratory Manual in Biophotonics; (Vadim Backman, Adam Wax, Hao F. Zhang)
5. Introduction to optical microscopy; (Jerome Mertz)
6. Biomedical Optical Phase Microscopy and Nanoscopy; (Natan Shaked, Zeev Zalevsky, Lisa L Satterwhite)

Evaluation Scheme:

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