SMTB1102	BIOSTATISTICS	L	T	P	EL	Credits	Total Marks
		3	1	0	0	3	100

COURSE OBJECTIVE

- The ability to identify, reflect upon, evaluate, and apply different types of information and knowledge to form independent judgments. Analytical, logical thinking and conclusions based on quantitative information will be the main objective of learning this course.

UNIT 1 INTRODUCTION TO STATISTICS

9 Hrs.

Introduction - collection and tabulation of data – Concept of primary and secondary data – quantitative and qualitative, attributes, variables, scales of measurement -Nominal, ordinal, interval and ratio –Data visualization - Bar diagram, Pie chart, histogram, frequency curve, and frequency polygon –Ogives.

UNIT 2 DESCRIPTIVE STATISTICS 9 Hrs.

Measures of central tendency: Mean, Median, Mode – Measures of dispersion: Quartile Deviation and Standard deviation –Coefficients of variation, Skewness and Kurtosis (Pearson's and Bowley's)

UNIT 3 CORRELATION AND REGRESSION 9 Hrs.

Correlation: Karl Pearson's Correlation Coefficient, Spearman's Rank Correlation Coefficient, Tied ranks – Linear Regression Analysis – Fitting of straight line and parabola by the method of least squares.

UNIT 4 INTRODUCTION TO PROBABILITY 9 Hrs.

Definitions: Sample Space, Events – Addition Law of probability ¬– Multiplication law of probability – Conditional probability – Baye's theorem (without proof) – problems on Baye's theorem.

UNIT 5 RANDOMVARIABLES AND PROBABILITYDISTRIBUTIONS 9 Hrs.

Definition of a random variable – Discrete and continuous random variables – Probability Mass function, Probability Density Function, Cumulative Distribution Function (Definition only) – Binomial Distribution – Poisson Distribution – Normal Distribution –application problems only.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - List the data visualization tools used in descriptive statistics.
CO2 - Explain measures of central tendency and measures of dispersion
CO3 - Evaluate correlation, regression and generate straight line and parabola.
CO4 - Apply the concept of probability and Bayes theorem to solve the problems.
CO5 - Analyze discrete and continuous random variables.
CO6 - Predict the appropriate probability distribution for the real time data.

TEXT BOOK / REFERENCE BOOK

1. Beri G, Business Statistics, Tata Mcgraw Hill Publishing Company Limited, 2009.
2. Hong R.V, Tanis E.A and Zimmerman D L, Probability and Statistical Inference, Pearson Education Limited, Nineth Edition, 2015.
3. Miller I.and Freund J.E, Probability and Statistics for Engineers, Pearson Publishers, Nineth Edition, 2017
4. S.P. Gupta, Business Statistics, Sultan Chand & Sons, New Delhi, 2008.
5. Veerarajan T, Probability, Statistics and Random Process, 4th Edition, Tata McGraw Hill, 2014.
6. Vittal.P.R., Business Statistics, Margham publications, Chennai, 2008.

7. B.Annadurai, A textbook of Biostatistics, New Age International, 2007
8. Pranab Kumar Banerjee, Introduction to Biostatistics (A Textbook of Biometry), S. Chand Limited, 2007

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SCYB1101	CHEMISTRY	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To understand the basic concepts of quantum chemistry from bonds to bands
- To learn the principles and applications of energy levels in molecules
- To know the importance of electrochemistry in batteries.
- To explore the concept of corrosion mechanism and design principles.
- To study the various synthetic approaches in nanochemistry.

UNIT 1 ATOMIC AND MOLECULAR STRUCTURE 9 Hrs.

Introduction to quantum chemistry – Motion of a quantum mechanical particle in one dimension (time-independent) – Physical meaning of wave function – Schrodinger equation for Hydrogen atom (No derivation. Only wave function). Angular and radial wave functions and probability densities – Quantum numbers – Principal, azimuthal, spin and magnetic quantum numbers – Wave functions and orbital shapes - s,p,d,f - LCAO-MO of H2 – Band theory of solids: Conductors, semi-conductors– Role of As and Ga doping on band structures.

UNIT 2 MOLECULAR SPECTROSCOPY 9 Hrs.

Electromagnetic spectrum – Interaction of radiation with matter – Energy levels in molecules – Microwave spectroscopy – Principle – Classification of molecules based on moment of Inertia – Rotational energy expression (J levels) – Calculation of J for CO molecule – Vibrational spectroscopy – Normal modes of vibrations – Vibrations of polyatomic molecules (CO2 and H2O) – Determination of Force constant – Electronic transitions in organic molecules – Mathematical derivation of Beer-Lambert's law.

UNIT 3 ELECTROCHEMISTRY 9 Hrs.

Electrochemistry: Galvanic cell - Electrochemical cell representation - EMF series and its significance. Batteries: Terminology – Mechanism of Lead-acid accumulator - Mechanism of Nickel-cadmium batteries. Mechanism of Lithium batteries: Li/SOCl2 cell - Li/I2 cell - Lithium-ion batteries. Mechanism of Fuel Cells: Hydrogen-oxygen fuel cells - Solid oxide fuel cell (SOFC).

UNIT 4 CORROSION SCIENCE 9 Hrs.

Introduction: Definition. Types: Dry corrosion: Mechanism - Pilling-Bedworth rule - Wet Corrosion: Mechanism. Types: Galvanic corrosion and differential aeration cell corrosion. Galvanic series and its significance. Factors influencing corrosion. Corrosion prevention: Material selection and design - Cathodic protection – Sacrificial anodic method and impressed current method – Inhibitors – Anodic and Cathodic inhibitors.

UNIT 5 CHEMISTRY OF MATERIAL SCIENCES 9 Hrs.

Phase equilibria: Gibbs phase rule – Terms involved in Phase rule – Phase diagram of water system – Thermal method of analysis – Construction of simple eutectic system (Lead-Silver alloy system).Fuels– Classification of fuels – Determination of calorific values of solid fuels by bomb calorimeter– Manufacture of synthetic petrol by Fischer-Tropsch method – Knocking in IC engines – Chemical structure – Octane and cetane rating of fuels.

Nanomaterials: Size dependent properties of nanomaterials – Synthesis of gold and silver nanoparticles by Chemical reduction method–Applications of nanoparticles in medicine.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course the student will be able to

CO1 - Apply the principles of quantum chemistry for energy level quantisation in molecules.
CO2 - Analyse the molecular transitions by interaction of EMR with matter
CO3 - Assess the reaction mechanism in electrochemical storage device
CO4 - Comprehend the corrosion mechanism for environmental sustainability. Examine the mechanism of corrosion for mitigation.
CO5 - Interpret the role of phase diagram/ fuels/ nanoparticles in chemical/ material science.
CO6 - Apply the concept of chemical science in real world applications.

TEXT BOOK / REFERENCE BOOK

1. A.K.Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill, 4th edition, 2019.
2. Ira N. Levine, Physical chemistry, 6th Edition, 2018.
3. Ira N. Levine, Quantum chemistry, 7th Edition, 2013.
4. David W. Ball and Thomas Baer, Physical Chemistry, Wadsworth Cengage Learning, 2nd Edition, 2014.
5. Mars G Fontana, Corrosion Engineering, 3rd Edition, Tata McGraw Hill, 2018.
6. Douglas A. Skoog and Donald M.West, Principles of Instrumental Analysis, Cengage, 6th Edition, 2014.
7. P.C. Jain and Monika Jain, Engineering Chemistry, Dhanpat Rai Publication, 2018.
8. David Linden, Thomas B Reddy, Handbook of Batteries, 4th Edition, McGraw-Hill, 2010.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB1101	CELL BIOLOGY AND MICROBIOLOGY	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To introduce extensive knowledge in cell structure, functions, cell signaling pathways and transfer across membranes in cell
- To enable students to learn about the principles of Microbiology to emphasize structure and biochemical aspects of various microorganisms
- To understand the basic principles of microscopy and sample preparation

UNIT 1 CELL STRUCTURE AND TRANSPORT ACROSS CELL MEMBRANE 9 Hrs.

Structure and functions of Eukaryotic cell, Plasma Membrane models and chemical composition, Permeases, Passive and active transports, Transport through cell membrane, Sodium - potassium pumps, co- transport, symport, antiport, Endocytosis and Exocytosis.

UNIT 2 CELL RECEPTORS AND CELL SIGNALING 9 Hrs.

Membrane bound receptors, Cytosolic and Nuclear receptors, autocrine, paracrine and endocrine signaling, signal amplification, CAMP and G-protein role in signal transduction, role of IP3, DAG and calcium in cell signaling.

UNIT 3 CELL DIVISION AND DNA REPLICATION 9 Hrs.

Cell cycle – interphase, cell cycle check points, cell cycle regulations, Cell division - Mitosis & Meiosis cell division, difference between mitosis and Meiosis cell division, DNA replication- Conservative, Semi -Conservative, & Dispersive models of DNA replication

UNIT 4 INTRODUCTION TO MICROBIOLOGY AND MICROBIAL GROWTH 9 Hrs.

History, overview and scope of microbiology, contributions of Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, and Fleming. Structure of bacteria; (nucleoid, plasmid, ribosomes, cell wall, flagella), morphology, reproduction of bacteria. Microbial growth types of media, growth curve and pure culture, Enumeration of microorganisms -Pour plate, Spread plate, and Streak plate, preservation of pure culture.

UNIT 5 MICROSCOPY AND STAINING TECHNIQUES 9 Hrs.

Microscope - compound microscope, phase contrast microscope, fluorescent microscope, electron microscope - Transmission electron microscope, scanning electron microscope. Sterilization and disinfection methods, Staining techniques- simple staining, Gram's staining, acid fast staining, capsule and spore staining.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understanding the principles of cell structure and transport across the cell membrane.
CO2 - Demonstrate the role of various cell receptors and the signaling between the cells.
CO3 - Learning the process of cell division and recognize the importance of chromosome.
CO4 - Understands the scope of microbiology, structure of microbes and their microbial growth.
CO5 - Demonstrates the morphology of microbes using various microscopes and staining techniques.
CO6 - Outline the problem encountered to stain the microbes and mechanism of staining reaction.

TEXT BOOK / REFERENCE BOOK

1. Thomas D. Poolard, Williams C. Earnshaw, Graham T. Johnson, Cellbiology, 3rd edition, 2017, Elsevier
2. C.B.Powar, Cell Biology, New Edition, Publisher : Himalaya Publishing House (1 January 2010) ISBN-10 9350246694, India.
3. Pelczar, Jr E.C. S Chan and noel R.Krieg, Microbiology, 5th edition Tata McGraw Hill 2006.
4. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton, Prescott's Microbiology, 8th Edition, McGraw Hill Higher Education, 2008.
5. Tortora, Funke, and Case's Microbiology, An Introduction 13th Edition, Publisher: Pearson, ISBN-10: 0134605187, January 8, 2018

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB1102	BIOCHEMISTRY	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To give an insight into the chemical aspects of biological macromolecules and its importance
- To understand the industrial-market value and significance of these biomolecules and to apply these in the fundamentals of biotechnology

UNIT 1 CARBOHYDRATES 9 Hrs.

Introduction. Classification, Properties and Biological importance. Isomers, epimers, enantiomers, mutarotation, open chain and closed chain structures of glucose, glycolysis, TCA cycle.

UNIT 2 AMINOACIDS AND PROTEINS 9 Hrs.

Amino acids and peptides: Definition, structure, classification- essential and non-essential amino acids, protein and non-protein amino acids, Zwitterions. Amino acids as ampholytes. Structure of proteins: primary, secondary, tertiary and quaternary biological significance. Concept of isoelectric point and its significance.

UNIT 3 LIPIDS 9 Hrs.

Introduction, Classification, Simple lipids – Physical and chemical properties of fats and biological importance. Fatty acid nomenclature and structure, Lipids in cell membrane, Steroids, Compound lipids – Structure and function of phospholipids, glycolipids and lipoproteins. Derived lipids. Hormones - structure and function.

UNIT 4 NUCLEIC ACIDS 9 Hrs.

Introduction- Nitrogenous bases - Purines and Pyrimidines - Nucleosides and Nucleotides -- Structure of nucleic acids- DNA, RNA: m-RNA, t-RNA, r-RNA- Biological importance of nucleic acids, nucleic acid sequencing.16srRNAandits significance.

UNIT 5 VITAMINS AND MINERALS 9 Hrs.

Vitamins: fat soluble and water-soluble vitamins – sources, structure and physiological functions. Minerals: Essential micro and essential macrominerals – sources and functions. Biological importance of vitamin and minerals, deficiency symptoms.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the Basic Units Give Rise to Large Molecules Such as Proteins, Carbohydrates, Lipids, Nucleic Acids

CO2 - Describes the Structure, Function and Classifications of Biomolecules.

CO3 - Illustrates the Various Types of Weak Interactions Between the Biomolecules

CO4 - Summarize the Structure, Function and Classification of Vitamins and Minerals

CO5 - Investigate the Biological Importance of Vitamins and Minerals

CO6 - Enumerates the Structure of Amino Acids and Protein

TEXT BOOK / REFERENCE BOOK

1. Lehninger, Nelson and Cox, “Principles of Biochemistry”, 6th edition, W.H. Freeman & Company, 2018
2. Dr. U. Satyanarayana, Dr. U. Chakrapani, ‘’Biochemistry’’ (with Clinical Concepts & Case Studies), 4th revised edition, Elsevier, 2018

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SCYB2101	CHEMISTRY LAB	L	T	P	EL	Credits	Total Marks
		0	0	2	0	1	50

COURSE OBJECTIVE

- To understand the basic principle involved in volumetric and instrumental analysis.
- To acquire practical knowledge in pHmetry, potentiometry and conductometry.
- To develop the skill in water analysis.

COURSE CONTENT

List of Experiments

1. Estimation of mixture of acids by conductometry.
2. Estimation of ferrous ion by potentiometry.
3. Determination of pKa value of glycine by pHmetry.
4. Estimation of hardness of water by EDTA method.
5. Determination of alkalinity of water
6. Estimation of Iron by photocolorimetry.
7. Estimation of copper in brass
8. Determination of high molecular weight polymer using Ostwald viscometer.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Estimate the ionic conductance of mixture of acids.
CO2 - Construct a redox cell for the emf measurement.
CO3 - Interpret the concept of Zwitter ion in amino acids
CO4 - Predict the quality of water sample for domestic and industrial applications.
CO5 - Demonstrate the validity of Beer-Lambert's law.
CO6 - Apply Poiseuille's law for molar mass measurement.

SBMB2101	BIOCHEMISTRY & MICROBIOLOGY LAB	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

COURSE OBJECTIVE

- To introduce the learners to study about the microscopic techniques and various staining reactions
- To enable students to analyze various sugar and amino acids

MICROBIOLOGY LAB

1. Laboratory rules and regulations employed in Microbiology department.
2. Handling of Bright field microscope
3. Sterilization techniques moist and dry heat
4. Preparation of culture media solid and liquid media
5. Pure Culture and culture characteristics-Streak plate method
6. Decimal dilution method-Spread plate method /Pour plate method
7. Determination of antibiotic sensitivity test-Kirby Bauer's Method

BIOCHEMISTRY LAB

1. Estimation of Protein by Lowry's Method
2. Preparation and quantification of casein from milk.
3. Amino acid Analysis-Aromatic non-aromatic amino acids.
4. Carbohydrate Analysis-Polysaccharides, disaccharides, monosaccharides.
5. Estimation of Creatinine level in serum and urine

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the principle and handling of light microscope.
CO2 - Remember the various sterilization methods employed in the bioscience's laboratory.
CO3 - Analyse the method adopted to differentiate morphology features and staining reaction among microbes.
CO4 - Apply the knowledge to quantify the protein in given samples.
CO5 - Design a protocol to demonstrate the presence of various sugar solutions.
CO6 - Create a methodology to differentiate aromatic and non-romantic amino acids.

S11BLH12	PROBLEM SOLVING TECHNIQUES USING C	L	T	P	EL	Credits	Total Marks
		2	0	2	0	3	100

COURSE OBJECTIVES

- Apply different concepts of variables, operators and basic math functions in C.
- Devise programs using Loops, Control structures and Array in C.
- Construct modules for real time applications using Functions in C.

UNIT 1 BITS AND BYTES IN COMPUTING 9 Hrs.

Computers: Hardware – Software – Processor – Memory – I/O devices – Interface – Programming Languages – Evolution from COBOL, FORTRAN to C, Python – Need

Algorithms: Role in problem solving – Analysis – Design – Flowcharts: Role in problem solving – Symbols – Design – Pseudocode: Role in problem solving – Design - Program: Role in problem solving – Design

PRACTICE PROBLEMS:

1. Describe a simple real world problem in your domain/department and describe it in the form of problem statement, input, output and provide its solution in terms of algorithm, flowchart, pseudo code and program.

UNIT 2 C: MATH BEHIND CODING 9 Hrs.

C: Structure of program – Character set – Tokens – Keywords – Identifiers – Constants – Variables – Datatypes – Strings – Operators and its types – Functions – Header Files

Algorithmic Strategies: Iteration and Recursion – Efficiency – Role of Time and Space consumption while building an algorithm – Complexities

PRACTICE PROBLEMS:

1. Describe a simple real world problem in your domain/department and provide a computing and non-computing solution for the same. Calculate the time and space consumed in both solutions. Compare and contrast the pros and cons in both solutions.
2. Write an algorithm, flowchart, pseudo code followed by a simple C code to do find the Factorial and Fibonacci series using both iteration and recursion.

UNIT 3 C: MAGIC BEHIND INSTANT OUTPUTS 9 Hrs.

Advanced Coding Concepts: Decision Making using Branching Statements and its types – Decision Making using Looping Statements and its types– Switch Statements –Break – Continue – Goto – Jump Statements

Case Study: Fun with Code -- Printing Alphabets / Flags of Countries / Flying Alphabet Screensaver

PRACTICE PROBLEMS:

1. Describe a problem statement in your domain/department whose solution involves repetition of same steps and provide code as solution involving for, while and do while loops.
2. Describe a problem statement in your domain/department whose solution involves decision making and provide code as solution involving if-else, nested if-else and ladder if-else.
3. Develop a simple scientific calculator using Switch case statement.

UNIT 4 STORING GROUP OF HOMOGENOUS ELEMENTS: ARRAYS 9 Hrs.

Diving into Arrays: Definition – Syntax – Types – Representation: Row & Colum Order – Dynamic Arrays

Idea behind Functions: Declaration – Definition – Types – Calling – Arguments – Prototypes – Call by Value – Call by Reference – Pointers

Case Study: Fun with Code – Simple Game Development using Arrays and Functions

PRACTICE PROBLEMS:

1. Describe a problem statement in your domain/department where you need to work with group of same type of data. Provide a solution in terms of C program to store and manage the data effectively.
2. You're playing UNO cards, suddenly a person is getting rev card. Write a C program to reverse the round by storing the number of players in array.
3. Write a C program for Vehicle Regulation System where odd number ending vehicles can use the road on odd days and even number ending vehicles can use the road on even days using two separate arrays to store and display the odd and even numbers.

UNIT 5 STORING GROUP OF HETROGENOUS ELEMENTS: ARRAYS 9 Hrs.

Outset of Structure and Union: Structure Definition & Declaration – Structures Fusion with: Arrays – Pointers – Functions– Union Initiation, Definition & Declaration

Working with Files: File Handling Functions – Read – Write – Other Operations – Different File Types

Case Study: Report on using File Functions to create Score Board for any game, importing it to program

PRACTICE PROBLEMS:

1. Describe a problem statement in your domain/department where you need to work with group of different type of data. Provide a solution in terms of C program to store and manage the data effectively.
2. Write a C program to get the details of the student (roll no, name, date of birth, state, 10th percentage and 12th percentage) using Structure. Calculate the age of the student and display the eligibility status for his admission.

Eligibility criteria: more than 60 percent in 10th and 12th, age>=17, state==TN.

1. Write a menu driven C program for library management system with ten entries:
   (i). Add Book (ii). Add Author (iii). Add Category (iv). Book Cost
   (v). Display - Book by Author, Book by Category, Book under cost
2. Write a C program to create an employee Union with employee details (id, name, salary) Accept the details of 'n' employees, rearrange the data in ascending order of employee name, id and salary as three different functions and display it.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Interpret the difference between components of problem solving such as algorithm, flowchart, pseudo code and source code.

CO2 - Build simple solution for any given problem statement using various components of problem solving techniques and measure its efficiency in terms of time and space.

CO3 - Infer and examine the roots and foundation of C programming's key concepts likedatatypes, operators.

CO4 - Devise and correlate the use of different core concepts such as Arrays and Functions in C language.

CO5 - Formulate real time solutions through programsusing Structure and Union in C language.

CO6 - Design and develop various application oriented program for solving real time societal problems.

TEXT/REFERENCE BOOKS

1. YashavantKanetkar, 'Let us C', BPB Publications, Fourteenth Edition
2. R.G.Dromey "How to solve it by computer", Pearson Education, Low Price Edition.
3. Balagurusamy, "Programming in ANSI C", McGrawHill Publications, Eighth Edition.
4. Greg Perry, Dean Miller "C Programming Absolute Beginner's Guide", Third Edition.

SHSB1101	TECHNICAL ENGLISH	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To understand specialized subject areas and skills included for their study.
- To comprehend and react in oral and written forms to the specialized texts
- To respond to listening, reading and writing tasks by using digital tools
- To enhance communication, collaboration and critical thinking skills
- To explore creativity through blended learning contexts

UNIT 1 **9 Hrs.**

Listening: Listening to choose the correct answer from the options given (MCQ)-Speaking: Self Introduction, Talking about likes and dislikes-Reading: Comprehending a passage-Skimming, scanning, detailed reading - Writing: Letter of Job Application, Resume, Letter to the Editor (problems and solutions) - Vocabulary: Kinds of Sentences, Affixes, Collocations, Sequence words, contextual guessing of words - Language Focus: Parts of Speech, Tense and its types, Voice - Impersonal Passive - Language Lab work: Focus Digital literacy: students join zoom platform/ using online tools.

UNIT 2 **9 Hrs.**

Listening: Listening to advertisements about a product, say true or false - Speaking: JAM on current topics, mini presentations - Reading: Identifying topic sentences by reading content - Writing: Writing compare/ contrast paragraphs, process description, E-Mail Writing - Vocabulary: Verbal phrases, Prepositions and Prepositional phrases, Concord, Discourse Markers - Language Focus: Clauses, Conjunctions, Sentence Types - Simple, Compound & Complex - Language Lab: Digital literacy: Responding to quiz using Kahoot application.

UNIT 3 **9 Hrs.**

Listening: Listening to summarize the information, debates/ discussions. - Speaking: Group discussion on a given topic - Reading : To find specific information and to prepare notes using the format - Writing: Framing open ended questions- Survey Report- Arranging the sentences in the right order - Vocabulary: Paired expressions, Adjectives/ adverbs, Technical definitions, Compound Nouns Language Focus: Punctuation, Editing, Same words used as different parts of speech - Language Lab: Digital literacy: Power point tools –Slide share to make presentation on the survey report.

UNIT 4 **9 Hrs.**

Listening: Listening to differentiate instructions and recommendations - Speaking: Debate on current issues - Reading: Reading to understand and classify the information - Writing: Instructions, Recommendations, Preparation of User Manual - Vocabulary: Classification of words, Abbreviations, Acronyms, - Language Focus: Reported Speech, Causatives, Basic Sentence Patterns - Language Lab: Digital literacy: Using online discussion forum.

UNIT 5 **9 Hrs.**

Listening and summarizing: Listening to identify the structure of sentences, small talks, TED talks - Speaking: Giving impromptu talks, Speech Writing - Reading: Read argumentative essays and paragraphs - Writing: Essay writing, Checklist preparation, Note making - Vocabulary: Homophones/Homonyms, Idioms and Phrases - Language Focus: Negatives, Tag questions, Similes and Metaphors - Language Lab: Digital literacy: Creating own Blogs and interactive exercises and quizzes online.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Classify technical words to use them in sentences framing, compose problem solving paragraphs.

CO2 - Categorize information based on the understanding of reading materials to prepare notes.

CO3 - Prepare and document to report, identify elements of editing.

CO4 - Interpret technical definitions related to the text and design a user manual using instructions.

CO5 - Summarize reading materials and outline an essay on any topic given.

CO6 - Demonstrate their language learning activities in the classroom/ online group environment.

TEXT BOOK / REFERENCE BOOK

1. Technical English [2019], Department of English, Sathyabama Institute of Science & Technology.
2. Beer, David F., and David McMurrey. A Guide to Writing as an Engineer. 4th ed., Wiley, 2013.
3. Alred, Gerald J., et al. Handbook of Technical Writing. 11th ed., Bedford/St. Martin's, 2019.
4. Pearsall, Thomas Edward. Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals. McGraw-Hill Education, 2017.
5. Straus, Jane. The Blue Book of Grammar and Punctuation. John Wiley & Sons, 2014.
6. O'Conner, Patricia T. Woe is I: The Grammarphobe's Guide to Better English in Plain English. Riverhead Books, 2019.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SMTB1202	MATRICES, CALCULUS AND SAMPLING (COMMON TO BIO GROUPS)	L	T	P	EL	Credits	Total Marks
		3	1	0	0	3	100

COURSE OBJECTIVE

- The ability to identify, reflect upon, evaluate and apply different types of information and knowledge to form independent judgments. Analytical, logical thinking and conclusions based on quantitative information will be the main objective of learning this course.

UNIT 1 MATRICES 9 Hrs.

Characteristic equation of a square matrix – Eigenvalues and Eigen vectors of a real matrix – Properties of Eigen values and Eigenvectors – Cayley-Hamilton theorem (without proof) verification – Finding Inverse and Power of a matrix using Cayley-Hamilton Theorem.

UNIT 2 DIFFERENTIAL CALCULUS 9 Hrs.

Definitions – Derivative of standard functions (Results only) - Differentiation of function of function – Logarithmic differentiation – Derivatives of implicit function – Partial derivatives – Euler's theorem (Simple Problems only).

UNIT 3 INTEGRAL CALCULUS

9 Hrs.

Integral of standard functions (Results only) – Integration by the method of substitution– Integration using partial fractions – Integration by parts – Generalization of integration by parts – Definite integral – Properties – Simple problems

UNIT 4 THEORY OF SAMPLING 9 Hrs.

Test of Hypothesis – Test of significance – Large samples – Z test - Single proportion – Difference of proportions – Single mean – Difference of means - Student 's t test – Single mean – Difference of means –Test of variance – Fisher's F test – Chi square test – Goodness of fit – Independence of attributes.

UNIT 5 DESIGN OF EXPERIMENTS AND STATISTICAL QUALITY CONTROL CHARTS 9 Hrs.

Design of experiments: Completely Randomized Design, Randomized Block Design–statistical Quality Control: Mean, Range, p, np, c – charts.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course the student will be able to

CO1 - Manipulate power, inverse, Eigen values and Eigenvectors of a matrix.
CO2 - Describe ordinary and partial derivatives and integrals of standard functions by various methods.
CO3 - Evaluate the gradient, directional derivative, irrotational and solenoidal of a vector.
CO4 - Estimate the value of Chi square, F,t and Z values for small samples.
CO5 - Apply design of experiments using analysis of variance.
CO6 - Sketch the control charts and interpret the results based on the charts.

TEXT BOOK / REFERENCE BOOK

1. Kreyszig.E, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, Singapore, 2001.
2. N.P. Bali and Manish Goyal, A Text book of Engineering Mathematics, Laxmi publications, 2008.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill, New Delhi, 11th Reprint, 2010.
4. Sivaramakrishna Das P., Vijaya Kumari C., Probability and Random Processes, Pearson Education, Sixth Edition, 2014.
5. Veerarajan T., Probability, Statistics and Random Processes, Tata McGraw-Hill, New Delhi, Fourth Edition, 2014.
6. Venkataraman M.K., Engineering Mathematics - First Year, 2nd Edition, NationalPublishing Co., Chennai, 2000.
7. B.Annadurai, A textbook of Biostatistics, New Age International, 2007
8. Pranab Kumar Banerjee, Introduction to Biostatistics (A Textbook of Biometry), S. Chand Limited, 2007.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SPHB1101	PHYSICS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To understand the concept of crystal structures and symmetry, the physics of scattering and diffraction theory, experimental diffraction from single crystals, instrumentation and powder diffraction.
- Students will be able to understand the Identify and describe properties of matter, including: flexibility, strength and transparency.
- The objective of this course is to develop a working knowledge of the laws and methods of thermodynamics and elementary statistical mechanics and to use this knowledge to explore various applications.
- Differentiate between various acoustic terms and understand how these apply to different materials and acoustic design solutions.
- To give knowledge about semiconductor physics and discuss working and applications of basic devices, including p-n junctions, BJTs and FETs.

UNIT 1 QUANTUM MECHANICS 9 Hrs.

Introduction to Quantum Mechanics-Energy distribution function, Wave – particle duality-de Broglie matter waves – Concept of wave function and its physical significance – Heisenberg's Uncertainty Principle – Schrodinger's wave equation – Time independent and Time dependent equations – Particle in a one-dimensional rigid box – tunnelling (Qualitative) – Scanning Tunnelling Microscope (STM).

UNIT 2 PROPERTIES OF MATTER 9 Hrs.

Introduction- Elasticity- Hooke's law - Torsional stress & deformations – Twisting couple – Torsion pendulum - theory and experiment–bending of beams - bending moment–cantilever: -Theory and experiment–uniform and non-uniform bending: theory and experiment- Magnetism - Basic definitions - Magnetic permeability, susceptibility, relation between permeability and susceptibility - Bohr magneton. Classification of magnetic materials-Hysteresis.

UNIT 3 CRYSTAL PHYSICS 9 Hrs.

Single crystalline, polycrystalline and amorphous materials – single crystals: unit cell, crystal systems, Bravais lattices, directions and planes in a crystal, Miller indices – inter-planar distances – coordination number and packing factor for SC, BCC, FCC, HCP. – crystal imperfections: point defects, line defects –growth of single crystals: solution and melt growth techniques.

UNIT 4 SEMICONDUCTOR PHYSICS 9 Hrs.

Classification of materials-Theory of semiconductors: Intrinsic and extrinsic semiconductors, band structure of semiconductors - Fermi level in intrinsic and extrinsic semiconductors. Theory of p-n junctions – diode and transistor: p-n junction under thermal equilibrium, forward bias, reverse bias, carrier density, V-I characteristics, junction capacitance and voltage breakdown. Zener diode and its characterization- Avalanche breakdown- JEFT- I-V characteristics- amplifying and switching.

UNIT 5 LASER AND ITS APPLICATIONS 9 Hrs.

Absorption and Emission of Radiation by atoms, ions and molecules. Laser medium Phenomenon of population inversion. Laser cavity (fiber laser, and other cavities), generation of coherent beam, Q-switching, short pulse generation, power amplification. Basic Laser Principles: Theory of Laser, Properties of Laser, Fundamental Optical properties, Modified Optical properties, Laser output – its characteristics.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course the student will be able to

CO1 - Solve the time independent Schrodinger wave equation for a particle in a box to obtain the Eigen values and Eigen functions.

CO2 - Understand the dual nature of radiation and matter

CO3 - Estimate the atomic packing factor for SC, BCC & FCC structures.

CO4 - Recognize sound level descriptors and how they are used in architectural acoustics & analyse acoustic properties of typically used materials for design consideration.

CO5 - Understanding the working, design considerations and applications of various semi conducting devices including p-n junctions, BJTs and FETs

CO6 - Demonstrate an understanding of optical fiber communication link, structure, propagation and transmission properties of an optical fiber.

TEXT BOOK / REFERENCE BOOK

1. Pillai S.O., Solid state Physics, New age International Publishers, 7th Edition.
2. Arthur Beiser, Concepts of Modern Physics, Tata McGraw Hill Publications.
3. M.N.Avadhanulu & P.G.Kshirasagar. A text book of Engineering Physics, S. Ch.Publishing.
4. B. B.Laud,Lasers and nonlinear optics, New age International Publishers, II-Edition.
5. R. Murugesan, Modern Physics, S. Chand Publishing, 15th Edition (2015).
6. D. S. Mathur, Elements of Properties of Matter, S. Chand Publishing (2014).
7. A. K. Bandyopadhyay, Nanomaterials, New age International Publishers,
8. K. K. Chattopadhyay, Introduction to nano science and nano technology, PHI publisher,
9. Sulabha Kulkarni, Introduction to Nanoscience and Nanotechnology 2nd Edition
10. David Griffiths, Introduction to electrodynamics, Addison-Wesley publishing 3rd Edition

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

		L	T	P	EL	Credits	Total Marks
SEEB1203	BASIC ELECTRICAL ENGINEERING (Common to Auto, Aero, Mech, Biomed, Chemical, Mechatronics, Bio Tech)	3	0	0	0	3	100

COURSE OBJECTIVES

- To understand the fundamental concepts of electrical wiring and its components
- To analyze DC and AC circuit behaviour.
- To impart and explore Knowledge on magnetic circuits and electrical machines.

UNIT 1 INTRODUCTION TO ELECTRICAL SYSTEMS 9 Hrs.

Basic Element Resistors, inductors and capacitors - Domestic Wiring - Wiring Materials and Accessories -Staircase Wiring - Fluorescent Tubes-Earthing-Types & Benefits.

UNIT 2 D.C. CIRCUITS 9 Hrs.

Electrical Quantities - Ohm's law - Kirchoff's laws -Resistance in series and parallel combinations - Current and Voltage division rules - Mesh analysis and Nodal analysis.

UNIT 3 A.C. CIRCUITS 9 Hrs.

Sinusoidal functions - R.M.S and Average values for Sinusoidal waveform - Phasor representation - Sinusoidal excitation applied to purely resistive, inductive and capacitive circuits - RL, RC and RLC series circuits - power and power factor - Introduction to three phase circuits.

UNIT 4 MAGNETIC CIRCUITS 9 Hrs.

Definition of MMF, Flux and Reluctance - Leakage Factor - Reluctances in Series and Parallel (Series and Parallel Magnetic Circuits)-Electromagnetic Induction-Fleming's Rule-Lenz's Law-Faraday's laws-statically and dynamically induced EMF -Self and mutual inductance-Analogy of Electric and Magnetic.

UNIT 5 INTRODUCTION TO MACHINES 9 Hrs.

Construction and Principle of Operation of DC Generators - DC Motors - Single Phase Transformer - Stepper Motor.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the fundamental electrical concepts.
CO2 - Analyze simple DC circuits using appropriate techniques.
CO3 - Apply phasor analysis techniques to solve AC circuits
CO4 - Develop the ability to solve problems involving magnetic circuits using analytical techniques
CO5 - Demonstrate the principles and operation of various electrical machines,
CO6 - Understand the principles, construction, and applications of special machines

TEXT / REFERENCE BOOKS

1. Ramana Pilla ,HD Mehta, "Basic Electrical Engineering", S CHAND & Company Limited, 2022
2. Mittle B.N. & Aravind Mittle, Basic Electrical Engineering, 2nd Edition, Tata McGraw Hill, 2011.
3. Theraja B.L., Fundamentals of Electrical Engineering and Electronics, 1st Edition, S.Chand & Co., 2009.
4. Smarajit Ghosh, Fundamentals of Electrical and Electronics Engineering, 2nd Edition, PHI Learning Private Ltd, 2010.
5. Thomas L Floyd, " Digital Fundamentals", 11th edtion, Pearson, 2015.
6. Sanjay Sharma, Electronic Devices and Circuits, 2nd Edition, S.K.Kataria & Sons, 2012.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SMEB2102	ENGINEERING DRAWING AND DESIGN	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

COURSE OBJECTIVE

The main learning objective of this course is

- To Understand the concept of graphic communication, develop the drawing skills for communicating concepts, ideas and designs of engineering products and to expose them to existing national standards related to technical drawings.
- To make the student to visualize and read the drawings.
- To learn about the orthographic and pictorial projections.

CONCEPTS AND CONVENTIONS

Importance of graphics in engineering applications - Use of drafting instruments - BIS conventions and specifications — Size, layout and folding of drawing sheets — Lettering and dimensioning.

UNIT 1 PLANE CURVES 9 Hrs.

Basic Geometrical constructions, Curves used in engineering practices: Conics — Construction of ellipse, parabola and hyperbola by eccentricity method — Construction of cycloid — Drawing of tangents and normal to the above curves.

UNIT 2 PROJECTION OF POINTS AND LINES 9 Hrs.

Projection - Types of projection - Projection of points lying in four quadrants - Projection of lines (First angle projection only) -Projection of lines parallel and inclined to one or both the planes.

UNIT 3 PROJECTION OF SOLIDS 9 Hrs.

Projection of simple solids like prisms, pyramids, cylinder, cone and truncated solids when the axis is inclined to one of the principal planes and parallel to the other by rotating object method.
Practicing three-dimensional modeling of simple objects by CAD Software (Not for examination)

UNIT 4 SECTION OF SOLIDS 9 Hrs.

Purpose of sectioning - Sectional views - Hatching - Section plane perpendicular to one plane and parallel to other plane -Section plane inclined to HP-True shape of the section.
Practicing three-dimensional modeling of simple objects by CAD Software (Not for examination)

UNIT 5 DEVELOPMENT OF SURFACES AND FREEHAND SKETCHING 9 Hrs.

Need for development of surfaces - Types of development of surfaces - Development of lateral surfaces of simple and sectioned solids — Prisms, pyramids, cylinders and cones.
ORTHOGRAPHIC PROJECTION-: Visualization concepts and Free Hand sketching: Visualization principles —Representation of Three-Dimensional objects — Layout of views- Freehand sketching of multiple views from pictorial views of objects. Practicing three-dimensional modeling of simple objects by CAD Software (Not for examination)

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Identify the national standards related to the Engineering drawing based on BIS and construct sections and polygons.
CO2 - Solve practical problems involving projection of lines.
CO3 - Draw orthographic projections of solids.
CO4 - Draw orthographic section of solids and improve the student's visualization skill to develop products.

CO5 - Draw the Development of surfaces and its applications in manufacturing industry
CO6 - Draw the orthographic view of solids and learn to convert pictorial into orthographic projection.

TEXT BOOK / REFERENCE BOOK

1. Bhatt N.D. and Panchal V.M., “Engineering Drawing”, Charotar Publishing House,53rd Edition, 2019.
2. Natrajan K.V., “A Text Book of Engineering Graphics”, Dhanalakshmi Publishers, Chennai, 2018.
3. Venugopal K. and Prabhu Raja V., “Engineering Graphics", New Age International (P) Limited,2018.
4. Engineering drawing practice for schools and colleges, SP 46 – 1988 (http:// web.iitd.ac.in/~achawla/ public_html/201/lectures/sp46.pdf).
5. Publication of Bureau of Indian Standards:
6. IS 10711 — 2001: Technical products Documentation — Size and lay out of drawing sheets.
7. IS 9609 (Parts 0 & 1) — 2001: Technical products Documentation — Lettering.
8. IS 10714 (Part 20) — 2001 & SP 46 — 2003: Lines for technical drawings.
9. IS 11669 — 1986 & SP 46 —2003: Dimensioning of Technical Drawings.
10. IS 15021 (Parts 1 to 4) — 2001: Technical drawings — Projection Methods.

SPHB2101	PHYSICS LAB	L	T	P	EL	Credits	Total Marks
		0	0	2	0	1	50

COURSE OBJECTIVE

- To introduce experiments in optics, semiconductors, magnetism, thermal physics and quantum mechanics in order to acquire the first-hand information and to realize the basic physics concepts.

LIST OF EXPERIMENTS

1. Determine the Rigidity modulus of a given wire by Torsional pendulum
2. To determine the angle of Minimum Deviation by I - D curve method.
3. Determine V-I characteristics of a photodiode
4. To determine the Numerical aperture of an optical fiber
5. To find the Energy gap of a semiconductor
6. Determination of Young's modulus- non-uniform bending
7. Determination of Young's modulus- Uniform bending
8. Determination of the wave length of the laser using grating- Laser.
9. Determination of thickness of a thin sheet/wire- Air wedge.
10. Determination of Numerical Aperture and acceptance angle- Optical fibre.
11. Photoelectric effect
12. Michelson Interferometer.
13. V-I characterisation of solar cell
14. CRO- Functions
15. DFT Theory and calculations

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Measure the rigidity modulus of a given wire by oscillations.
CO2 - Measure the angle of minimum deviation by spectrometer.
CO3 - Analyse the I-V characteristics of the given photo diode.
CO4 - Measure the band gap of the given semiconductor.
CO5 - Measure the young's modulus of bar by uniform bending method.
CO6 - Determine the wavelength of the given laser light source.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 50 **Exam Duration: 2 Hrs.**

CAE : Evaluation of Regular Lab class 15 Marks exam practical 10 Marks **25 Marks**
ESE : End Semester Practical exam **25 Marks**

S24BLH21	BIOSENSORS AND MEASUREMENTS	L	T	P	EL	Credits	Total Marks
		3	0	2	0	4	100

COURSE OBJECTIVE

- To provide the basics of measurements, knowledge on the principle and operation of different medical transducers.
- To introduce the application of sensors and transducers in the physiological parameter measuring system.

UNIT 1 MEASUREMENT SYSTEM 9 Hrs.

Measurement System – Functional elements of an instrumentation system - Static and Dynamic Characteristics - Errors in Measurements and their statistical analysis – Calibration - Primary and secondary standards. Sensor for Motion and Position Measurement, GPS, INS, Doppler, SONAR.

UNIT 2 PASSIVE AND ACTIVE TRANSDUCERS 9 Hrs.

Classification of transducers and characteristics for selection of transducers - Resistive Transducers- Strain Gauge, Capacitive transducer - various arrangements, Capacitor microphone, Capacitive pressure sensor, Proximity sensor. Inductive transducer, LVDT, Passive types: RTD materials & range, relative resistance vs. temperature characteristics, thermistor characteristics, Active type: Thermocouple - characteristics. Piezoelectric active transducer.

UNIT 3 BIO POTENTIAL ELECTRODES AND CHEMICAL SENSORS 9 Hrs.

Electrodes Electrolyte Interface, Half-Cell Potential, Polarization, Polarizable and Non-Polarizable, Electrodes, Reference Electrode, Hydrogen Electrode, Electrode Skin-Interface and Motion Artifact. Surface Electrodes. Oxygen electrodes, CO2 electrodes, enzyme electrode, construction, ISFET for glucose, urea etc. fiber optic sensors.

UNIT 4 SMART AND BIOSENSORS 9 Hrs.

Biological Sensors: Study of various corpuscles like Pacinian, functions and modelling, sensors for smell, sound, vision, osmolality and taste.

Biosensors: Introduction, Advantages and limitations, various components of Biosensors, Biocatalysts based biosensors, bio-affinity based biosensors & microorganisms-based biosensors, Types of membranes used in biosensor constructions, Electronic Nose. SMART SENSORS. Introduction to Smart Sensors and Semiconductor sensors, MEMS.

UNIT 5 DISPLAY AND RECORDING DEVICES 9 Hrs.

Digital Display System and Indicators: Classification of display devices, DOT Matrix display, Digital voltmeter, Multimeter, Digital storage oscilloscope, LCD monitor, Recorders: Graphic recorders, strip chart recorders, Galvanometer type recorders and self-balancing type potentiometric recorders, Magnetic tape recorders and Disc recorders.

Max.15 Hrs.

PRACTICE EXERCISE

1. Characteristics of Temperature Transducers.
2. Characteristics of Optical Transducer.
3. Characteristics of LVDT and Potentiometer Transducer
4. Characteristics of Strain Gauge.
5. Dead weight measurement
6. Study of Characteristics of Hall effect Transducer using Arduino.
7. Measurement of pulse and body temperature using Arduino

Max.60 Hrs.

COURSE OUTCOMES

CO1 - Understand the calibration procedure for the basic instruments involved in physiological parameter measurement.
CO2 - Identify the characteristics of various transducers and classify transducers.
CO3 - Attain adequate knowledge about the various sensors and measuring instruments used for measurement and detection of physical quantities.
CO4 - Demonstrate the concepts, types, working and practical applications of important biosensors.
CO5 - Apply the suitable design criteria for developing a medical sensor for a particular application.
CO6 - Employ Multimeter, CRO and different types of recorders for appropriate measurement.

TEXT BOOK / REFERENCE BOOK

1. A. K. Sawhney, A course in electronic Measurements and Instruments, Dhanpat Rai Sons, 2014
2. H.S. Kalsi, Electronic Instrumentation & Measurement, Tata McGraw Hill, 2011.
3. John G. Webster, Medical Instrumentation Application and Design, 4th Edition, Wiley India Pvt. Ltd., New Delhi, 2015.
4. Richard S.C. Cobbold, Transducers for Biomedical Measurements: Principles and Applications, John Wiley & Sons, 2004.
5. Nandini K. Jog, Electronics in Medicine and Biomedical Instrumentation, PHI, 2nd Edition 2013.
6. Harry N, Norton, Biomedical sensors – Fundamentals and Application, 2001.
7. Tatsuo Togawa, Toshiyo Tamma and P. Ake Öberg, Biomedical Transducers and Instruments, 2018.Pillai S.O., Solid state Physics, New age International Publishers, 7th Edition.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SMTB1303	DIFFERENTIAL EQUATIONS AND NUMERICAL METHODS	L	T	P	EL	Credits	Total Marks
		3	1	0	0	3	100

COURSE OBJECTIVE

- The ability to identify, reflect upon, evaluate and apply different types of information and knowledge to form independent judgments. Analytical, logical thinking and conclusions based on quantitative information will be the main objective of learning this course.

UNIT 1 ORDINARY DIFFERENTIAL EQUATION 9 Hrs.

Formation of ODE – Solution of second order linear differential equations with constant coefficients – Particular integrals for eax, sinax, cosax, xn, xneax, eaxsinbx, eaxcosbx.

UNIT 2 PARTIAL DIFFERENTIAL EQUATION 9 Hrs.

Formation of PDE by elimination of arbitrary constants and arbitrary functions – Lagrange's linear equations.

UNIT 3 NUMERICAL SOLUTION OF ALGEBRAIC AND TRANSCENDENTAL EQUATION 9 Hrs.

Numerical solution of Algebraic and Transcendental equations – Newton Raphson method – Numerical solution of a system of linear equations – Gauss Jordan method, Crout's Method, Gauss Seidel method.

UNIT 4 INTERPOLATION, NUMERICAL DIFFERENTIATION AND INTEGRATION 9 Hrs.

Interpolation – Gregory Newton's Forward and Backward Interpolation for equal intervals - Numerical differentiation: Newton's forward and backward differences to compute first and second derivatives – Numerical integration: Simpson's1/3rd rule and Simpson's 3/8 th rule.

UNIT 5 NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS 9 Hrs.

Numerical Solution of first order ordinary differential equations – Taylor's series method – Modified Euler's method - Runge-Kutta method of fourth order.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Illustrate the first order exact and second order linear ordinary differential equations.
CO2 - Compute the partial differential equation by eliminating arbitrary constants or functions
CO3 - Apply the concept of the numerical solutions to algebraic and transcendental equations.
CO4 - Categorize and implement the various numerical methods for Interpolation
CO5 - Appraise the solution of ordinary differential equations by choosing the suitable method.
CO6 - Produce the solution of ordinary differential equations.

TEXT BOOK / REFERENCE BOOK

1. Grewal B.S., Higher Engineering Mathematics, 35th Edition, Khanna Publishers, Delhi, 2000.
2. Kandasamy P., Thilagavathy K., Engineering Mathematics, Volumes II & III (4th revised edition), S. Chand & Co., New Delhi, 2001.
3. Kandasamy P., Thilagavathy, K., and Gunavathy K., Applied Numerical Methods, S.Chand& Co., New Delhi, 2003.
4. Kreyszig.E, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, Singapore, 2001.

5. Steven C. Chapra, Raymond P. Canale, Numerical Methods for Engineers, Tata Mcgraw Hill Publishing Co., NewDelhi, 2003.
6. Veerarajan T., Engineering Mathematics, Tata McGraw Hill Publishing Co., New Delhi, 2005

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SISB4301	UNIVERSAL HUMAN VALUES	L	T	P	EL	Credits	Total Marks
		2	0	0	3	3	100

COURSE OBJECTIVE

- To develop a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence
- To understand (or developing clarity) the harmony in the human being, family, society and nature/existence
- To strengthen self-reflection
- To develop commitment and courage to act

MODULE 1 COURSE INTRODUCTION - NEED, BASIC GUIDELINES, CONTENT AND PROCESS FOR VALUE EDUCATION 9 Hrs.

Purpose and motivation for the course, recapitulation from Universal Human Values-I - Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self- exploration - Continuous Happiness and Prosperity- A look at basic Human Aspirations - right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority - Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario - Method to fulfil the above human aspirations: understanding and living in harmony at various levels. - Practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking.

MODULE 2 UNDERSTANDING HARMONY IN THE HUMAN BEING - HARMONY IN MYSELF! 9 Hrs.

Understanding human being as a co-existence of the sentient 'I' and the material 'Body' - Understanding the needs of Self ('I') and 'Body' - happiness and physical facility - Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer) - Understanding the characteristics and activities of 'I' and harmony in 'I' - Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail - Programs to ensure Sanyam and Health. - Practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.

MODULE 3 UNDERSTANDING HARMONY IN THE FAMILY AND SOCIETY- HARMONY IN HUMAN-HUMAN RELATIONSHIP 9 Hrs.

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship - Understanding the meaning of Trust; Difference between intention and competence - Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship - Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals - Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family. - Practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.

MODULE 4 UNDERSTANDING HARMONY IN THE NATURE AND EXISTENCE – WHOLE EXISTENCE AS COEXISTENCE 9 Hrs.

Understanding the harmony in the Nature - Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self-regulation in nature - Understanding Existence as Co-existence of mutually interacting units in all-pervasive space - Holistic perception of harmony at all levels of existence. - Practice sessions to discuss human being as cause of imbalance in nature (film “Home” can be used), pollution, depletion of resources and role of technology etc.

MODULE 5 IMPLICATIONS OF THE ABOVE HOLISTIC UNDERSTANDING OF HARMONY ON PROFESSIONAL ETHICS 9 Hrs.

Natural acceptance of human values - Definitiveness of Ethical Human Conduct - Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order - Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. - Case studies of typical holistic technologies, management models and production systems - Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations - Sum up. - Practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions eg. To discuss the conduct as an engineer or scientist etc.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, the student is expected

CO1 - To become more aware of themselves, and their surroundings (family, society, nature)

CO2 - They would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind

CO3 - To have better critical ability

CO4 - To become sensitive to their commitment towards what they have understood (human values, human relationship and human society)

CO5 - To apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction

TEXT BOOK / REFERENCE BOOK

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010
2. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4. The Story of Stuff (Book).
5. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
6. Small is Beautiful - E. F Schumacher.
7. Slow is Beautiful - Cecile Andrews
8. Economy of Permanence - J C Kumarappa
9. Bharat Mein Angreji Raj – PanditSunderlal
10. Rediscovering India - by Dharampal
11. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
12. India Wins Freedom - Maulana Abdul Kalam Azad
13. Vivekananda - Romain Rolland (English)
14. Gandhi - Romain Rolland (English)

ASSESSMENT

Assessment by faculty mentor	:	10 Marks
Self-assessment	:	10 Marks
Assessment by peers	:	10 Marks
Socially relevant project/Group Activities/Assignments	:	20 Marks
Semester End Examination	:	50 Marks

SBMB1301	BIO SIGNALS AND SYSTEMS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To have adequate knowledge basics of signals and systems.
- It helps to understand the basic definition and classification of continuous time and discrete time signals.
- To study its analysis and its relevance to physiological signals.

UNIT 1 CLASSIFICATION OF SIGNALS AND SYSTEMS 8 Hrs.

Continuous time signals (CT Signals) and Discrete time signals (DT Signals)- Step, Ramp, Pulse, Impulse, Exponential - Classification of CT and DT signals - Periodic, aperiodic and Random signals - Real and complex signals - Energy and power signals - CT systems and DT systems - Linear time invariant systems - Basic properties of continuous time systems - Linearity, Causality, Time invariance, Stability.

UNIT 2 ANALYSIS OF CONTINUOUS TIME SIGNALS 8 Hrs.

Definition - Continuous time Fourier transform and Laplace transform analysis with examples - Decaying exponential - Rising exponential - Double exponential - Basic properties - Linearity - Parseval's relation - Convolution in time and frequency domain - Time shifting & Time reversal - Relation between Fourier transform and Laplace transform.

UNIT 3 ANALYSIS OF DISCRETE TIME SIGNALS 9 Hrs.

Spectrum of DT signals, Sampling theorem – Graphical and analytical proof for Band Limited Signals, effect of under sampling – Aliasing - Basic principles of Z-Transform - Z-Transform definition - Region of convergence - Properties of ROC - Properties of Z- Transform - Poles and zeros - Inverse Z-Transform using contour integration, Residue theorem, power series expansion and Partial fraction expansion.

UNIT 4 LINEAR TIME INVARIENT SYSTEMS 15 Hrs.

Frequency response of LTI systems - Analysis and characterization of LTI systems using Laplace transform - computation of impulse response and transfer function using Laplace transform – Differential equation - Impulse response - Convolution integral and frequency response. Causality and Stability of LTI Systems – Impulse response, convolution sum and Frequency Response - Computation of Impulse response and Transfer function using Z-Transform. Random signal-characterization of random signal-stationary and nonstationary random signal –relationship Between two random signals-properties of autocorrelation and cross correlation functions.

UNIT 5 MEDICAL APPLICATIONS OF SIGNAL ANALYSIS 5 Hrs.

Analysis of bio signals- Spatial and Frequency domain methods- Detailed Signals analysis of ECG, EMG, EEG.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the basics of signals and systems.
CO2 - Acquire knowledge in the types of signals and systems.
CO3 - Apply the acquired knowledge in understanding the signal manipulations.
CO4 - Analyse the various signals using different tools and techniques.
CO5 - Explore techniques to analyze biosignals.
CO6 - Develop the system to analyze the real-time biosignals.

TEXT BOOK / REFERENCE BOOK

1. Allan V. Oppenheim et al., Signals and Systems, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2003
2. Ramesh Babu P., Signals and Systems, 4th Edition, Scitech Publishers, 2011.
3. Salivahanan S., Digital signal processing, 2nd Edition, Tata McGraw Hill, 2009.
4. Signals and Systems 2Nd Edition by Simon Haykin, WILEY INDIA,2018
5. Michael Roberts, Govind Sharma, Fundamentals of Signals and Systems, McGraw Hill Education, 2017
6. Chittode J.S., Signals & Systems, Technical Publication, 2021.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB1302	BASIC ELECTRONIC DEVICES, CIRCUITS AND ITS APPLICATIONS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To expose the student to gain knowledge on semiconductor devices such as diode, transistor etc.
- To understand the analysis of different circuits like amplifier, oscillator etc.

UNIT 1 PN JUNCTION DEVICES 9 Hrs.

PN junction diode –structure, operation and V-I characteristics, diffusion and transient capacitance - Rectifiers – Half Wave and Full Wave Rectifier – Display devices- LED, Laser diodes- Zener diode characteristics-Zener Reverse characteristics – Zener as regulator.

UNIT 2 TRANSISTORS 9 Hrs.

BJT, JFET, (Construction, principal of Operation and Volt –Ampere characteristics). Pinch- off voltage-Small signal model of JFET). MOSFET - structure, operation, characteristics and Biasing, UJT, Thyristor and IGBT - Structure and characteristics.

UNIT 3 AMPLIFIERS 9 Hrs.

BJT small signal model – Analysis of CE, CB, CC amplifiers-Gain and frequency response – MOSFET small signal model– Analysis of CS and Source follower – Gain and frequency response- High frequency analysis.

UNIT 4 MULTISTAGE AMPLIFIERS AND DIFFERENTIAL AMPLIFIER 9 Hrs.

BIMOS cascade amplifier, Differential amplifier – Common mode and Difference mode analysis – FET input stages – Single tuned amplifiers – Gain and frequency response – Neutralization methods, power amplifiers –Types (Qualitative analysis).

UNIT 5 FEEDBACK AMPLIFIERS AND OSCILLATORS 9 Hrs.

Advantages of negative feedback – voltage / current, series / shunt feedback –positive feedback – Condition for oscillations, phase shift – Wien bridge, Hartley, Colpitts and Crystal oscillators.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understands the characteristics of semiconductor diode and the design concepts of Rectifiers and Regulators.
CO2 - Explores the characteristics and biasing of various transistors.
CO3 - Explains the design and analysis of different amplifiers
CO4 - Interprets the Frequency response of multistage and differential amplifiers
CO5 - Explains the importance of Tuned and power amplifier and its efficiency
CO6 - Analyse the effects of feedback on amplifier circuit and analysis of feedback amplifier and oscillators.

TEXT BOOK / REFERENCE BOOK

1. Electronics Principles, Albert Malvino, 7th Edition, 2006.
2. Electronics Device and circuits, S Salivahanan and N Suresh Kumar, McGraw Hill Publication, 2nd Edition, 2006.
3. Electronics Device and circuits, Jacob Milman and Christos C. Halkias, Tata Mcgraw Hill Publication, 2nd Edition, 2007.
4. Basic Electronics devices and Circuits, Mahesh B Patil, PHI Learning Pvt. Ltd., 2013

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB1303	RADIOIMAGING AND THERAPEUTICS	L	T	P	EL	Credits	Total Marks
		3	0	0	2	3	100

COURSE OBJECTIVE

- To provide the knowledge about the specialty of medicine in radiation therapy.
- To make the student understand about the application of imaging technology and effects of radiation.

UNIT 1 ELEMENTS OF RADIATION 9 Hrs.

Radioactive elements and Radioisotopes in medicine, Radioactivity, General properties of alpha, beta and gamma rays-Laws of radioactivity, Radioactive decay - alpha decay, beta decay, positron decay, decay energy and half-life. Radiation units-Roentgen, Rad-rem-sievert. Radiation sources-Natural and artificial radioactive sources.

UNIT 2 RADIATION GENERATORS 9 Hrs.

Particle Accelerators-Cyclotron, Klystron, Magnetron, Cascade generator, VanDeGraff generator Xray films, Xray film processing, Xray cassettes, Intensifying screens-new phosphor technology, Photo stimulable phosphor imaging, collimators, grids-Bucky grids.

UNIT3 RADIODIAGNOSIS 9 Hrs.

Fluoroscopy – Digital Fluoroscopy. Angiography, Cine Angiography, Digital subtraction Angiography. Mammography and Dentalx-rayunit, Digital radiography, Angiography, Image intensifier, PET, SPECT.

UNIT 4 RADIOTHERAPHY 9 Hrs.

COBALT-60, Linac, Gamma camera, nuclear scintigraphy, Brachytherapy, Cyber Knife, Gamma knife, Intra operative radiotherapy, MRI system magnet (Permanent, Electromagnet and Super conductors), generations of gradient magnetic fields.

UNIT 5 RADIATION SAFETY MEASURES 9 Hrs.

Radiation Protection, Protective barrier-primary& secondary, Equivalent Dose, Biological effects of radiation, Somatic & genetic effects of radiation-LD 50/30, Effect of radiation on skin, blood forming organs, Personnel and area monitoring systems, Radiation measuring devices-dosimeter, survey meter.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understandingtheelementsofradiationandradioactivedecayinvolvedinradiationtherapy.
CO2 - Illustrate the working principle of radiation generators with the processing of Xray machine and its application.
CO3 - Understandingthetechniqueoffluoroscopyandvariousradiodiagnosistechniques.
CO4 - Demonstrate the applications of radiotherapy.
CO5 - Attaintheadequateknowledgeaboutradiationmeasurementsandeffectofradiationonbody.
CO6 - Outline the methods of radiation safety.

TEXT BOOK / REFERENCE BOOK

1. Thomas S. Curry, III, James E. Dowdey, Robert C. Murry JR., Christensen, The Physics of Diagnostic Radiology Lea & Febiger,6th Edition 2008.
2. Faiz M. Khan, The Physics of Radiation Therapy, 4th Edition,2009.
3. Gopal, B. Saha, Physics & Radiology of nuclear medicine, Springer 2nd Edition, 2006.

4. Khandpur R.S., Handbook of Biomedical Instrumentation, Tata McGraw Hill Publishing Company Ltd., New Delhi and revised edition,2007.
5. Thayalan K., Basic Radiological Physics, Jaypee Brothers Medical Publishers Pvt. Ltd., Revised Edition, 2005.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB2301	ELECTRICAL CIRCUITS AND ELECTRONIC DEVICES LAB	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

COURSE OBJECTIVE

- To impart knowledge about the characteristics of basic electronic devices such as Diode, BJT, FET, SCR.
- To understand the working of RL, RC and RLC circuits.
- To provide hand on experience in Thevinin & Norton theorem, KVL & KCL, and Super Position Theorems.

SUGGESTED LIST OF EXPERIMENTS

1. Connecting simple resistance in serial and parallel circuit and colour codes
2. Verification of Kirchoff's Voltage and current law
3. Verification of Thevenin Theorem
4. Verification of Norton Theorem
5. Verification of Superposition Theorem
6. Characteristics of PN Junction Diode.
7. Characteristics of Zener Diode.
8. Characteristics of UJT.
9. Characteristics of JFET.
10. Characteristics of DIAC, TRIAC, SCR
11. Common Emitter input-output Characteristics.
12. Common Base input-output Characteristics

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the origin and characteristics of various electronic devices.
CO2 - Identify the application of electrical circuits for biomedical field.
CO3 - Recognize various diode and Transistor application.
CO4 - Analyze and deign RL, RC and RLC circuits used in medical signal conditioning.
CO5 - Apply the concepts in designing various medical circuits using different diodes and transistors.
CO6 - Verify Thevinin & Norton theorem KVL & KCL, and Super Position Theorems.

S24BLH31	HUMAN ANATOMY AND PHYSIOLOGY	L	T	P	EL	Credits	Total Marks
		3	0	2	0	4	100

COURSE OBJECTIVE

- To learn to appreciate the fascinating and ancient branch of science because it unfolds the mystery of complicated and functional aspects of individual organs of the body.
- The learning provides a solid foundation for understanding the structure and function of the human body.

UNIT 1 THE MUSCULOSKELETAL SYSTEM 9 Hrs.

Types of bones, Bone structure – General structure of a long bone, Structure of short, irregular flat and sesmoid bones, Development of bone tissue, functions of bones, Axial and Appendicular Skeleton, Types of Joints and movements, Healing of bones, Muscle tissue – Smooth muscle, Cardiac muscle, Skeletal muscle, Functions of skeletal muscle, Electromyogram, Diseases of bone and muscles.

UNIT 2 CARDIOVASCULAR SYSTEM 9 Hrs.

Blood – Properties, composition and functions. Heart – Position, Structure, Flow of blood through the heart, Coagulation of Blood, The Cardiac cycle, Electrocardiogram, Arterial Blood pressure, Control of blood pressure, Diseases of heart, Disorders of blood pressure.

UNIT 3 DIGESTIVE AND RENAL PHYSIOLOGY 9 Hrs.

Organs of the digestive system - mouth, stomach, Pancreas, Liver and Gall bladder, Gastrointestinal hormones, Structure of Kidney, Physiology of urine formation, Role of the kidney in the regulation of water, salt and acid base balance.

UNIT 4 ENDOCRINE AND NERVOUS SYSTEM 9 Hrs.

Endocrine System **-** Pituitary Gland and hypothalamus, Thyroid Gland, Pancreas, Adrenal Glands, Neuron, Organization of Nervous System **-** Brain and Spinal cord, Synapse, Physiology of Pain, EEG, Epilepsy.

UNIT 5 RESPIRATORY AND SENSORY SYSTEM 9 Hrs.

Physiology of Respiration, Lung volumes and capacities, Exchange and transport of gases in the Blood, Structure of eye and ear, physiology of vision, Mechanism of hearing.

Max.15 Hrs.

PRACTICE EXCERCISE

1. Study of Human Skeletal System and identification of bones
2. Recording of Blood Pressure measurement by indirect method
3. Determination of Bleeding Time
4. Determination of Clotting Time by capillary tube method
5. Estimation of Haemoglobin by sahli's method
6. Enumeration of Red Blood Cell by Hemocytometer.
7. Enumeration of Total Leucocytes by Hemocytometer

Max.60 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - understands the fascinating and ancient branch of science because it unfolds the mystery of complicated and functional aspects of individual organs of the body.

CO2 - remembers a solid foundation for understanding the structure and function of the human body

CO3 - explains how body systems function to maintain homeostasis on day-to-day basis through the process of circulation, respiration, digestion, cellular metabolism, urinary functions and buffer systems

CO4 - explores the students for careers in health-related professions

CO5 - Recognize and explain the interrelationships within and between anatomical and physiological systems of the human body.

CO6 - Demonstrate laboratory procedures used to examine anatomical structures and evaluate physiological functions of each organ system

TEXT BOOK / REFERENCE BOOK

1. Ross and Wilson, Anatomy and Physiology in Health and Illness, Churchill Livingstone, 12th Edition 2019
2. Gerard. J. Tortora Principles of Human Anatomy and physiology, Harper Collins College Publishers, 9th Edition 2015
3. Arthur C. Guyton & John E. Hall, Text Book of Medical Physiology, W.B. Saunders Company, London, 12th Edition 2015
4. P. Saraswathi, Handbook of Anatomy for Nurses Jaypee Brothers Medical Publishers (P) Ltd, 3rd Edition 2018
5. Gillian Pocock, Christopher D. Richards, The human Body – An introduction for Biomedical and Health Sciences, Oxford University Press, USA, 2018
6. William F.Ganong, ―Review of Medical Physiology, 22nd Edition, Mc Graw Hill, New Delhi,2017

SBMB1401	FUNDAMENTALS OF DIGITAL SYSTEMS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To impart knowledge on various types of Binary logics.
- To motivate the students to apply Boolean algebra and study the basics of Logic expressions
- It focuses on combinational logic of digital systems.
- To understand the usage of registers and counters used in various digital circuits.
- To understand the functioning and usage of memory devices
- To get an exposure about the electronics behind design of Basic digital logical elements.

UNIT 1 NUMBER SYSTEM AND BOOLEAN ALGEBRA 9 Hrs.

Introduction to number systems- Types and Conversions, Binary Arithmetic, Signed Binary Numbers, Binary Codes - BCD, ASCII, Excess-3 codes, Gray codes, Boolean Algebra - De-Morgans Theorem, Reduction of Switching Equations Using Boolean Algebra. Realization of switching function

UNIT 2 LOGIC GATES AND MINIMIZATION TECHNIQUES 9 Hrs.

Introduction to logic gates- Design of two-level gate network-Two level NAND-NAND and NOR-NOR networks, Universal property of NAND and NOR gates, - Canonical SOP - Canonical POS – Minimization of SOP and POS- Karnaugh maps Advantages and Limitations- Tabulation method - Simplifications of Boolean functions using Tabulation method.

UNIT 3 COMBINATIONAL CIRCUITS 9 Hrs.

Binary Adder-Subtractor, Parallel Binary Adder, Parallel Binary Subtractor, Parallel Adder/Subtractor, Decoders, Encoders, Priority Encoders, Multiplexers and Demultiplexer, Magnitude Comparators-one bit and two bit, Code converters – Binary to Gray, Gray to Binary, Binary to BCD.

UNIT 4 SEQUENTIALCIRCUITS 9 Hrs.

Flipflops- SR, JK, T, D Characteristic and Excitation table, State Diagram representation of filpflops, Shift Registers, Counters –two bit and three bit Asynchronous and Synchronous Counters -UP/DOWN Counter – Realization of one flip flop with other flip flops.

UNIT 5 LOGICFAMILIES AND MEMORIES 9 Hrs.

Classification and Characteristics of Logic Families - Operation of RTL, DTL, HTL, ECL - Comparison of Logic Families Memories – Random Access Memory – Static RAM, Dynamic RAM, Read Only Memory, Programmable memory -EPROM, EEPROM.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course the students will be able to

CO1 - Remember the various types of Digital Number systems and Boolean algebra
CO2 - Understand about Minimization Techniques
CO3 - Implementation of various types of Combinational Circuits
CO4 - Analyze the operation of flip-flops and Shift register
CO5 - Design and implement the digital circuit using sequential logic.
CO6 - Comparison on Logic families and memories

TEXT BOOK / REFERENCE BOOK

1. Morris Mano, “Digital design-With an Introduction to the Verilog HDL”, 5th Edition, Pearson, 2013.
2. Thomas L Floyd, “ Digital Fundamentals”, 11th Edition, Pearson, 2015
3. Charles H.Roth, Fundamentals Logic Degisn, Jaico Publishing, 4th Edition, 2002.
4. William H. Gothmann, “Digital Electronics”, Prentice Hall, 2001.
5. John M. Yarbrough, “Digital logic: Applications and Design”, Thomas - Vikas Publishing House, 2002.
6. Malvino.A.P. and Donald.P.Leach, Digital Principal and Applications, 4 th Edition, Tata McGraw Hill, 2007

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB1402	DIGITAL SIGNAL PROCESSING AND ITS APPLICATION	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- This course will introduce the basic concepts and techniques for processing signals on a computer
- By the end of the course, the student will be familiar with the most important methods in DSP, including digital filter design, transform-domain processing.

UNIT 1 INTRODUCTION TO DISCRETE TIME SIGNALS AND SYSTEMS 9 Hrs.

Concepts of Signal processing - Advantages of digital signal processing compared with analog processing, representation of sampling theorem using MATLAB, Convolution - Linear convolution, Circular convolution, MATLAB code for Linear and Circular Convolution.

UNIT 2 FREQUENCY ANALYSIS OF SIGNALS 9 Hrs.

General computation of DFT - Introduction to Fast Fourier Transform - Radix-2 FFT algorithms - Decimation in time (DIT), Decimation in Frequency (DIF) algorithms, MATLAB simulation for DFT & IDFT, DIT and DIF FFT.

UNIT 3 DIGITAL FILTER DESIGNING 9 Hrs.

Introduction - Frequency selective filters - Digital versus Analog filters - Advantages & disadvantages of digital filters - Design of Low pass IIR filters using Butterworth and Chebyshev Filters, Designing of FIR Filters - Design of FIR filters using windows - rectangular window - Hamming Window - Hanning Window functions, MATLAB Simulation of FIR filters using hamming windows technique, M script to design an IIR Butterworth filter and chebyshev filter.

UNIT 4 BIOSIGNAL DETECTION AND COMPRESSION 9 Hrs.

QRS detection methods-Differentiation-based and template-based. Rhythm analysis and Arrhythmia detection algorithms. Matlab code for QRS Peak detection and Arrhythmia detection algorithm, Data compression techniques: Data reduction algorithms- Lossy and Lossless types, Turning Point algorithm.

UNIT 5 BIOSIGNAL ANALYSIS USING WAVELETS 9 Hrs.

Wavelets in Medicine: Need for wavelets, Types of wavelets, Selection of a wavelet for an application, Decomposition and reconstruction of signals using wavelets, Denoising using wavelets, Typical medical applications, demonstration of effect of the types of wavelets on medical images.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course the students will be able to

CO1 - Understand the basics of signal processing.
CO2 - Acquire knowledge to process the signals on a computer.
CO3 - Apply the acquired knowledge to process the biosignals on a computer.
CO4 - Analyse the various signals using different detection and compression techniques.
CO5 - Investigate the results of various compressed signals in their frequency domain.
CO6 - Develop the system to analyse the real time biosignals on a personal computer.

TEXT BOOK / REFERENCE BOOK

1. John G. Proakis& Dimitris G.Manolakis, Digital Signal Processing - Principles, Algorithms & Applications, 4th Edition, Pearson Education / Prentice Hall, 2007.
2. Haykin. S and Van Been. B., Signals and Systems, 2nd Edition, John Wiley & Sons, 2003.
3. Willis J.Tompkins, Biomedical Digital Signal Processing, Prentice Hall of India Pvt. Ltd., 2012.
4. Sanjit K. Mitra, Digital Signal Processing - A Computer Based Approach, Tata McGraw Hill, 2007.
5. Oppenheim, A.V., R.W. Schafer and J.R. Buck, Discrete Time Signal Processing, 8th Indian Reprint, Pearson, 2004.
6. Stephane Mallat, Wavelet Tour of Signal Processing: The Sparse Way, 3rd Edition, Academic Press, 2008
7. V. K. Ingle and J.G. Proaksis, J.G, “Digital Signal Processing-A MATLAB Based Approach”, Cengage Learning Publisher
8. S. Salivahanan, A. Vallavaraj and C. Gnanapriya, “Digital Signal Processing”, McGraw-Hill Publication

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB2401	DIGITAL SYSTEMS AND SIGNAL PROCESSING LAB	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

COURSE OBJECTIVE

- This course will introduce the basic designing concepts of logic gates.
- The course emphasizes intuitive understanding and practical implementations logic circuits
- To teach about the signal processing tool.
- To impart knowledge about the measurements and recordings of bioelectric and bio signals.

SUGGESTED LIST OF EXPERIMENTS

DIGITAL SYSTEMS LAB

1. Verification of Logic Gates.
2. Design of Half Adder and Full Adder.
3. Code converters.
4. Design of Encoder and Decoder.
5. Design of Multiplexer and Demultiplexer.
6. Design of Comparator.
7. Verification of State Transition of Flip Flops.
8. Design of Johnson and Ring Counter.
9. Design of Asynchronous Counter.
10. Design of Shift Registers.

SIGNAL PROCESSING LAB

List of Experiments created via MATLAB

11. Representation of basic signals
12. Sampling and Quantization
13. Fast Fourier transforms of the signals
14. Circular convolution and Linear convolution
15. Digital IIR filter (Butter worth &Chebyshev)
16. FIR filter design (Hamming &Hanning)
17. Correlation of the signals
18. Analysis of EEG & ECG, EMG signal
19. Detection of QRS complex in ECG
20. Analysis of bio signals for biomedical Applications

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the basics of logic gates and transducers

CO2 - Acquire knowledge to design the combinational circuits using logic gates and transducers for biomedical applications.

CO3 - Apply the acquired knowledge for designing of combinational circuits

CO4 - Analyse the various combinational circuits using logic gates in breadboard

CO5 - Investigate the results of various combinational circuits in breadboard

CO6 - Develop new circuits and transducers for implementing the biomedical applications.

S24BLH41	IMMUNOLOGY AND PATHOLOGY	L	T	P	EL	Credits	Total Marks
		3	0	2	0	4	100

COURSE OBJECTIVE

- To know the fundamentals of innate and acquired immunity.
- To understand how immune system fights and combats the infection and diseases.
- To know the control and preventive measures of pathophysiology of various disorders.

UNIT 1 FUNDAMENTAL CONCEPTS OF IMMUNOLOGY 9 Hrs.

History and Scope of Immunology, Innate and Acquired Immunity; Hematopoiesis, Cells of the immune system, Primary and Secondary lymphoid organs, Immune response-primary and secondary immune response.

UNIT 2 HUMORAL IMMUNITY 9 Hrs.

Antigens: Characteristics and Types of Antigens, Factors affecting the immunogenicity, Haptens, Adjuvants, Immunoglobulins: Basic structures, classes and sub classes; Monoclonal antibodies, Complement System-Alternate, Classical and Lectin pathways.

UNIT 3 CELL MEDIATED IMMUNITY 9 Hrs.

Structure, types and function of MHC, Exogenous and Endogenous pathways of antigen processing and presentation; Cytokines- Structure, function, application and regulation of the immune response, Hyper-Sensitivity-Type I, Type II, Type III and Type IV, Autoimmunity.

UNIT 4 IMMUNOTECHNOLOGY 9 Hrs.

Antigen-antibody reaction-Cross reactivity, Precipitation reactions, Agglutination reactions, Agglutination inhibition test Immuno diffusion and Immuno electrophoretic techniques, Immune fluorescence, ELISA.

UNIT 5 INFLAMMATION AND NEOPLASIA 9 Hrs.

Introduction to pathology, Necrosis, inflammation, acute and chronic inflammation, mediators of inflammation, apoptosis, neoplasia, classification, difference between benign and malignant tumor spread of tumors and etiology of tumors, leukemia and lymphoma. .

Max.15 Hrs.

PRACTICE EXERCISE

1. Determination of ABO blood grouping
2. Detection of CRP in human serum
3. Detection of Rheumatoid factor
4. Determination of O and H antigen using Widal slide test
5. Compare and characterize the antigen relationship Ouchterlony Double Diffusion method
6. Characterization of antibody by Immuno Electrophoresis techniques.

Max.60 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand overall concept of immune system.
CO2 - Acquire knowledge about different cells and organs involved in immune system.
CO3 - Recognize effectors molecules fight against infectious diseases.
CO4 - Demonstrate to produce monoclonal antibodies to diagnose and treat infectious diseases.
CO5 - Implement immune techniques to diagnose infectious diseases.
CO6 - Describes the basic elements in cell injury, inflammation and neoplasia.

TEXT BOOK / REFERENCE BOOK

1. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, Roitt's Essential Immunology, 13th Edition, Wiley-Blackwell Publishers 2017.
2. Ivan M. Roitt, Essential Immunology, 4th Edition, Blackwell Scientific Publications, Oxford, London, 2002.
3. Jenni Punt; Sharon Stranford; Patricia Jones; Judy Owen, Kuby Immunology, Eighth Edition, Macmillan, 2019
4. Vinay Kumar, Abul Abbas, Jon Aster, Robbins Basic Pathology, 10th Edition, ELSEVIER, 2017.

SCSBDPROJ	DESIGN THINKING AND INNOVATIONS	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

COURSE OBJECTIVE

- To apply knowledge in Real time problem solving.
- To foster innovation in design of products, processes or systems.
- To develop creative thinking in finding viable solutions to Engineering /Non-Engineering problems.

Activity 1: Design thinking introduction:
Phases of design thinking- a study approach - Group Discussion on Ideation- Users perspective - Formation of team – Thinking skills- Brain storming.

Activity 2: Problem identification (phase I)
Selecting user requirements - Survey on various user's applications - Specific Problem selection to proceed with the work – Team presentation on identified problems and various possible solutions.

Activity 3: Problem identification (Phase II)
Study of an application and its importance to end user. - Various models of an applications - Finalize the identified problem.

Activity 4: Design ideation and various stages
Sketch design diagram - Architecture or full diagrammatic study

Activity 5: Review and upgradation
Review of the ideation (one to one interaction) - Feedback - Upgradation plan

Activity 6: Implementation (Phase I)
Build the prototype using available resources - Record Module diagrams

Activity 7: Implementation (Phase II)
Display and review of the prototype. - Record its functionality and its Usage-Technical manual

Activity 8: Testing To test the product design with real time environment - Record Process-user manual

Activity 9: IPR-Activity I To study various IPR activities - To prepare for IPR Process - To file an IPR

Activity 10: Start-ups Formation
To exhibit the product to public: feedback approach - To prepare full documentation - Start-ups registration/apply patent/publish paper/submit model/prototype/Apply for seed/submit as research proposal

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

CO1 - Solve real world problems by applying knowledge across domains
CO2 - Develop various design products, processes or technologies for sustainable and socially relevant applications
CO3 - Demonstrate knowledge of resource utilization/budgets to Implement appropriate methodologies

CO4 - Execute tasks by application of engineering standards/ requirements/ design criteria, within timelines

CO5 - Conduct extended investigation that results in the translation of idea to product / production of a research thesis/ developing a proof of concept.

CO6 - Communicate well organized technical and scientific findings effectively in written and oral forms, following ethical and professional norms.

TEXT BOOK / REFERENCE BOOK

1. Mueller-Roterberg, Christian. "Handbook of Design Thinking." Hochschule Ruhr West (2018).
2. Design Kit by IDEO.org. "The field guide to human centered design." (2015), ISBN: 978-0-9914063-1-9.
3. https://www.interaction-design.org/literature/article/design-thinking-getting-started-with-empathy
4. https://www.interaction-design.org/literature/article/stage-4-in-the-design-thinking-process-prototype
5. https://www.interaction-design.org/literature/article/test-your-prototypes-how-to-gather-feedback-and-maximise-learning
6. https://uxplanet.org/what-are-insights-aa1f2d1b3b9c
7. https://labs.sogeti.com/using-design-thinking-to-design-business-models/
8. https://www.northeastern.edu/graduate/blog/implementing-business-model-innovation/

Course Assessment Methods

Direct Methods Design innovation Reviews, Report Submission, IPR Registration
Indirect Methods Course Exit Survey
Weightages

Assessment Method	Rubrics	Marks allotted	Assessment Type
Review 1	1	30	CAE
Internal Guide	2	10	CAE
IPR Process and Registration	5	10	ESE
Total – Internal		**50**	
Final Review	3	30	ESE
Report Submission	4	20	ESE
Total –External		**50**	

SBMB1501	BIOMECHANICS AND BIOFLUIDS	L	T	P	EL	Credits	Total Marks
		3	0	0	2	3	100

COURSE OBJECTIVE

- To observe the fundamentals of biomechanics and fluid mechanics.
- To distinguish properties and mechanics of hard and soft tissues.
- To apply techniques mastered in biomechanics to real life applications.

UNIT 1 BIOMECHANICS 9 Hrs.

Biomechanics- Definition and perspective, Fundamental Mechanical Concepts- Kinetics and Kinematics, Newton's Laws, Mechanical Properties -Stress, Strain, Elasticity, Shear, Tension, Compression, Plastic Deformation, Creep, and Fatigue. Mechanical testing of biomaterials-UTM- Basic Engineering mechanics, Force - Resolution of forces, Projectiles, All or None law

UNIT 2 FLUID MECHANICS 9 Hrs.

Viscosity-Definition, properties. Types of fluids- Newtonian fluid, non-Newtonian fluid, Types of fluid flow. Hagen- Poiseulle's equation. Viscoelasticity- Viscoelastic Models, Vascular tree, Flow properties of Blood, Physical, Chemical and Rheological properties of blood, Apparent and Relative and viscosity, Fahraeus- Lindqvist Effect.

UNIT 3 HUMAN LOCOMOTION AND RESPIRATORY MECHANICS 9 Hrs.

Anthropometric Characteristics of human body. Types of motion in humans, Gait analysis. Goniometry. Accelerometer, Foot Pressure Measurements - Pedobarograph-Force platform. Mechanics of foot. Alveoli mechanics, blood and lung interaction, PV curve of lungs, cardiac mechanics, fluid dynamics of aortic and mitral valves.

UNIT 4 HARD AND SOFT TISSUE MECHANICS 9 Hrs.

Biomechanics of upper extremities-Elbow, Shoulder. Biomechanics of lower extremities-Hip and Knee.- Tissue Mechanics-Mechanical Properties of Tissues, Biological materials, Properties of Cortical, Cancellous Bone. Soft Tissue properties Mechanical testing of Soft tissue.

UNIT 5 SPORTS MECHANICS 9 Hrs.

Application of biomechanics to neuromuscular fitness, gymnastics, Application of aerodynamics in sports, hydrodynamics in swimming. Analysis of throw and push patterns. Yoga Mechanics, Sports Medicine.

Max.45 Hrs.

COURSE OUTCOMES On completion of the course the students will be able to

CO1 - Interpret the different material properties to aid in selecting appropriate biomaterials.
CO2 - Identify the mechanics involved in flow of blood and viscosity.
CO3 - Predict the movements of human beings and lung mechanics.
CO4 - Analyse the biomechanics of hard and soft tissues.
CO5 - Establish the applications of biomechanics in different sports
CO6 - Generalize on distinct aspects of mechanics in the biological systems.

TEXT BOOK / REFERENCE BOOK

1. 1.Duane Knudson, Fundamental of Biomechanics, Kluwer Academic, Second Edition, 2020.
2. Shyamal Koley, Textbook of Biomechanics, AITBS, 2021
3. 3.Y. G. Fung, Biomechanics, Springer-verlag New York Inc, 2013

4. 4.Joseph Hamill and Kathleen M. Knutzen, Biomechanical Basis of Human Movement, Lippincott Williams & Wilkins, Third Edition, 2018.
5. 5.Peter McGinnis, Biomechanics of Sports and Exercise, Human kinetics,2020.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB1502	BIOSIGNAL CONDITIONING	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To gain in depth knowledge of fundamentals of operational amplifier circuits and to study the various applications using operational amplifiers.
- To discuss filters and circuits and introduce the application of signal conditioning in biomedical field.

UNIT 1 INTRODUCTION TO OPAMP 9 Hrs.

Introduction, Signal conditioning, 741 General purpose OPAMP: ideal characteristics, offset voltages and currents. Open &Closed Loop Configuration. Inverting, Non-Inverting, Summing, Voltage Follower, Integrator, differentiators, Log & Anti-Log Amplifiers, Differential Amplifiers, CMRR.

UNIT 2 APPLICATION OF OPAMP 9 Hrs.

Comparator-Zero crossing detector, Inverting and non-inverting comparator, Schmitt Trigger, Precision Rectifiers-Half wave and Full wave rectifiers, Peak detectors, Monostable, Astable multivibrators, Sawtooth generator, Triangular waveform generator, Sine Wave Generators-RC Phase Shift Oscillator, Wein Bridge oscillator.

UNIT 3 FILTERS 9 Hrs.

Introduction- Analog Filters, Active Filters and Passive Filters, First order and Second order Low Pass Filters, High Pass Filters, Band Pass Filters- Narrow Band Pass, Wide band Pass Filters, Band Reject Filters- Notch Filter, All Pass filters and higher Order Filters-Design and applications.

UNIT 4 DATA CONVERTERS AND TIMERS 9 Hrs.

Sample and Hold circuit - D/A converters: Resistive divider and R-2R ladder networks, inverted R-2R DAC. A/D converters: Counting type, Successive approximation, parallel comparator. Voltage to Current Converter, 555 Timer and its applications-Astable multivibrators and Monostable Multivibrator.

UNIT 5 BIOMEDICAL AMPLIFIER 9 Hrs.

Instrumentation amplifiers, Isolation Amplifiers –Optical and capacitive, Introduction to CMOS- CMOS instrumentation amplifier- voltage and power amplifier. Biomedical application of CMOS.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the working of linear and non-linear applications of operational amplifiers.
CO2 - Analyze waveform generation using operational amplifier.
CO3 - Evaluate the bio filters and isolation circuits used in signal conditioning.
CO4 - Design ADC and DAC using Operational Amplifiers.
CO5 - Examine the construction and working of CMOS and Instrumentation bio amplifiers.
CO6 - Recognize various bio amplifier for Biosignal acquisitions using opamps.

TEXT BOOK / REFERENCE BOOK

1. Ramakant A Gayakwad, Operational Amplifiers & Linear Integrated Circuits. Prentice Hall, Fourth edition, 2015.
2. Joseph J. Carr & John M. Brown, Introduction to Biomedical Equipment Technology, 4th edition, Pearson Education Pvt. Ltd, 2001.
3. Roy Choudhary &Shail Bala Jain, Linear Integrated Circuits, New Age International (P) Ltd, 2018.
4. DA Bell, Operational Amplifiers and Linear ICs 3rd Edition, 2021.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB1503	BIOMATERIALS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- The course provides an intriguing insight in chemistry, engineering, biology and medicine that has a significant impact on biomaterials.
- It highlights the way in which modern biology and medicine is inextricably linked to scientific discipline and helping us to understand the complex world of biomaterials.
- To implement the biomaterials for ophthalmic application to correct vision.

UNIT 1 METALLIC BIOMATERIALS 9 Hrs.

Biomaterials - Overview, Classification of biomaterials, Biocompatibility and Hemocompatibility, Metals and alloys -Stainless steel, Titanium and its alloys, Cobalt chromium alloy, Metallic corrosion, Dental implants - Impression Materials, Fillings and Restoration Materials, Materials for Deep Cavities, Material for oral and Maxillofacial Implants.

UNIT 2 SYNTHETIC POLYMERSANDAPPLICATIONS 9 Hrs.

Synthetic Polymers, Polymers in biomedical use, Polyethylene, Perfluorinated Polymers, Acrylic Polymers, Hydrogels, Polyurethanes, biodegradable synthetic polymers, silicone rubber, microorganisms in polymeric implants, Polymer Sterilization.

UNIT 3 BIOCERAMICSANDCOMPOSITES 9 Hrs.

Bio ceramics, types- Carbon, Alumina, Zirconia - bioactive resorbable and non – resorbable bioceramics, bioceramic coatings on metallic implants and bone bonding reactions on implantation, Hydroxyapatite-properties and applications. Composites-Types and Applications, Bioglass.

UNIT 4 HARD AND SOFT TISSUE REPLACEMENT 9 Hrs.

Bioelectric effect, Wolff's Law, Temporary orthopaedic fixation devices-pins, screws and plates, Intra Medullary and spinal nails, hard tissue replacements - total hip and knee joint replacements. Soft Tissue Replacements-Sutures-Tapes, Staples, Adhesives, Wound Dressings, Biomaterials in urological practice.

UNIT 5 BIOMATERIALS IN OPTHALMOLOGY AND BIOLOGICALTESTS 9 Hrs.

Ophthalmology- Introduction, Optical implants, Contact lenses, Eye shields, Viscoelastic solutions, Vitreous implants, Acrylate adhesives, Scleral buckling materials for retinal detachment, artificial tears, Biological Tests.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Identify different types of biomaterials used for various biomedical applications.
CO2 - Recognize various synthetic polymers, used as biomaterials for organ replacement.
CO3 - Understand different types of ceramics and composite used as biomaterials
CO4 - Acquire knowledge about hard tissue replacement and soft tissue replacement for various fixations.
CO5 - Apply knowledge about how to rectify eye defect using various biomaterials.
CO6 - Implement various methods to test Biocompatibility and Hemocompatibility test of biomaterials.

TEXT BOOK / REFERENCE BOOK

1. Sujata V.Bhat, Biomaterials, Narosa Publishing House, New Delhi, India, 2012.
2. William Wagner, Shelly Sakiyama-Elbert, Guigen Zhang, Michael Yaszemski, Biomaterials Science: An Introduction to Materials in Medicine, ELSEVIER, 4th Edition -, 2020
3. Park, Biomaterials an Introduction, Third Edition, Springer, 2007.
4. Joseph D Bronzino, The Biomedical Engineering Hand Book, Fourth Edition, CRC Press, 2015.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

S24BLH51	FUNDAMENTALS OF MICROPROCESSOR AND MICROCONTROLLER	L	T	P	EL	Credits	Total Marks
		3	0	2	0	4	100

COURSE OBJECTIVE

- The prime objective of this course is to introduce to the students the fundamentals of Microprocessor Microcontroller, ARM and Arduino Uno
- Learn to design, construct, program, verify, analyze and troubleshoot Microcontroller ARM and Arduino

UNIT 1 INTEL 8085 MICROPROCESSOR AND INTERFACING 9 Hrs.

Evolution of Microprocessor-Architecture of 8085-Instructionformat-Addressingmodes-Interruptsof8085-Software interrupts, Hardware interrupts- Interfacing devices-8255 Programmable Peripherals Interface-Architecture & various modes of operation- 8251 USART Architecture and programming features-8237.

UNIT 2 INTRODUCTION TO 8051 9 Hrs.

Introduction to 8-bit Microcontrollers – 8051/8051, Microcontroller Architecture – Internal RAM & Internal ROM, Instruction set, Addressing Modes- Simple programs.

UNIT 3 INTERNAL PERIPERALS OF 8051 9 Hrs.

Modes of Timer/Counter operation – Serial Port operation & Modes – Interrupt Structure of 8051 - Memory Interfacing with 8051 – I/O ports- Input and output devices interfacing with 8051.

UNIT 4 INTRODUCTION TO ARM ARCHITECTURE 9 Hrs.

Basic ARM Architecture- Introduction to the ARM Instruction set: Introduction, Data processing instructions, Load – Store instruction, Software interrupt instructions- THUMB instruction set Program status register instructions- Loading constants- ARMv5E extensions- Conditional Execution.

UNIT 5 ARDUINO UNO 9 Hrs.

Arduino – Architecture, Pin diagram, Programming Structure, working principles of sensors IOT deployment for Raspberry Pi /Arduino -Simple program to blink LED, Subroutine, 16x2 LED display, Interfacing with Arduino: LCD, Temperature Sensor, Humidity Sensor and ultrasonic sensor.

Max.15 Hrs.

PRACTICE EXERCISE

1. Study of 8-bit microprocessor 8 0 8 5 and 8051 microcontroller.
2. Addition and subtraction of 8-bit number with and without carry using 8 0 8 5
3. 8-bit multiplication and division using 8 0 8 5
4. Arranging n numbers in ascending and descending order using 8085
5. Addition and subtraction of 8-bit number with and without carry using 8051
6. 8-bit multiplication and division using 8051
7. Arranging n numbers in ascending and descending order using 8051.
8. Interfacing 8 0 8 5 with stepper motor.
9. Keyboard and Display interfacing with 8085.
10. Introduction to Arduino board.
11. Interfacing LCD display with Arduino.
12. Interfacing temperature sensor with Arduino.
13. Interfacing ultrasonic sensor with Arduino.

Max.60 Hrs.

COURSE OUTCOMES

On completion of the course the students will be able to

CO1 - Understand the feature of 8085 Microprocessor8051 Microcontroller
CO2 - Interpret the various peripherals devices with 8085 & 8051 microprocessor
CO3 - Design and implement programs on 8051 microprocessors.
CO4 - Examine various I/O devices with 8051 microcontrollers
CO5 - Analyse and understand the instruction set and development tools of ARM
CO6 - Implement the interface circuit with various sensor and I/O devices with microprocessor and microcontroller and Arduino Board.

TEXT BOOK / REFERENCE BOOK

1. Ramesh S Gaonkar, Microprocessor Architecture, Programming and application with 8085, 4th Edition, Penram International Publishing, New Delhi, 2000
2. KennithJ.Ayala, 8051 Microcontroller, Thomson, 2005.
3. CharlessM.Gilmore, Microprocessor Principle and Application, McGraw Hill Publication, 1995.
4. Nagoor Kani A., Microprocessor & Microcontroller, Tata McGraw Hill, 3rd Edition, 2012.
5. Ram B., Fundamentals of Microprocessors and Microcomputers, Dhanpat Rai Publications, 2001.
6. Michael Mc Roberts, beginning Arduino, 2nd Edition, 2013.
7. ARM System Developer's guide –Andrew N. SLOSS, ELSEVIER Publications, ISBN 978-81-8147-646-3, 2016

SBMB2501	BIOMECHANICS & BIOMATERIALS LAB	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

COURSE OBJECTIVE

- To enable students to learn the synthesis and characterization of Biomaterials
- To understand and analyze the mechanics of human body.

SUGGESTED LIST OF EXPERIMENTS

BIOMECHANICS LAB

1. Gait Analysis measurement and analysis.
2. Angle and Force Measurement Analysis of human body
3. Movement Analysis with Accelerometer
4. Measurement of foot pressure and force exerted using force platform.
5. Application into Rehabilitation and sports analysis.

BIOMATERIALS LAB

1. Synthesis of Nano Hydroxyapatite by Sol-Gel Method.
2. Synthesis of Bioactive Glass Ceramic Using Sol-Gel Method.
3. Synthesis of Hydro gels For Effective Wound Healing.
4. Bioactive Glass Reinforced PVA Scaffold for Effective Tissue Regeneration
5. Demonstration of operation and applications of 3D Printing.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the gait patterns of human body
CO2 - Analyze the working of accelerometer and goniometer to measure human movements.
CO3 - Apply the techniques to real time sports and rehabilitation scenarios.
CO4 - Apply the knowledge to characterize biomaterials prepared by sol gel method.
CO5 - Design a protocol for effective wound healing using scaffold.
CO6 - Create a methodology to prepare miniaturized biomaterial using 3D Printing.

SBMB2502	MEDICAL ELECTRONICS AND CIRCUIT DESIGNING LAB	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

COURSE OBJECTIVE

- This course will introduce the basic designing concepts of circuits using IC741.
- By the end of the course, the student will be familiar in the designing of circuits using electronic work bench.
- The course emphasizes intuitive understanding and practical implementations of linear integrated circuits using IC741.

SUGGESTED LIST OF EXPERIMENTS

1. Study of operational amplifier IC 741.
2. Inverting and non-inverting mode of operation.
3. Operational amplifier as summer and subtractor.
4. Operational amplifier as integrator and differentiator.
5. Instrumentation amplifier using electronic work bench
6. RC phase shift oscillator using electronic work bench
7. Design and implementation of Comparator to detect R peak using Op Amp.
8. Active high pass filter and Low pass (Second order)
9. Design of 50 Hz notch filter using Op Amp.
10. Design of band pass filter to filter the alpha wave of an EEG signal
11. Acquisition and Analysis of EOG signals using BIOPAC

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understands the basics of linear integrated circuits.
CO2 - Acquire knowledge to design the circuits using IC741.
CO3 - Apply the acquired knowledge for designing of linear integrated circuits.
CO4 - Analyse the various circuits using IC741 in breadboard.
CO5 - Investigate the Biosignals using BIOPAC
CO6 - Develop new circuits for biomedical applications using electronic work bench.

SBMB1601	DIAGNOSTIC INSTRUMENTATION	L	T	P	EL	Credits	Total Marks
		3	0	0	2	3	100

COURSE OBJECTIVE

- To gather knowledge about measurements of parameters from humans.
- To learn about different instruments used for diagnosis of diseases.
- To propose designs to manufacture diagnostic equipment.

UNIT 1 INTRODUCTION AND GENERAL-PURPOSE EQUIPMENT 9 Hrs.

Basic Medical Instrumentation system and performance requirements, Intelligent medical Instrumentation systems, Basic Audiometer – Bekesy audiometer, Conventional and Digital Hearing aids, BERA Test, Spirometry, Pneumotachometers. Auto Refractometer, Retinoscope, Tonometer's.

UNIT 2 BIOMEDICAL RECORDERS 9 Hrs.

ECG-Lead Configuration-Instrumentation set-up - Artifacts. Arrhythmia Monitors, EEG-10-20 Electrodes configuration - Instrumentation - Evoked potentials, Magnetoencephalogram EMG - Measurement of nerve conduction velocity. ERG, EOG, EGG, PCG, Ambulatory Monitors.

UNIT 3 IMAGING EQUIPMENTS 9 Hrs.

X-Ray machine, Dental X Ray Machine, Mobile Units, Computed Tomography - Gantry Scanning system & Instrumentation. MRI - The magnet, RF transmitter system, Gradient system, imaging system, Safety considerations, Ultrasonic imaging systems – Instrument & Scan modes, Echocardiography, Thermographic Equipment- Camera and Detectors

UNIT 4 FLOW METERS & PSYCOPHYSIOLOGICAL SYSTEMS 9 Hrs.

Flow meters - Electromagnetic flow meters, Ultrasonic Blood flow meters, Laser Doppler Flowmeter, Point of Care Devices- Glucometer, Polygraph GSR Measurement

UNIT 5 PATIENT MONITORING SYSTEMS 9 Hrs.

BP measurement - Direct and indirect method, Pulse measurement, Temperature measurement, Respiration Rate Measurement, Apnea Monitors, Central monitoring system. Endoscopy and types, Laparoscopy, Oximetry, Neonatal Instrumentation.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course the students will be able to

CO1 - Discuss on the measurement systems and instruments for respiration, eye and hearing diagnosis.
CO2 - Explore the instruments used to record Biosignals.
CO3 - Understand and discuss about the various image acquisition machines.
CO4 - Evaluate the flowmeters and point of care devices.
CO5 - Examine the equipment for patient monitoring in hospitals.
CO6 - Apply the knowledge acquired to design diverse diagnostic equipment.

TEXT BOOK / REFERENCE BOOK

1. R. S. Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill Publication company Ltd, New Delhi, 2016.
2. Joseph J. Carr, John Michael Brown, Introduction to Biomedical Equipment Technology 4th edition, Pearson Education.2012
3. John G. Webster, Biomedical Instrumentation, Wiley Publications.5th edition,2020.
4. R. AnandaNatarajan, Biomedical Instrumentation & Measurements, PHI Publication, 2015.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SEEB1604	BIOLOGICAL CONTROL SYSTEMS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To study physical system with mathematical and electrical analogues.
- To study the system efficiency and stability using time domain and frequency domain techniques.

UNIT 1 SYSTEM CONCEPTS 9 Hrs.

Types of systems - Open loop systems, closed systems, Effects of feedback, Block diagram algebra and Signal flow graphs, Mathematical Models of Physical systems: Differential equations, Transfer functions and block diagrams of simple electrical networks, Translational and Rotational mechanical systems.

UNIT 2 TIME RESPONSE ANALYSIS OF CONTROL SYSTEMS 9 Hrs.

Standard test signals, Time response of first order and second order systems with unit step as input, Time domain specification, steady state errors and static error constants, P, PI, PD and PID controllers, Concept of stability and Algebraic Criteria.

UNIT 3 THE CONCEPT OF STABILITY & ROOT LOCUS TECHNIQUE 9 Hrs.

The concept of stability, Routh stability criterion qualitative stability and conditional stability. the Root locus concept, construction of root loci.

UNIT 4 FREQUENCY RESPONSE ANALYSIS 9 Hrs.

Frequency response of the systems - Correlation between time and frequency responses - Gain and phase margins, Bode plots, Polar Plots, Nyquist stability Criteria.

UNIT 5 BIOMEDICAL APPLICATIONS 9 Hrs.

Examples of Biological control Systems: Cardiovascular Control System, Endocrine Control Systems, Pupil Control System, Skeletal Muscle Servomechanism, Oculo - motor system, sugar level Control Mechanism. Temperature control, Blood pressure control, Example of physiological control system, difference between engineering and physiological control systems, linear models of physiological systems-Examples.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the basics of physical systems and mathematical model of electrical systems
CO2 - Acquire knowledge to process the physical systems using mathematical expressions.
CO3 - Apply the acquired knowledge to process the physical systems to check the stability.
CO4 - Analyse the various physical systems in both time and frequency domain
CO5 - Investigate the results of various physical systems in their frequency domain
CO6 - Develop the system to analyse the real time biosignals in time and frequency domain.

TEXT / REFERENCE BOOKS

1. Nagrath J. and Gopal, Control Systems: Engineering, New Age International Pvt. Ltd., Publishers, 7th Edition, 2021.
2. Richard C. Dorf, Robert H. Bishop, “Modern control systems”, Thirteen edition, Pearson, 2017.
3. Gopal M., “Control Systems Principles and Design”, Tata McGraw Hill, 2008.
4. Sinha N.K., Control Systems, 4th Edition, New Age International Pvt. Ltd. Publishers, 2013.
5. Nageswara Rao, Control Systems, 3rd Edition, A.R. Publications, 2003.
6. Michael C.K. Khoo, “Physiological Control Systems”, IEEE Press, Prentice Hall of India, 2018.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB2601	DIAGNOSTIC INSTRUMENTATION LAB	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

COURSE OBJECTIVE

- To provide hands-on knowledge on different diagnostic and therapeutic equipment.
- To demonstrate and analyse various bio signals.

SUGGESTEDLISTOFEXPERIMENTS

1. ECG monitoring using trainer kit and real time monitoring.
2. Plot respiratory waveforms using Spirometer
3. Measuring pulse rate and analyse waveforms.
4. Phonocardiogram monitor
5. Multi parameter monitoring system
6. Respiration rate analysis
7. Measurement of EMG signals.
8. EEG monitoring using simulator.
9. Medical telemetry system to transmit and receive ECG signals.
10. Human auditory response using an Audiometer

COURSE OUTCOMES

On completion of the course the students will be able to

CO1 - Measure different bioelectrical signals using various methods
CO2 - Illustrate various diagnostic and therapeutic techniques
CO3 - Analyze the different bio signals using suitable tools
CO4 - Apply the learnt knowledge to design or troubleshoot instruments.
CO5 - Acquire skills to operate medical equipment.
CO6 - Design cost effective and simple biomedical instruments.

S24BPB61	MEDICAL IMAGE PROCESSING	L	T	P	EL	Credits	Total Marks
		3	0	2	0	4	100

COURSE OBJECTIVE

- To acquire knowledge about the various medical imaging techniques
- To impart knowledge on segmentation, compression, recognition and analyze images
- To understand the fundamental principle and working of the medical imaging systems involved in the diagnosis of health care.

UNIT 1 IMAGE FUNDAMENTALS 9 Hrs.

Introduction - Steps in Digital Image Processing – Components of image processing, Image Sampling and Quantization – Gray level transformations - Histogram processing. Basics of Spatial Filtering - Smoothing and Sharpening Spatial Filtering.

UNIT 2 IMAGE ENHANCEMENT AND RESTORATION 9 Hrs.

Enhancements in Frequency Domain -low pass filtering - High pass filtering. Model Image Restoration - degradation model, Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering.

UNIT 3 IMAGE SEGMENTATION AND VISUALIZATION 9 Hrs.

Edge and Line Detection, Edge linking via Hough transform – Thresholding - Region based segmentation – Region growing – Region splitting and merging, Morphological processing- erosion and dilation, Data Visualization and types of visualization.

UNIT 4 IMAGE COMPRESSION AND RECOGNITION 9 Hrs.

Fundamentals, Image compression models, Huffman, Run Length Encoding, Arithmetic coding, Lossless Predictive Coding and Lossy Predictive Coding, Boundary representation, Boundary descriptors - Fourier Descriptor, Regional Descriptors –Topological feature, Texture, Patterns and Pattern classes - Recognition based on matching.

UNIT 5 MEDICAL APPLICATIONS OF IMAGING 9 Hrs.

Computer-aided diagnosis in mammography, Tumour imaging and treatment, Angiography, Bone strength and osteoporosis, Tortuosity, Software implementation of medical image processing-Enhancement-Histogram processing of Images - Extraction of shape and texture features from an image- Image segmentation using thresholding and region-based method-Morphological Operations-Multiresolution analysis of images using wavelets-Image compression using lossless and lossy methods.

Max.15 Hrs.

PRACTICE EXERCISE

1. Arithmetic operations on images, Image Negative, Image Cropping
2. Histogram Processing–Techniques
3. Line and Edge detection
4. FFT and DCT of images
5. Contact stretching, Threshold Technique-Enhancement
6. Adaptive filters. Sharpening and smoothing Filters.
7. Restoration Filters-Median Filtering, Mean, Min-Max, Bandpass/Rejects, and notch.
8. Basic Morphological Operations
9. Segmentation using watershed transform
10. Extraction of shape and texture features from an image

Max.60 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Describe the digital image fundamentals for a given condition
CO2 - Illustrate the effect of image enhancement techniques on images
CO3 - Distinguish between image restoration filters
CO4 - Discuss about the image segmentation procedure
CO5 - Compute the level of compression achieved for the given image data
CO6 - Explain and compute features useful for image representation and recognition

TEXT / REFERENCE BOOKS

1. Nagrath J. and Gopal, Control Systems: Engineering, New Age International Pvt. Ltd., Publishers, 7th Edition, 2021.
2. Richard C. Dorf, Robert H. Bishop, “Modern control systems”, Thirteen edition, Pearson, 2017.
3. Gopal M., “Control Systems Principles and Design”, Tata McGraw Hill, 2008.
4. Sinha N.K., Control Systems, 4th Edition, New Age International Pvt. Ltd. Publishers, 2013.
5. Nageswara Rao, Control Systems, 3rd Edition, A.R. Publications, 2003.
6. Michael C.K. Khoo, “Physiological Control Systems”, IEEE Press, Prentice Hall of India, 2018.

SBMB1701	THERAPEUTIC INSTRUMENTATION	L	T	P	EL	Credits	Total Marks
		3	0	0	2	3	100

COURSE OBJECTIVE

- To acquire knowledge on the different therapeutic equipment available in the healthcare industry
- To understand the fundamental principles and working of the biomedical instruments involved in the therapy.

UNIT 1 INSTRUMENTS FOR CARDIOLOGY 9 Hrs.

Cardiac Pacemakers – Evolution of pacemakers, Need for Cardiac Pacemaker - External Pacemakers - implantable Pacemakers - Recent Developments in Pacemakers, Pacemaker analyzer. Cardiac Defibrillators -Need for a Defibrillator - DC Defibrillator – Automatic Implantable Defibrillators (AID) - Pacer-cardioverter - defibrillator analyzers, LVAD, IABP Machine- Working

UNIT 2 DIATHERMY AND ELECTROTHERAPY EQUIPMENT 9 Hrs.

Surgical diathermy machine – Principle -Working, Hazards and safety aspects in ESU. High frequency heat therapy - Short wave Diathermy - Microwave diathermy - Ultrasonic diathermy - TENS – Interferential Current Therapy –IFT therapy unit, Bladder Stimulators - DBS.

UNIT 3 EXTRACORPOREAL UNITS 9 Hrs.

Hemodialysis Machines - Artificial Kidney - Dialyzers - Membranes, Peritoneal Dialysis -Portable Kidney machines. Lithotripters – First and modern lithotripter systems - Extracorporeal Shockwave Therapy, Heart Lung Machine – Oxygenators-Pumps, Cryogenics.

UNIT 4 PULMONARY ASSIST INSTRUMENTS 9 Hrs.

Anesthesia Machine –Components - Electronics in Anesthesia machine. Ventilators – Types and classification- Modern microprocessor-based ventilators, HF Ventilators, Humidifiers - Nebulizers and Aspirators.

UNIT 5 DRUG DELIVERY AND NEONATAL SYSTEMS 9 Hrs.

Infusion Pumps- Components- Implantable infusion pumps -Insulin Pumps- Syringe Pumps, Peristalitic Pumps, Incubators-Radiant Warmer – Phototherapy Units.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Infer on the components required to design a pacemaker and defibrillator.
CO2 - Discuss on the use of heat and electricity in instruments for therapy.
CO3 - Evaluate the working of dialysis machines and lithotripters.
CO4 - Demonstrate the working of an anaesthesia machine and ventilators.
CO5 - Assess equipment utilised in paediatric care and drug delivery units.
CO6 - Design various therapeutic devices based on the knowledge gathered.

TEXT BOOK / REFERENCE BOOK

1. R. S. Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill Publication company Ltd, New Delhi, 2016.
2. Joseph J. Carr, John Michael Brown, Introduction to Biomedical Equipment Technology 4th edition, Pearson Education.2012
3. John G. Webster, Biomedical Instrumentation, Wiley Publications.5th edition,2020.
4. Andrew G Webb, Principles of Biomedical Instrumentation, Cambridge Press,2018

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

S24BLH71	BIOVIRTUAL INSTRUMENTATION	L	T	P	EL	Credits	Total Marks
		3	0	2	0	4	100

COURSE OBJECTIVE

- To introduce the concept of virtual instrumentation.
- To enable them to design applications in the field of biomedicine.

UNIT 1 INTRODUCTION 6 Hrs.

Historical perspective, advantages, block diagram and architecture of a virtual instrument, data-flow techniques, data types and data structures, graphical programming in data flow, comparison with conventional programming, Front Panel, and block diagram objects.

UNIT 2 PROGRAMMING TECHNIQUES 9 Hrs.

VIS and sub-VIS, loops & charts, arrays, clusters, graphs, case & sequence structures, formula modes, local and global variable, string & file input. Publishing measurement data in the web. Flat and Stacked sequence structures - Event structures- Formula Node.

UNIT 3 DATA COMMUNICATION & SYNCHRONIZATION 9 Hrs.

Local, global, and shared variables – Data Socket - TCP and UDP – Synchronization – Notifiers – Queues - VI Server - configuring the VI Server - Error handling VIs and functions - Debugging tools and techniques.

UNIT 4 DESIGN OF INTEGRATED REAL-TIME BIOMEDICAL SYSTEMS 9 Hrs.

Getting started with LabVIEW Field-Programmable gate array (FPGA) 2 7. Programming using LabVIEW FPGA - Synchronizing FPGA loops and I/O 2 8. Sharing physiological data like ECG, EEG etc, on FPGA.

UNIT 5 APPLICATION OF VI 12 Hrs.

Fourier Transforms, Power spectrum, Correlation methods, windowing & flittering. temperature data acquisition system, VI based ECG monitor, ECG and EEG signal Processing, Image acquisition and processing, – ON/OFF controller – P-I-D controller – Emulation of CRO - Simulation of a simple second order system – Generation of HTML page.

Max.15 Hrs.

PRACTICE EXERCISE

1. Wave form generator
2. Temperature Analyzer
3. Band pass filter
4. 60 Hz notch filter
5. Simulation of Bio signals and data logging
6. Acquire, Process, Analyze and saving of data
7. Arrhythmia Detector
8. Heart rate detector
9. EEG Analyzer for seizure detection
10. Simulation of pace maker

Max.60 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the basic concepts of virtual instrumentation.
CO2 - Acquire knowledge about the programming techniques in LabVIEW.
CO3 - Apply the knowledge in acquiring real time data.
CO4 - Analyse the integrated real-time design of biomedical systems using LabVIEW.
CO5 - Explore the techniques used to process and analyse bio signals.
CO6 - Develop LabVIEW based real time biomedical devices.

TEXT BOOK / REFERENCE BOOK

1. Kevin James, P.C. Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newnes, 2000.
2. Gupta S., Gupta J.P., PC Interfacing for Data Acquisition and Process Control, ISA, 2nd Edition, 2004.
3. Technical Manuals for DAS Modules of Advantech and National Instruments, 2008.
4. Jerome, Virtual Instrumentation Using LabView, PHI, 2010.
5. Jon B. Olansen, Eric Rosow, Virtual Bio-Instrumentation: Biomedical, Clinical, and Healthcare Applications in LabVIEW, 2001.

SBMB2701	THERAPEUTIC INSTRUMENTATION LAB	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

COURSE OBJECTIVE

- To provide hands-on knowledge on different therapeutic equipment.
- To demonstrate and analyse various bio signals.

SUGGESTEDLISTOFEXPERIMENTS

THERAPEUTIC INSTRUMENTS

1. Cutting and coagulation using Surgical Diathermy machine.
2. Working of Defibrillator
3. Study of Hemodialysis machine
4. Demonstration of Ventilators
5. Study of Shortwave diathermy
6. Design a Pacemaker circuit using modules.
7. Stimulate nerves using a nerve stimulator
8. Study of Heart lung machine model
9. Working of anesthesia machine.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Measure different bioelectrical signals using various methods.
CO2 - Illustrate various therapeutic techniques.
CO3 - Analyze the different bio signals using suitable tools.
CO4 - Apply the learnt knowledge to design or troubleshoot instruments.
CO5 - Acquire skills to operate medical equipment.
CO6 - Design cost effective and simple biomedical instruments.

SBMB3001	MEDICAL EQUIPMENT MAINTENANCE AND TROUBLESHOOTING	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To identify and learn the troubleshooting of instruments used for diagnosis and therapy
- To understand how to maintain and service the overall working of any medical equipment.
- To acquire an idea about the basic troubleshooting procedures for biomedical equipment

UNIT 1 INTRODUCTION 9 Hrs.

Causes of Equipment Failure, testing of electrical equipment: AC, DC power supply, Grounding, shielding, Guarding, insulation testing, insulation resistance measurement, Types of Circuit Breakers, Rating - Testing of circuit breakers – Transformer testing- Earthing –Earth wires - Earthing of appliances – contactor, relay testing–CT and PT, Megger-Testing equipment and instruments.

UNIT 2 TESTING AND TROUBLESHOOTING 9 Hrs.

Testing of electronic components: Troubleshooting of PCB boards, Calibration of analog and digital sensor probes, Display interface, DC Power supply design, testing, Safe electrical practice, Cables, and standard, Fuse.

UNIT 3 TESTING OF MEDICAL EQUIPMENT 9 Hrs.

Testing of Surgical Equipment: Functions and operating procedure-Testing and maintenance of Heart lung machine, surgical lights, ventilator, patient monitor, anesthesia machine, dialyzer, and surgical tools.

UNIT 4 TROUBLESHOOTING OF MEDICAL EQUIPMENT 9 Hrs.

Troubleshooting of equipments: X-ray machines, Troubleshooting of ECG recorders, Ultrasound machines incubator, baby warmer, infusion pumps, Patient Monitors, annual maintenance, contract requirements, vendor services, quality and safety standards.

UNIT 5 MAINTENANCE MANAGEMENT 9 Hrs.

Objectives, Maintenance Policy, Contracts and Provisions, Essentials of a Good Equipment Program, Installation Procedures, Service and Maintenance laboratory, Documentation, Professional Qualities, and Work Habits.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Identify the instruments used to recognize faults in equipment.
CO2 - Compare general testing and troubleshooting of equipment.
CO3 - Analyze faults occurring in operation theatre instruments.
CO4 - Discuss the troubleshooting of medical equipment and safety standards.
CO5 - Summarize how to manage the maintenance files and documents.
CO6 - Apply the tools in design, testing and developing medical equipment

TEXT BOOK / REFERENCE BOOK

1. 1.Shakti Chatterjee, Aubert Miller, “Biomedical Equipment Repair”, Cengage Learning Technology & Engineering, 2018.
2. 2.David Herres, “Troubleshooting and Repairing Commercial Electrical Equipment”, McGraw Hill Professional edition, 2016.
3. 3.Rao S, “Testing, Commissioning, Operation and Maintenance of Electrical Equipment”, Khanna Publishers, New Delhi, 2014.
4. 4.Francis Hegarty, John Amoore, “Health care technology management – A systematic approach” CRC Press, USA, 2017.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3002	MEDICAL ROBOTICS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To expose the students to the field of medical (surgical and oncology) robotics.
- To understand the design aspects of medical robots.

UNIT 1 INTRODUCTION 9 Hrs.

Definition and origin of robotics, Generations of robots, - Robotics system components – Robot classification Coordinate frames, Asimov's laws of robotics. Degrees of freedom – dynamic stabilization of robots - work volume.

UNIT 2 ROBOT DRIVE SYSTEMS AND END EFFECTORS 9 Hrs.

Pneumatic Drives-Hydraulic Drives-Mechanical Drives-Electrical Drives-D.C. Servo Motors, Stepper Motors, A.C. Servo Motors-Salient Features, End Effectors-Grippers-Mechanical Grippers, Pneumatic and Hydraulic- Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers.

UNIT 3 SENSORS AND TRACKING 9 Hrs.

Localization And Tracking, Position sensors requirements - Tracking - Mechanical linkages - Optical - Sound-based - Electromagnetic - Impedance-based - In-bore MRI tracking - Video matching - Fiber optic tracking systems - Hybrid systems, Basic control concepts -impedance, admittance.

UNIT 4 SURGERY AND IMAGING 9 Hrs.

Minimally Invasive Surgery (MIS), Human-machine interfaces, Robot design concepts, Video images in MIS, Augmented reality Image-Guided Interventions, Robot compatibility with medical imagers (e.g., MRI, US, X-ray, CT), Image segmentation and modeling, Tracking devices, Surgical navigation, Calibration.

UNIT 5 APPLICATIONS/ CASE STUDIES 9 Hrs.

Cardiac, abdominal, and urologic procedures with teleoperated robots, Robotic catheters for heart electrophysiology, Orthopedic surgery with cooperative robots, Mobile robots in the body, Biologically Inspired Robots, socially assistive robotics, and Rehabilitation robotics.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Describe the types of medical robots and the concepts of navigation and motion replication.
CO2 - Discuss the sensors used for localization and tracking
CO3 - Summarize the applications of surgical robotics
CO4 - Classify the types of assistive robots
CO5 - Apply robotics to the healthcare field.
CO6 - Analyze the design characteristics, methodology, and technological choices for medical robots

TEXT BOOK / REFERENCE BOOK

1. 1.Thomas Bräunl, Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems, Third Edition, Springer-Verlag Berlin Heidelberg, 2018.
2. Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2016.
3. Daniel Faust, "Medical Robots", Rosen Publishers, 2016.
4. Jocelyne Troccaz, "Medical Robotics", Wiley, 2015.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3003	MEDICAL OPTICS AND LASER APPLICATIONS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To introduce the concept of optical properties of tissues and their measurements.
- To have knowledge of Lasers used in medicine.
- To analyze the applications of Lasers for diagnosis surgery and therapy.

UNIT 1 OPTICAL PROPERTIES 9 Hrs.

Refraction, Scattering, Absorption, Instrumentation for absorption, Scattering and emission measurements, Light transport inside the tissue, Tissue properties Laser tissue Interaction-Chemical-Thermal Electromechanical.

UNIT 2 LASERS USED IN MEDICINE 9 Hrs.

Types of lasers, construction and working principle of solid-state laser, atomic laser, Molecular laser, Liquid dye laser, Diode laser, Solid state dye laser.

UNIT 3 SURGICAL APPLICATIONS OF LASERS 9 Hrs.

Lasersinophthalmology-Dermatology–Typesoflasersusedindermatology, Cosmetic dermatology–Dentistry-TypesofDentallasers-Urology–Surgicaltherapyinurology–Cardiology, Oxyhemoglobin-Tissue welding–Specifications.

UNIT 4 NON-THERMAL DIAGNOSTIC APPLICATIONS 9 Hrs.

Optical coherence tomography, Elastography, Laser induced fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM–Holo graphic and speckle application of lasers in biology and medicine.

UNIT 5 THERAPEUTIC APPLICATIONS 9 Hrs.

Phototherapy, Photodynamic therapy (PDT)-Principle and Mechanism-Oncological and non-oncological applications of PDT-Bio stimulation effect–applications-Laser Safety Procedures.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understandthebasicconceptsofopticalpropertiesandtheirinteractionwiththetissues
CO2 - AcquireknowledgeaboutthevariouskindsofLasersusedinmedicine
CO3 - ApplythelaserstechniquesinSurgery
CO4 - AnalysetheapplicationofLaserindiagnosis
CO5 - ExploretheLasertechniquesusedintherapy
CO6 - IdentifytheuseofLasersthatcanbeusedforspecificmedicalapplication

TEXT BOOK / REFERENCE BOOK

1. Abraham Katzir, Lasers and Optical Fibers in Medicine, AcademicPress Edition,1998.
2. TuanVoDirh, Biomedical Photonics–Handbook, CRC Press, Bocaraton,2003.
3. G. David Baxter, Therapeutic Lasers–Theory and practice, Churchill Livingstone Publications Edition-2001.
4. Helena Jelinkova, “Lasers for medical applications: Diagnostics, Therapy and Surgery”, Woodhead Publishing,1stedition,2013.
5. MarkolfH.Neimz, “Laser tissue interactions-Fundamentals and applications”, Springer,3rd edition,2014.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3004	REHABILITATION ENGINEERING	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To design assistive devices, prosthetics, and orthotics for the disabled.
- To provide the basic concept so that the students can implement their knowledge for developing innovative and effective rehabilitation and assistive technologies.
- To explore the advanced technologies in rehabilitation engineering.

UNIT 1 INTRODUCTION TO REHABILITATION 9 Hrs.

Introduction, Concepts of rehabilitation engineering, Principles of Rehabilitation Engineering - Key Engineering Principles - Key Ergonomic Principles, Principles of Assistive Technology Assessment, Rehabilitation Team., Adaptive Sports and Recreation Technology.

UNIT 2 ORTHOTICS & ORTHOPROSTHETICS 9 Hrs.

Orthopedic prosthetics and orthotics in Rehabilitation Fundamentals, Applications: Computer Aided Engineering in customized component design. Intelligent prosthetic knee and hand. A self-aligning orthotic knee joint. FES System: Restoration of hand function; restoration of standing and walking. Body Powered Prosthetics, Hybrid Assistive Systems (HAS) Active prostheses. Active Above-knee Prosthesis. Myoelectric hand and arm prostheses. Orthotics - FO, AFO, TLSO, LSO

UNIT 3 WHEELED MOBILITY 9 Hrs.

History and Categories of Wheelchairs. Wheelchair Structure and Component Design. Ergonomics of wheelchair propulsion. Power Wheelchair Electrical System. Solar Powered Wheelchairs, Personal transportation. Tricycles, Lift mechanism in an ambulance

UNIT 4 SENSORY AUGMENTATION AND SUBSTITUTION 9 Hrs.

Visual System: Visual augmentation. Tactual vision substitution. Auditory vision substitution: Auditory System: Auditory augmentation. Cochlear implants. Visual auditory substitution. Tactual auditory substitution. Tactual system: Tactual augmentation. Tactual substitution. Alternative and Augmentative Communication, User Interface: Outputs: Acceleration Techniques, HAAT model. Artificial larynx, biofeedback in communicative disorders

UNIT 5 ADVANCED APPLICATIONS IN REHABILITATION ENGINEERING 9 Hrs.

Computer-assisted lip reading, Brain-computer interface, Smart Sensors for Activity Recognition, Robotics for Medical Rehabilitation, Neuro Rehabilitation, Visual Aids, Hearing Aids, Writing Aids Electronic Travel Applications (ETA): Path Sounder, Laser Cane, Ultrasonic Torch, Nottingham Obstacle Sensor, Polarized Ultrasonic Travel Aid, IOT assisted Smart Devices for visually impaired

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Apply the various principles involved in rehabilitation.
CO2 - Develop orthotic and prosthetic devices for assisting disabled persons.
CO3 - Categorize the types of wheelchairs to assist disabled persons.
CO4 - Evaluate new augmentation and substitution devices for the visual and hearing impaired.
CO5 - Summarize the new technological devices to aid disabled people.
CO6 - Develop and design rehabilitation devices cost-effectively and purposefully

TEXT BOOK / REFERENCE BOOK

1. J.D. Bronzino, The Biomedical Engineering Hand Book, Volume 1, Academic Press. 2016.
2. Textbook of rehabilitation, Sunder, Jaypee Publications, 2015
3. Intelligent Systems for Rehabilitation Engineering, by Roshani Raut, Pranav Pathak, Sandeep Kautish, Pradeep N., Wiley-Scrivener, 2022,
4. Marion A. Hersh, “Assistive Technology for Visually Impaired and Blind People”, CRC Press, 2014.
5. Yves Rybarczyk, Assistive and Rehabilitation Engineering, Intech open, 2019.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3005	WEARABLE SYSTEMS FOR HEALTHCARE	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To impart the importance of smart sensors, sensor interface standards for wearable device applications
- Identify the need for the development of wearable devices and its implications on various sectors
- Comprehend the design and development of various wearable bioelectrode and physiological activity monitoring devices for use in healthcare applications.

UNIT 1 SENSORS FOR WEARABLE SYSTEMS 9 Hrs.

Need for wearable systems, Sensors for wearable systems-Inertia movement sensors, Respiration activity sensors, Inductive plethysmography, Impedance plethysmography, pneumography, Radiant thermal sensor, Wearable motion sensors, Wearable biochemical Sensors, and Wearable gas sensors.

UNIT 2 SIGNAL PROCESSING AND ENERGY HARVESTING 9 Hrs.

Wearability issues -physical shape and placement of the sensor, technical challenges – sensor design, signal acquisition, lightweight signal processing, Rejection of irrelevant information, Solar cell, Vibration-based, Thermal based, Human body as a heat source for power generation, Hybrid thermoelectric photovoltaic energy harvests.

UNIT 3 SCOPE OF WEARABLE DEVICES 9 Hrs.

Role of Wearables, Attributes of Wearables, The Meta Wearables – Textiles and clothing, Social Aspects: Interpretation of Aesthetics, Adoption of Innovation, On-Body Interaction; Wearables: Challenges and Opportunities, Future and Research Roadmap.

UNIT 4 WIRELESS SYSTEMS AND IOT 9 Hrs.

Need for wireless monitoring, Definition of Body area network, BAN and Healthcare, Technical Challenges- System security and reliability, BAN Architecture – Introduction, IoT- Definition and characteristics of IoT, Physical design of IoT, IoT functional blocks, IoT levels, IoT design methodology.

UNIT 5 APPLICATIONS OF WEARABLE DEVICES 9 Hrs.

Medical Diagnostics, Medical Monitoring-Patients with chronic disease, Elderly patients, arthritic patients, multi-parameter monitoring, Gait analysis, Sports Medicine, Smart Fabrics.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Discuss and analyse the usage of various biochemical and gas sensors as wearable devices.
CO2 - Identify the technical challenges for signal processing and Energy Harvesting.
CO3 - Describe the scope of the wearable devices and its design constraints for measuring physical and biological signals.
CO4 - Design and develop various wearable device for detection of physiological body signals, blood pressure and body temperature for use in healthcare applications.
CO5 - Acquaint the usage of wearable devices as assistive devices, diagnostic devices and other modern applications.
CO6 - Able to design and perform experiments on the sensors and develop the projects based on the customer needs.

TEXT BOOK / REFERENCE BOOK

1. John G. Webster, Amit J. Nimunkar, Medical Instrumentation application and design – 5th Edition, (An Indian Adaptation), Wiley India, 2021.
2. R. Ananda Natarajan, Biomedical Instrumentation and Measurements, 2nd Edition, PHI, 2016.
3. Leslie Cromwell, ―Biomedical Instrumentation and measurement, Prentice Hall of India, New Delhi, 2nd edition, 2015.
4. Khandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw Hill, New Delhi, 3rd edition, 2014.
5. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", edition, 2015. Pearson education, 2012.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3006	BIOSIGNAL ANALYSIS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To enable the students to analyze various Biosignals
- To analyze the Biosignals in Time, frequency, and Time-Frequency Analysis
- To analyze Non-Stationary and Multicomponent Analysis

UNIT 1 EVENT DETECTION 9 Hrs.

Events and waves detection-Heart sound detection- Analysis of EEG Rhythms using correlation- Cross spectral Analysis-ECG Rhythm Analysis - Application: Identification of Heart Sounds, Detection of the Aortic Component of S2.

UNIT 2 WAVESHAPE AND WAVEFORM COMPLEXITY ANALYSIS 9 Hrs.

Analysis of ERPs- Morphological Analysis of ECG Waves- Envelope Extraction and Analysis- Analysis of Activity. Application- Normal and Ectopic ECG Beats- Analysis of Exercise ECG- Analysis of the EMG in Relation to Force- Correlates of Muscular Contraction- Statistical Analysis of VAG Signals.

UNIT 3 TIME DOMAIN ANALYSIS 9 Hrs.

Statistical Parameters- Descriptive Statistics-Inferential Statistics-Predictive Analysis.

UNIT 4 FREQUENCY-DOMAIN CHARACTERIZATION 9 Hrs.

Estimation of the PSD- Measures Derived from PSDs-Application- Evaluation of Prosthetic Valves-Fractal Analysis of VAG Signals- Spectral Analysis of EEG Signals- The effect of myocardial elasticity on heart sound spectra-Frequency analysis of murmurs to diagnose valvular defects.

UNIT 5 ANALYSIS OF NONSTATIONARY AND MULTICOMPONENT SIGNALS 9 Hrs.

Wavelets and Time-frequency Analysis- Separation of Mixtures of Signals-Applications- Time-varying Analysis of HRV- Detection of Epileptic Seizures in EEG Signals- Analysis of Crying Sounds of Infants.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Comprehend the various events occurring in biosignals.
CO2 - Analyze the waveshape and waveform complexity of Biosignals
CO3 - Perform Time domain analysis on biosignals
CO4 - Characterize the biosignals based on frequency domain analysis
CO5 - Implement signal analysis procedures for non-stationary and multicomponent signals
CO6 - Develop a time, frequency, and time-frequency analysis models for biomedical signals

TEXT BOOK / REFERENCE BOOK

1. Rangaraj M. Rangayyan, Biomedical Signal Analysis, John Wiley Publication, Edition 2,2015.
2. Willis J. Tompkins, Biomedical Digital Signal Processing, Prentice Hall of India, New Delhi, 2006.
3. Dr. P. Ramesh Babu, Digital Signal Processing SciTech Publications, 4th Edition 2010
4. D.C. Reddy, Biomedical Signal Processing–Principles and Techniques, TMH, New Delhi, 2005
5. Avtar Singh and S. Srinivasan, Digital Signal Processing, Thomson Publishing 2004, Singapore.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3007	DRUG DELIVERY SYSTEMS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To enhance the student on drug delivery system which would enable a comprehensive analysis of drug delivery.
- To explore the efficacy and safe release of the drug in to host using implantable and nanomaterials.

UNIT 1 SUSTAINEDANDCONTROLLEDDRUGDELIVERY 9 Hrs.

Introduction, properties of drugs, Pharmacokinetic properties of drugs, sustained release formulations – concept, physical-chemical biological properties of drugs, advantages, and disadvantages –controlled drug delivery systems–automatically controlled drug delivery systems and their biomedical applications.

UNIT 2 POLYMERS & TARGETTED DRUG DELIVERY SYSTEMS 9 Hrs.

Polymers used in drug delivery systems – modules, classification, characterization, advantages and disadvantages of polymer, targeted drug delivery systems–concepts–nanoparticles–liposomes, microspheres–hydrogels.

UNIT 3 TRANSDERMAL DRUG DELIVERY SYSTEMS 9 Hrs.

Transdermal penetration of drugs – formulation – addition – polymers in transdermal drug delivery system– iontophoresis–transdermal controlled release products and devices Development in insulin therapy using biomedical controlled drug delivery systems

UNIT 4 IMPLANTABLEDRUGDELIVERYSYSTEMS 9 Hrs.

Implantable micro–pump systems–peristaltic micro pump–osmotic micro pump-diaphragm micro pump–Fluorocarbon propellent driven micropump–solenoid driver reciprocates micropump–programmable implanted drug administrative device (DAD).

UNIT 5 NANOMEDICINE INDRUGDELIVERYSYSTEMS 9 Hrs.

Drug delivery using monoclonal antibodies– Role of biosensors and transducer in diagnostic. drug delivery to cells using nanotubes and nanowires. Quantum dots for drug delivery and imaging. Quantum dots for cancer treatment.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - UnderstandsthePharmacokinetic properties of drugs and their delivery mode.
CO2 - Explorethetechniquesusedinthedevelopmentofdrugdeliverysystems using polymers.
CO3 - Analysethecurrenttrendsindrugtargeting by the transdermal route and controlled release.
CO4 - Designtheadvanced techniques that are implantable devices for drug delivery.
CO5 - Examine the efficacy and release of various drugs using quantum dots and monoclonal antibodies.
CO6 - Create a methodology for diagnosing the tumor antigen and delivering the drug against cancer cells via nanotubes and nanowires.

TEXT BOOK / REFERENCE BOOK

1. Vyas S.P. Khar RK Targeted and controlled drug delivery Novel Carrier System CBSPD, Second Edition,2019.
2. Anya MHillery et al Drug delivery and targeting CRC Press, Second Edition, 2016.
3. Robinson R Robinson Conventional drug delivery systems, CRC Press,2004

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3008	TISSUE ENGINEERING AND REGENERATIVE MEDICINE	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To learn the fundamentals of molecular and cellular processes with special emphasis on stem cells, biomaterials and their applications.
- To introduce students to tissue engineering, tissue repair and its practical applications in clinical settings.'

UNIT 1 CELL AND MOLECULAR BIOLOGY 9 Hrs.

Cell physiology in the Engineer's perspective – Cell Technology – System Physiology – Molecular Technology.

UNIT 2 IMMUNOLOGY AND REGENERATIVE MEDICINE 9 Hrs.

Pathogenic factors – Transplant immunology – Overview of Regenerative Engineering Technologies – Advanced methods applied in the Regenerative medical field.

UNIT 3 TISSUE ENGINEERING 9 Hrs.

Origins – Engineering Principles and Triad – Fundamentals of Stem Cells – Biomaterials – Bio Scaffold and Engineering Materials – Bioreactors.

UNIT 4 TISSUE ENGINEERING APPLICATIONS 9 Hrs.

Stem Cell Therapy – In vitro Organogenesis – Tissue-specific engineering: Hard and Soft tissues – Immunomodulation: designer tissues.

UNIT 5 CHALLENGES, REGULATION AND ETHICS 9 Hrs.

Assessment and Standardization of engineered tissues – Cryopreservation – Immuno isolation: Engineering challenges – Ethical consideration, Evaluation and Regulation of tissue-engineered products.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand the pathophysiology of human diseases and the potency of stem cells in regenerative medicine.

CO2 - Acquire knowledge of biomaterials in regenerative medicine and their interaction with host tissues.

CO3 - Identify host-graft interaction with a focus on immune and infectious issues related to regeneration and transplants.

CO4 - Demonstrate multidisciplinary aspects in tissue engineering to solve healthcare problems.

CO5 - Apply regenerative engineering strategies to replace damaged or destroyed cells.

CO6 - Implement experimental therapies from the laboratory to the clinic.

TEXT BOOK / REFERENCE BOOK

1. Jose A Andrades Regenerative medicine and tissue engineering Intech Open 2013
2. Joseph P. Vacanti Tissue Engineering and Regenerative Medicine A Cold Spring Harbor Prospectives 2017
3. Tatevik Sahakyants & Joseph P. Vacanti Tissue engineering: from the bedside to the bench and back to the bedside Springer Link 2020
4. Anwarul Hasan Tissue Engineering for Artificial Organs: Regenerative Medicine Wiley 2017
5. Robert E Marx and Randy B Miller Stem Cells and Regenerative Medicine Kindle Edition 2020

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3009	ARTIFICIAL ORGANS AND TISSUE ENGINEERING	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To provide a general introduction to the use of artificial materials in the human body for the purpose of aiding healing, correcting deformities and restoring lost function.
- It is expected that the student will have successfully completed an elementary course in the mechanics of deformable bodies and an introductory course to material science prior to undertake a course in biomaterials.

UNIT 1 ORGAN REPLACEMENT 9 Hrs.

Artificial organs – Future scope and importance, Evolution of organ replacement technology. Substitutive medicine, Organ replacement outlook, design considerations, evaluation process. Bioartificial organ manufacturing- Material basis of organ manufacturing, organ manufacturing process, and organ manufacturing technologies.

UNIT 2 ARTIFICIAL ORGANS 9 Hrs.

Artificial heart valves, Heart valve prosthesis- mechanical and tissue valves, Cardiac pacemakers, Pacemaker Implantation, Cardiac Stents, Artificial Lung, Artificial skin, Artificial pancreas, Artificial blood, Artificial kidney, Dialysis-Dialysis Procedure and the Dialysis System, Dialyzer Cartridge Reuse.

UNIT 3 ORTHOTIC DEVICES 9 Hrs.

Orthotic devices- Types of orthotic devices- upper limb orthoses, lower limb orthoses, foot orthoses, Ankle foot orthoses, Knee orthoses, Knee-ankle-foot orthoses, spinal orthoses, and soft braces.

UNIT 4 TISSUE ENGINEERING 9 Hrs.

Tissue engineering - Basic principles and considerations, control of tissue organization, Bioreactor - design and applications, Biomaterials – Protein surface interaction, Protein adsorption, Biomaterials for Tissue Engineering-10 to 100-micron size scale.

UNIT 5 STEMCELLS 9 Hrs.

The Biology of Stem Cells-Embryonic stem Cells, Control of stem cell development, adult stem cells, aging of Stem Cells, Tissue Composition and stromal cell-Fibroblast, Endothelial Cells, adipocytes, macrophages. Tissue engineering of Bone marrow, Tissue Regeneration

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand organ replacement technology and the evaluation process of various artificial organs.
CO2 - Acquire knowledge about different types of artificial organs and their implantation.
CO3 - Recognize the orthotic devices for paralyzed and non-paralyzed individuals.
CO4 - Demonstrate principles of stem cells and biomaterials used for tissue engineering.
CO5 - Apply tissue engineering to produce biomolecules.
CO6 - Implement artificial organs to replace malfunctioning natural organs.

TEXT BOOK / REFERENCE BOOK

1. Michael Lysaght, Thomas J Webster, Biomaterials for Artificial Organs, 1st Edition, ELSEVIER, 2010.
2. Gerald E. Miller, Artificial organs,1st edition, A Publication in the Morgan & Claypool Publishers series, United States of America, 2006.

3. Park J.B. and R.S. Lakes, Biomaterials: An Introduction 3rd Edition, Springer Science & Business Media,2007.
4. Joseph D Bronzino, The Biomedical Engineering Handbook, 4th Edition, CRC Press,2019.
5. Robert Lanza Principles of Tissue Engineering, Edition 5th, Publisher: Academic Press Inc, 2020.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3010	3D PRINTING FOR BIOMATERIALS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To provide opportunities for training and research in all aspects of 3D printing.To educate the students in the development of high-quality printing technology to provide a satisfactory environment to the manufacturing sector.
- To implement 3D printing in the health care industry for the future betterment of society.

UNIT 1 DIGITAL MANUFACTURING FOR 3D PRINTING 9 Hrs.

Introduction- Definition of 3D Printing, Terminologies, Types additive manufacturing operations- Stereolithography (SLA), Digital Light Processing (DLP), Fused Deposition Modeling (FDM), Selective laser sintering (SLS), Selective Laser Melting (SLM), Electron Beam Melting (EBM), Details of Laminated Object Manufacturing (LOM); Granular Materials Binding, 3D innovative printers and application.

UNIT 2 DESIGN FOR 3D PRINTING 9 Hrs.

DESIGN FOR 3D PRINTING Design criteria, Design consideration, Types of fast filament fusion support, Top-Down support structures, designing for selective Laser Sintering, Designing for material Jetting, OBJ-VRML files, CAD-STL files, Rules for STL format.

UNIT 3 3D PRINTING EVOLVING 9 Hrs.

Introduction, Development of physical goods, Nomenclature; milestones of 3D systems, Nontraditional manufacturing innovative technique, shorter lead time and design freedom, 3D printing possibilities, The digital model, CAD software- 3D scanners process, 3D printing pen, 3D printing geometry restrictions, STL file, Professional and home 3D printers, 3D printers improvements, Phases of rapid prototyping to home fabrication.

UNIT 4 ADDITIVE MANUFACTURING 9 Hrs.

Limited prototyping, Hazards of printing materials, 3D printing state and federal laws, Steps towards AM cybersecurity, 3D printing in forensic science, ethics and legality of 3D printing, Intricacy of 3D printing, Impact of 3D printing, 3D printing impact on global manufacturing, Revolutionizing mass manufacturing, Advance perception of additive manufacturing.

UNIT 5 3D PRINTING IN HEALTH CARE 9 Hrs.

Bone reconstructive surgery, living tissues- Bioprinting 2D and 3D tissues Bioink components, Hydrogels for Bioprinting; Implants of printed organs- Human Ear, Kidneys artificial liver, Bioprinting skin, Bioprinting nerves, 3D printed ovaries, obstacles to bio printing organs, 3D Bio-Printing, 3D Printing for implant and medical device- Hearing Aid, sensor arm, Knee replacement, Aorta, dental implants, 3D print future medical implants.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand the basic principles of 3D printing.
CO2 - Outline the problem encountered during the design for 3D printing.
CO3 - Recognize the importance and future scope of 3D printing and evolve.
CO4 - Demonstrate the types of additive manufacturing in 3D printing technology.
CO5 - Application of 3D printing in the health care system.
CO6 - Identify the importance of 3D printing in health care systems.

TEXT BOOK / REFERENCE BOOK

1. Sabrie Soloman,3D printing and design, Khanna Book Publishing Co., (P) Ltd., 2020.
2. Ad van Wijk and Iris van Wijk, 3D PRINTING WITH BIOMATERIALS TOWARDS A SUSTAINABLE AND CIRCULAR ECONOMY, Published by IOS Press, under the imprint Delft
3. University Press. 2020.
4. Ian Gibson, David Rosen, Brent Stucker, Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, 2nd Edition. 2015
5. Andreas Gebhadt, Julia Kessler, and Laura Thurn, 3D Printing Understanding Additive Manufacturing, Second Edition, Science Direct, 2019.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A : 10 Questions of 2 marks each - No choice **20 Marks**
PART B : 2 Questions from each unit with internal choice, each carrying 16 marks **80 Marks**

SBMB3011	ANALYTICAL INSTRUMENTATION	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- The course offers a wide portfolio of study programs in the areas of technology, engineering and sophisticated analytical instrument application in biomedical fields
- It provides an introduction to the fundamental principles, and characterization of various samples by analytical techniques used in medical diagnosis, quality assurance, and research studies.

UNIT 1 SPECTROPHOTOMETER 9 Hrs.

The electromagnetic spectrum, the interaction of radiations with the matter, absorption spectra beer Lamberts law, spectrophotometer UV and visible ranges, single and double beam instruments, FTIR, and Raman spectra. spectrofluorometer, flame photometry, flame emission, atomic absorption spectrometer. Basic principles and biomedical applications.

UNIT 2 MASS SPECTROPHOTOMETER AND RADIOCHEMICAL INSTRUMENTS 9 Hrs.

Mass spectrometer, Magnetic detection, Time of flight, quadrupole mass spectrophotometer, GCMS, LCMS, Basic principle, biomedical applications. Radiochemical analytical instruments Radiation types Ionization chamber, GM counter, proportional counter, Liquid scintillation and applications.

UNIT 3 AUTOMATED BIOCHEMICAL ANALYZERANDELECTROPHORESIS 9 Hrs.

System concept, system components, sampler control units, sampling mechanism, dialyzer, SAMACII Principle of electrophoresis paper electrophoresis agarose gel electrophoresis Iso electric focusing, SDS page, pulse field electrophoresis and its applications.

UNIT 4 GAS ANALYZER&POLLUTION MONITORING INSTRUMENTS 9 Hrs.

Types of gas analyzers-oxygen, NO2, H2S types, IR analyzers, thermal conductivity analyzers. Air pollution due to carbon monoxide, hydrocarbons, nitrogen oxides, Sulphur dioxide estimation, Dust and smoke measurements.

UNIT 5 CHROMATOGRAPHY 9 Hrs.

Principles types of chromatography, paper chromatography, thin layer chromatography, column chromatography, ion exchange chromatography, gel permeation chromatography, high-pressure liquid chromatography, HPTLC and applications in biomedical.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand the elements of UV visible radiation and characterize their spectrum analysis
CO2 - Illustrates the working principle, emission of mass spectrum and radiation chamber
CO3 - Explore the knowledge of electrophoresis and analyzer to separate the constituents from a complex mixture
CO4 - Analyse the analytical methods of industrial gases and pollution monitoring instruments
CO5 - Determines the oxygen level using a gas analyzer by applying both electrostatic and magnetic properties
CO6 - Compares the types of chromatography and their importance and applications in the biomedical field

TEXT BOOK / REFERENCE BOOK

1. D.A. Skoog, F.J. Holler & T.A. Nieman, Principles of Instrumental Analysis, 7th Edition, 2016.
2. Williard H.H., Merrit, Dean J.A, Seattle F.L, CBS, Instrumental Methods of Analysis 7th Edition, 2005.
3. Ewing G.W., Instrumental Methods of Analysis, McGraw Hill,5th Edition, 2002.
4. Robert D. Braun Introduction to Instrumental Analysis, McGraw Hill, Second Edition 2012.
5. R.S. Khandpur, A Handbook of Analytical Instrumentation, 3rd Edition, Tata McGraw Hill Publication, 2014.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3012	MEDICAL GENETICS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To understand the concepts, introduction of medical genetics sources and their role in human diseases.
- To determine the gene responsible for hereditary disorders and human health.
- To learn about the transmission, distribution, arrangement, and alteration of genetic information and how it functions and is maintained in populations.

UNIT 1 INTRODUCTION TO HUMAN GENETICS 9 Hrs.

Early perception, development, and documentation; Study tools in human genetics: Pedigree symbols, construction of pedigree, pedigree analysis in monogenetic traits, autosomal dominant and autosomal recessive inheritance, sex-linked dominant and sex-linked recessive inheritance; Sex-linked anomalies (hemophilia, color-blindness), sex linked and sex influenced traits, sex determination in man.

UNIT 2 HUMAN KARYOTYPES 9 Hrs.

Banding patterns, the nomenclature of aberrant karyotypes; Human genome mapping methods, physical mapping, introduction to physical map markers, chromosomal, Giemsa stain (G) and quinacrine stain (Q) banding, radiation hybrid; Fluorescence in situ hybridization; Comparative genome hybridization; Long range restriction mapping.

UNIT 3 HUMAN HEALTH AND DISEASE 9 Hrs.

Chromosomal disorders: Structural and numerical chromosomal anomalies; Mechanisms of mitotic non-disjunction /meiotic non-disjunction/ chromosomal rearrangements; Some examples (Klinefelter syndrome, Down's syndrome, Turner syndrome, 19 Achondroplasia); Single gene hypothesis: Beadle and Tatum experiment, inborn errors of metabolism (Phenylketonuria (PKU), Alkaptonuria, Albinism, Galactosemia); Haemoglobinopathies, ABO blood group system, Thalassemia syndromes; Multifactorial disorders- Diabetes, Huntington disease.

UNIT 4 ONCOGENETICS 9 Hrs.

Properties of malignant cells, Types of genes – Proto-oncogenes, Oncogenes, Cellular oncogenes, Tumor Suppressor genes, Chromosomal abnormalities associated with the specific malignancies- APL, CML & Retinoblastoma.

UNIT 5 ETHICAL AND SOCIAL ISSUES IN MEDICAL GENETICS 9 Hrs.

Prenatal/adult (individual/family/population) screening of mutation/risk factor for genetic diseases; Confidentiality/privacy, discrimination; Ethical dilemma, human rights, surrogate mothers; Human cloning and eugenics, Genetic counseling.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understanding the principles of human genetics.
CO2 - Demonstrate the role of karyotype to identify various sizes of human chromosomes.
CO3 - Learning the process of human genetic disorder and recognize the importance of chromosome.
CO4 - Identify the oncogenes and demonstrate the gene responsible for cancer.
CO5 - Understanding the procedure of legal and ethical issues of human genetics.
CO6 - Outlinetheproblemencounteredduetochromosomalabnormalityandcounselingtothesociety.

TEXT BOOK / REFERENCE BOOK

1. Bruce. R. & Korf. (2013) Human Genetics and genome (4th ed.). Kindle edition. Gunder, L., & Martin, S. (2010).
2. Essentials of medical genetics for health professionals. Jones & Bartlett Learning. Jin Kim. (2017) Cancer Genetics and Genomics for Personalized Medicine (2nd ed.).
3. Strachan, T., & Read, A. P. (2012). Human molecular genetics. Garland science. Edition.
4. Principles of Molecular Biology: VeerBalaRastogi,2016
5. Genetics, Veer Bala Rastogi, S. Chand Publication,4thEdition,2018

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3013	ENTREPRENEURSHIP IN HEALTHCARE MANAGEMENT	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To gain the knowledge necessary to launch a biomedical start-up
- To implement the concepts into practice and copyright the Inventions
- To understand the significance of sales and marketing.

UNIT 1 BIOMEDICAL SECTOR 9 Hrs.

Challenges & Opportunities – Medical Technology – Pharmaceutical Industry – Innovations in Medical Technology - Development and Growth of Pacemaker Industry – Impact of MedTech innovations on Healthcare – Three Development Phases of Entrepreneurship.

UNIT 2 EVALUATING AND STARTING THE VENTURE 9 Hrs.

Evaluating the Entrepreneurship: Entrepreneur Team – Nature – Practising Entrepreneurship – Development of Wearable & Wireless Devices, Evaluating the Invention – Robotics & Artificial Intelligence – Medical Imaging, Forming the Company: Organizational Structure – Capitals required for the Company's Operation – Company Registration – Share Distribution – Exit Strategy, Patenting the Invention: US Patent –Trademark Office – Importance of Patenting – Process of Patenting, Safety & Effectiveness of Medical Devices.

UNIT 3 ESTABLISHING THE ENTERPRISE 9 Hrs.

Financing & Accounting: Account Management – Budgeting – Financial Projections, Negotiating Process, Manufacturing the Product: Procurement & Outsourcing – Current Good Management Practice (cGMP) – Accountability – Risk Management – Lifecycle Management for Maximum Value.

UNIT 4 BUSINESS MARKETING AND GLOBALIZATION 9 Hrs.

Marketing & Sales: Know the Customers – Market Characteristics of Medical Devices – Customer Relationship Management (CRM) – Marketing Ethics and Legal Compliance, Expanding & Globalizing the Business: World Prevalence of Diseases – Healthcare in UK/Germany/France/Italy – Healthcare Systems and Biomedical Industry in China – Global Markets of Medical Devices – Challenges of Global Marketing.

UNIT 5 INSTANCES OF APPLICATIONS IN BIOMEDICAL AREAS 9 Hrs.

Covid-19 Pandemic Assistive Devices - Inventions in various fields of Biomedical Engineering – Devices Developed.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - To study the Technologies in Medical Industry
CO2 - To understand the concepts of Entrepreneurship
CO3 - To analyze the need in building an organization, patenting
CO4 - To understand Financial Management and Product Manufacturing
CO5 - To familiarize Marketing and Business Globalization
CO6 - To apply the concepts of Biomedical Engineering for inventions and device development

TEXT BOOK / REFERENCE BOOK

1. Jen-shih Lee, “Being A Biomedical Entrepreneur - Growth of The Biomedical Industry”, World Scientific Publication Co. Pvt. Ltd., 2019.
2. Jen-shih Lee, “Biomedical Engineering Entrepreneurship”, World Scientific Publication Co. Pvt. Ltd., 2016.
3. Riadh Habash, “Green Engineering: Innovation, Entrepreneurship and Design”, CRC Press, Taylor & Francis Group, 2017.
4. Michael Friebe, Novel Innovation Design for the Future of Health Entrepreneurial Concepts for Patient Empowerment and Health Democratization, Springer International Publishing, 2022.
5. Shreefal S. Mehta, Commercializing Successful Biomedical Technologies, Cambridge University Press, 2022.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3014	MEDICAL ETHICS AND REGULATORY AFFAIRS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- Students will be able to know about the legal and ethical principles
- To apply these principles in health care settings & gain knowledge about the medical standards that to be followed in hospitals.

UNIT 1 INTRODUCTION TO MEDICAL ETHICS 9 Hrs.

Definition of Medical Ethics, Scope of Ethics In Medicine, American Medical Association Code of Ethics, CMA Code of Ethics Fundamental Responsibilities. The Doctor and Patient, Doctor and Safety, Professional Independence.

UNIT 2 ETHICAL THEORIES MORAL PRINCIPLES 9 Hrs.

Theories-Deontology and Utilitarianism Casuist Theory Virtue Theory, The Right Theory, Ethical Issues in Biomedical Research, Bioethical Issues in Human Genetics and Reproductive Medicine.

UNIT 3 MEDICAL EQUIPMENTS SAFETY STANDARDS 9 Hrs.

General Requirements for Basic Safety and Essential Performance of Medical Equipments.Iec60601 Standard Indian and International Standards Base Standard General Requirement of Electrical Medical Devices. Collateral Standards Particular Types of Medical Device.

UNIT 4 MEDICAL DEVICE AND INVITRO DIAGNOSTIC 9 Hrs.

Introduction And Types of Devices Including Combination Devices. Medical Devices Rules 2017.Implication on Medical Device, Classification of Medical Devices. Labelling Of Medical Devices and Invitro Diagnostic.

UNIT 5 STANDARDS OF MEDICAL DEVICE, QUALITY ASSURANCE AND TESTING 9 Hrs.

Regulatory Requirements of Biocompatibility of Medical Devices and ISO 10993 Clinical Investigation of Medical Devices, Regulation of Investigational Medical Devices.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand the Social Responsibility in Health Care Systems.
CO2 - Analyse the Role of Biomedical Engineers to Know the Importance.
CO3 - Comphrend the Medical Equipment Safety Standards to Medical Device Maintenance.
CO4 - Examine the Types of Medical Devices and Their Invitro Diagnostic Methods.
CO5 - Interpret the Quality Assurance and Testing Procedure for Standard Medical Devices.
CO6 - Create A Protocol for Regulatory Requirement of Biocompatibility on Medical Devices.

TEXT BOOK / REFERENCE BOOK

1. Johnna Fisher, Biomedical Ethics: A Canadian Focus., Oxford University Press Canada, 2009.
2. Robert M Veatch, The Basics of Bio Ethics, 3 Rd Edition. Routledge, 2011.
3. Joint Commission Accreditation Standards for Hospitals, 6th Edition 2018
4. Medical Devices Rules 2017, Related Guidance Documents Available at CDCSO Websites.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3015	HOSPITAL & MEDICAL WASTE MANAGEMENT	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- The study would ensure to design the hospital's different zones and their management services.
- To understand the importance of medical waste in patient and public healthcare, the community and their segregation and disposal method.

UNIT 1 HOSPITALORGANIZATION 9 Hrs.

Concept of Hospital Management-Role of Administrator-Responsibilities of Administrator-Hospital Design, Outlines for establishing Departmental Zones-Hospital Engineering. OrganizationofOut-PatientServices-ProblemsencounteredinfunctioningofO.PDepartment-Organization of In-Patient Services

UNIT 2 HOSPITAL SERVICES 9 Hrs.

Casualty & Emergency Services – Organization and management of Operation theatres, Organization of Ancillary Services: Lab Services-Department of Physiotherapy & Occupational Therapy-Organization of Blood Transfusion Services - Department of Radio - diagnosis - Organization and management of Nursing services and Dietary Services in hospital, Hospital Pharmacy.

UNIT 3 HOSPITAL SAFETY AND MAINTENANCE 9 Hrs.

Sterilization and disinfection methods, Hospital safety-Radiation Safety, hazardous safety, -Maintenance of Equipments &Instruments. Housekeeping and maintenance -Medical Records- Human resources management in the hospital.

UNIT 4 BIOMEDICAL WASTE SEGREGATION 9 Hrs.

General Introduction, Biomedical Waste, General and Hazardous health care waste – Color Coding and types of containers for disposal of medical waste, Segregation, Collection & Disposal.

UNIT 5 BIOMEDICAL WASTE TYPES& ITS DISPOSAL 9 Hrs.

Infectious waste, Genotoxic waste, Waste Sharps – Categories, Categorization and composition of Biomedical waste. Liquid Biomedical Waste - Radioactive wastes, Metals, Chemicals & drugs, pathological wastes, Contaminated sharps, and contaminated animal carcasses. Autoclaving, Incineration, Plasma Pyrolysis/ Gasification systems, Composting.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand the concept of hospital design, zone, and role f administrator.
CO2 - Acquire adequate knowledge about types of hospital services and organizations. biomedical waste and the severity of hazardousness
CO3 - Analyse the safety measures and maintenance of various hospital units.
CO4 - Demonstrate the types of biomedical waste and its segregation procedures.
CO5 - Design a container with different color codes to separate various healthcare waste.
CO6 - Create an effective technology for the disposal of hazardous waste.

TEXT BOOK / REFERENCE BOOK

1. A Tabish, Principles of Hospital Management, OUP, Jaypee Publishers. 8thEdition2006.
2. SL Goel, Dr. R. Kumar, Encyclopedia of Hospital Management-Text and Case Studies Hospitals in Community HealthCare,2010.
3. J. GlynHendry & Gary W Heinke, Environmental Science, and Engineering, Prentice-Hall India,2004
4. Shyam Divan, Environmental law and policy in India, Oxford India Press, 2004.
5. Dr.L.L.Rao, Hospital Management .Annamalai University Press, 2007.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A : 10 Questions of 2 marks each - No choice **20 Marks**
PART B : 2 Questions from each unit with internal choice, each carrying 16 marks **80 Marks**

SBMB3016	MEDICAL ETHICS & IPR	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- Achieve familiarity with some basic ethical frameworks & understand how these ethical frameworks can help us to think through contemporary questions in medical ethics.
- Know about the legal and ethical principles and application of these principles in health care settings.

UNIT 1 INTRODUCTION TO MEDICAL ETHICS 9 Hrs.

Definition of Medical Ethics, Scope of Ethics in Medicine, American Medical Association Code of Ethics, CMA Code of Ethics- Fundamental Responsibilities, The Doctor and the Patient, The Doctor and the Profession, Professional Independence, The Doctor, and Society.

UNIT 2 ETHICAL THEORIES AND MORAL PRINCIPLES 9 Hrs.

Theories - Deontology & Utilitarianism, Casuist theory, Virtue theory, The Right Theory. Principles Non-Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, and Bioethical issues in Human Genetics & Reproductive Medicine.

UNIT 3 UNDERSTANDING AND OVERVIEW OF IPR REGIME 9 Hrs.

Introduction to IPR, types of intellectual property, need for intellectual property rights, the rationale for the protection of IPR, the impact of IPR on the protection of development, health, agriculture, and genetic resources, IPR in India – Genesis and development, IPR in abroad – Some important examples of IPR, International organizations, agencies.

UNIT 4 PATENTS 9 Hrs.

Definition, kind of inventions protected by patents - Patentable and non-patentable inventions, Process, and product patents, legal requirements for patents, granting of a patent – rights of patent – exclusive right, the patent application process, searching a patent, drafting of a patent, filing of a patent, types of patent applications, patent documentation - specification and claims, Management of IP assets and IP portfolio.

UNIT 5 COPYRIGHTS 9 Hrs.

Rights and protection covered by copyrights - law of copyrights, fundamentals of copyright law, originality of materials, rights of reproduction, rights to perform the work, copyright ownership issues, obtaining copyright registration, a notice of copyright, international copyright law, Infringement of copyright under the copyright act, Related rights – the difference between related rights and copyrights, celebrity rights

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Identify the scope of medical ethics
CO2 - Illustrate the concepts of ethical theories and moral principles for the health professions
CO3 - Identify criteria to fit one own intellectual works in a particular form of IPRs
CO4 - Apply statutory provisions to protect particular forms of IPRs
CO5 - Identify procedures to protect different forms of IPRs national and international level
CO6 - Analyze rights and responsibilities of the holder of patents, copyrights, and industrial designs

TEXT BOOK / REFERENCE BOOK

1. Nils Hoppe and Jose Miola, “Medical law and Medical Ethics”, Cambridge University Press 2014.
2. Robert M Veatch,” Basics of Bio-Ethics”, Second Edition. Prentice-Hall, Inc, 2018
3. Fundamentals of IP for engineers K. Bansal and P. Bansal
4. Intellectual Property rights Deborah E Bouchoux, Cengage learning
5. Intellectual property rights – NPTEL resource

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3017	DESIGN THINKING IN INDUSTRY 5.0	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To introduce the concept of Industry 5.0.
- To develop industry 5.0 projects with the help of Design thinking concepts.

UNIT 1 INTRODUCTION TO INDUSTRY 5.0 9 Hrs.

Industry 4.0- the difference between Industry 4.0 and Industry 5.0, Society 5.0, Human Centric Approach, Advantages of Industry 5.0, Implementation of Industry 5.0.-Challenges-Human Centric solution.

UNIT 2 FEATURES OF INDUSTRY 5.0 9 Hrs.

Definitions, Features of Industry 5.0- Smart additive manufacturing-Digital Twin- Predictive maintenance- Hyper customization- Cyber Physical Cognitive systems- Supply chain management-Collaborative Robots-6G communication-big Data Analytics.

UNIT 3 INDUSTRY 5.0 IN BIOMEDICINE 9 Hrs.

Smart hospitals- Smart Sensors- 4D CT and MRI scans-Holography in medicine-AI in medicine-Robotic Surgery-Smart materials and 4D printing, Patient Centric health care.

UNIT 4 INTRODUCTION, DESIGN THINKING PROCESS AND COGITATION 9 Hrs.

Introduction to design thinking- Johari Window – Persona - DCAFE and VAL. – Theory of prioritization – Brainstorming - 25 brainstorming techniques- Elements of great design - Human element of design thinking – Lateral thinking – HOTS – Out of box thinking.

UNIT 5 IMPLEMENTATION OF INDUSTRY 5.0 USING DESIGN THINKING CONCEPTS 9 Hrs.

Activities: Formation of the team – Brainstorming – Case study

Problem Identification – Identification of a specific Real Word Problem after brainstorming – Team Presentation on identified problem.

Activities: Specific Problem selection to proceed with the work – Team presentation on identified problems and various possible solutions.

Phase 2- Identification of stakeholders – Roles and responsibilities – Conduct of surveys and interviews for addressing Real World Problems – Literature Surveys - Data collection.

Activities: SWOT Analysis – Finalize the identified problem-Documentation: Functional decomposition diagram, Decision on implementation, Evaluation criteria.

Phase 3 Brainstorming alternate solutions- Developing proof of concept

Project: Poster presentation and Proof of concept display

Activities: Development of POC

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand the basic concepts of Industry 5.0.
CO2 - Acquire knowledge about the features of Industry 5.0
CO3 - Apply the knowledge in the field of Biomedicine.
CO4 - Analyse the various design thinking concepts
CO5 - Implement projects using design thinking concepts to develop the real-time project
CO6 - Develop device or software using design thinking concepts according to Industry 5.0

TEXT BOOK / REFERENCE BOOK

1. The Art of Innovation, Tom Kelley & Jonathan Littman, Profile Books Ltd, UK, 2008
2. G.Pahl and W.Beitz (Translated by Ken Wallace et al.,) „Engineering Design: A Systematic Approach, Second Edition, Springer, 2005.
3. George E. Dieter and Linda C. Schmidt, "Engineering Design", Fourth Edition, McGraw Hill Higher Education, 2009.
4. PowerPoint Presentation material by Prof.D.K. Subramanian in the Workshop on Engineering Design at TCE, Madurai.
5. Foundation Skills in Integrated Product Development, NASSCOM, Edition 2015.
6. Uthayan Elangovan, Industry 5.0: The Future of the Industrial Economy,2021

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

SBMB3018	BIOMEMS AND NANOTECHNOLOGY	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- The students should be made to acquire knowledge about the basic principles of MEMS and its fabrication
- To understand the concepts of nanotechnology and its applications.

UNIT 1 MEMS & MICROSYSTEMS 9 Hrs.

Fundamentals and basics of MEMS and Microsystems, the origin of MEMS, Types of MEMS materials and their properties, working principles of Microsystems, Microsensors, Microactuators Integrated MEMS, Applications of MEMS the in the health care industry, MEMS&NEMS technology.

UNIT 2 MEMS FABRICATION TECHNOLOGY 9 Hrs.

Lithography, Etching Dry-wet etching, Electrochemical etching thin film deposition, LPCVD, Sputtering, evaporation, electroplating, wafer bonding, coating technology, Bulk and Surface Micromachining, LIGA process, Intelligent materials.

UNIT 3 MOEMS & MICROFLUIDICS 9 Hrs.

Fundamentals of MOEMS Technology-light modulators Beam splitter, Microlens Micro-mirrors –Digital Micromirror Devices, Light detectors., Fundamentals of Microfluidics, LAB-ON-A-Chip devices, Silicon and glass micromachining for Micro total analysis system

UNIT 4 NANOMATERIALS& ITS CHARACTERIZATION 9 Hrs.

Nanomaterials –Introduction- synthesis of nanomaterials physical, chemical & Biological method Nanomaterial characterization, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, X-ray diffraction, Raman Analysis, Nanorobotics for surgery.

UNIT 5 NANO BIOSENSORS AND ITS APPLICATIONS 9 Hrs.

Nano biosensors for living cells, carbon nanotubes. Synthesis & monitoring antigen-antibody reactions., DNA chips, cantilever-based Nanosensors, nanotoxicology, and medical applications for nanotechnology.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understands the concepts of MEMS and its integration process.
CO2 - Analyze the fabrication of MEMS devices and micromachining technology.
CO3 - Examine the basic principles, synthesis of MOEMS, and micro total analysis system.
CO4 - Design a protocol for synthesizing nanoparticles by various methods.
CO5 - Interpret the methods adopted to characterize the nanomaterials by analytical techniques.
CO6 - Create a nano biosensor device in a miniaturized form for the well-being to society.

TEXT BOOK / REFERENCE BOOK

1. Tai-Ran Hsu, MEMS & Microsystem, Design and manufacture, and Nanoscale Engineering John Wiley & Sons,2nd edition 2008.
2. Wanjun Wang & Steven. A. Aopers BioMEMS-Technologies and Applications CRC Press, First edition 2007.
3. Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, 3rd Edition, Three-Volume Set, CRC Press 2011.
4. Mohamed Gad-el-Hak, The MEMS Handbook, CRC Press, Second Edition 2019.
5. Gerald A. Urban BioMEMS Springer, First Edition 2006.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

S24BPB71	VR AND AR IN BIOMEDICAL APPLICATIONS	L	T	P	EL	Credits	Total Marks
		2	0	2	0	3	100

COURSE OBJECTIVE

- To understand virtual reality, and augmented reality and use them to build Biomedical engineering applications.
- To know the intricacies of these platforms to develop PDA applications with better optimality.

UNIT 1 INTRODUCTION 9 Hrs.

Introduction to AR and VR. Difference between AR and VR. The three I 's of virtual reality-Components of AR and VR technology - Input Devices:(Trackers, Navigation, and Gesture Interfaces): Three-dimensional position trackers navigation and manipulation interfaces and gesture interfaces. Output Devices: Graphics displays-sound displays.

UNIT 2 VR DEVELOPMENT PROCESS AND CONTENT CREATION CONSIDERATIONS FOR VR 9 Hrs.

Geometric modeling-kinematics modeling-physical modeling, behavior modeling, model Management. Methodology and terminology-user performance studies-VR health and safety issues-Usability of virtual reality system-cyber sickness effects of exposures to virtual reality environment

UNIT 3 STEREOSCOPIC VISION & HAPTIC RENDERING 9 Hrs.

The human optical system, Depth cues, Stereopsis, Retinal disparity, Haptic sense, Haptic devices, Haptic rendering and parallax algorithms, Stereo pairs Synthesis, and Stereo images pipelines.

UNIT 4 SOFTWARES FOR AR AND VR 9 Hrs.

AR software, Camera parameters and calibration, AR based on markers, and AR Toolkit. JS-pros and cons-building blocks (WebVR, WebGL), Three.js, device orientation events) frameworks (A-frame, React VR)-Google VR for Android-Scripts, mobile device configuration, building to android-cameras and interaction-teleporting-spatialaudio-Assessinghumanparameters-devicedevelopmentanddrivers-DesignHaptics.

UNIT 5 APPLICATIONS 9 Hrs.

Medical applications-military applications-robotics applications-Advanced Realtime Tracking of other applications-games, movies, simulations, therapy

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understands the system or process to meet given specifications with realistic engineering constraints
CO2 - Identify problem statements and function as a member of an engineering design team.
CO3 - Examine the Stereoscopic vision and haptic rendering
CO4 - Explore the various software used for the development of AR and VR
CO5 - Apply the concepts of AR and VR to medical and industrial applications
CO6 - Design various medical applications based on augmented reality.

TEXTBOOK / REFERENCE BOOK

1. C. Burdea & Philippe Coiffet, Virtual Reality Technology, Second Edition, Gregory, John Wiley & Sons, Inc., 2008
2. Jason Jerald, 2015.TheVRBook: Human-Centred Design for Virtual Reality. Association for Computing Machinery and Morgan & Claypool, New York, NY, USA,.2015.
3. Augmented Reality: Principles and Practice (Usability)by Dieter Schmalstieg & Tobias Hollerer, Pearson Education (US), Addison-Wesley Educational Publishers Inc, New Jersey, United States, 2016.
4. Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web, and Mobile, Tony Parisi, O'Reilly Media;1edition, 2015.
5. Vasanth Mohan, Creating Augmented and Virtual Realities: Theory and Practice for Next-Generation Spatial Computing, Shroff/O'Reilly, 2019.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

S24BPB72	AI FOR HEALTH CARE	L	T	P	EL	Credits	Total Marks
		2	0	2	0	3	100

COURSE OBJECTIVE

- To develop fundamental knowledge in the area of artificial intelligence and to establish useful applications for it
- To organize and model a complex issue as a state space, then use intelligent search techniques to identify the most effective solutions
- To design and create methods for making decisions in challenging, unpredictable situations.

UNIT 1 INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND PROBLEM-SOLVING AGENT 9 Hrs.

Introduction–Definition – Future of Artificial Intelligence – Characteristics of Intelligent Agents–Typical Intelligent Agents – Problem-Solving Approach to Typical AI Problems.

UNIT 2 INFORMED SEARCH ALGORITHMS 9 Hrs.

Informed Search - Introduction to Heuristics – Greedy Breadth First Search, A* - Local Search Optimization Algorithms - Hill Climbing, Simulated Annealing.

UNIT 3 OPTIMAL SEARCH ALGORITHMS 9 Hrs.

Global optimization algorithms - Genetic Algorithms, Particle Swarm Optimization Algorithm, Ant Colony Optimization, Gravitational Search Algorithm - Games – Optimal Decisions in Games - Minimax Algorithm, Alpha-Beta Pruning Algorithm.

UNIT 4 KNOWLEDGE REPRESENTATION AND REASONING 9 Hrs.

First Order Predicate Logic – Prolog Programming – Unification – Forward Chaining-Backward Chaining – Resolution – Knowledge Representation – Ontological Engineering-Categories and Objects – Events – Mental Events and Mental Objects – Reasoning Systems for Categories – Reasoning with Default Information.

UNIT 5 DECISION THEORY AND PLANNING 9 Hrs.

Basics of utility theory, decision theory, sequential decision problems, decision networks, elementary game theory, Planning: planning as search, partial order planning, construction and use of planning graph.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Demonstrate a fundamental understanding of the evaluation of Artificial Intelligence (AI) and its foundations.

CO2 - Elucidate the basic knowledge representation, problem-solving, and learning methods of Artificial Intelligence

CO3 - Apply basic principles of AI in solutions that require problem-solving through Optimal Search Algorithms

CO4 - Demonstrate working knowledge of reasoning in the presence of uncertain information and show how search algorithms are essential for problem-solving

CO5 - Illustrate the importance of artificial intelligence and planning in solving real-world problems

CO6 - Design applications for healthcare that use Artificial Intelligence.

TEXT BOOK / REFERENCE BOOK

1. Russell S and Norvig P, Artificial Intelligence – A Modern Approach, 3rd Edition, Prentice Hall, 2015.
2. Elaine Rich, Kevin Knight, Shivashankar B Nair., "Artificial Intelligence", 3rd Edition, McGraw Hill Education, 2017.
3. Wolfgang Ertel," Introduction to Artificial Intelligence", Second Edition, Springer, 2017.
4. Stephen Lucci and Danny Kopec," Artificial Intelligence in the 21st Century, Second Edition, Mercury Learning and Information, 2015.
5. David L. Poole and Alan K. Mackworth, "Artificial Intelligence: Foundations of Computational Agents", Second Edition, Cambridge University Press, 2017.
6. Saroj Kaushik, "Logic & Prolog Programming", New Age International, Ist edition, 2002.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

S24BPB73	MACHINE LEARNING	L	T	P	EL	Credits	Total Marks
		2	0	2	0	3	100

COURSE OBJECTIVE

- To focus on the construction and study of algorithms that can learn from data.
- To emphasize the logical, knowledge-based approach.
- To introduce students to the basic concepts and techniques of Machine Learning.
- To develop skills in using recent machine learning software for solving practical problems.
- To gain experience in doing independent study and research.

UNIT 1 INTRODUCTION TO MACHINE LEARNING 9 Hrs.

Machine learning - examples of machine learning applications - Learning associations - Classification - Regression - Unsupervised learning - Supervised Learning - Learning class from examples - PAC learning -Noise, model selection, and generalization - Dimension of the supervised machine learning algorithm.

UNIT 2 MULTILAYER PERCEPTRONS 9 Hrs.

Structure of brain - Neural networks as parallel processing - Perceptron - Multilayer perceptron - Backpropagation - Training procedures - Tuning the network size - Learning time.

UNIT 3 SOM AND ART 9 Hrs.

Counter propagation network -Training of Kohenen and Grossberg Layer-feature mapping, self-organizing feature maps, Adaptive Resonance theory (ART) Network- ART1 and ART 2 Architecture, Evolving Support Vector Machine.

UNIT 4 DECISION THEORY 9 Hrs.

Bayesian Decision Theory- Introduction- Classification - Discriminant function-Bayesian Networks-Association rule - Parametric Methods - Introduction - Estimation –Multivariate methods-Data Parameter estimation–Dimensionality Reduction- PCA-Linear discriminant analysis.

UNIT 5 CLUSTERING & REGRESSION 9 Hrs.

Clustering - Mixture densities - k-means clustering - Supervised Learning after clustering - Hierarchical clustering - Nonparametric Methods - Density estimation - Generalization of multivariate data - Smoothing models -Decision Trees - Univariate trees - Multivariate trees - Learning rules from data - Linear Discrimination-Gradient Descent.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand the complexity of Machine Learning algorithms and their limitations;
CO2 - Understand modern notions in data analysis-oriented computing;
CO3 - Be capable of confidently applying common Machine Learning algorithms in practice
CO4 - Be capable of performing distributed computations;
CO5 - Can demonstrate working knowledge of reasoning in the presence of incomplete and/or uncertain information
CO6 - Gain the ability to apply knowledge representation, reasoning, and machine-learning techniques to real-world problems

TEXT BOOK / REFERENCE BOOK

1. EthemAlpaydin, “Introduction to Machine Learning”, MIT Press, 2004.
2. Tom Mitchell, “Machine Learning”, McGraw Hill, 1997.
3. Shai Shalev-Shwartz and Shai Ben-David, “Understanding Machine Learning: From Theory to Algorithms”, Cambridge University Press, 2014.
4. James A. Freeman & David M.Skapura, Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education 1991.
5. S.Haykin, Neural Networks: A Comprehensive Foundation, Pearson Education (Asia) Pvt. Ltd., Prentice Hall of India, 2003.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

S24BPB74	DEEP LEARNING FOR BIOMEDICAL APPLICATIONS	L	T	P	EL	Credits	Total Marks
		2	0	2	0	3	100

COURSE OBJECTIVE

- To gain knowledge on the concepts of deep learning
- To provide insight into recent CNN architectures and deep models
- To enable the students to know deep learning techniques to support real-time applications.

UNIT 1 FOUNDATION OF NEURAL NETWORKS AND DEEP LEARNING 9 Hrs.

Neural Networks-Training neural networks, Activation Functions, Loss functions, Hyperparameters, Fundamentals of Deep Networks-Defining Deep Learning, Common Architectural Principles of Deep Networks, Parameters, Layers, Activation Functions, Loss Functions, Optimization Algorithms, Hyperparameters.

UNIT 2 CONVOLUTION NEURAL NETWORKS 9 Hrs.

Architectural Overview – Input Layers, Convolutional Layers, Pooling Layers, Fully Connected Layers – Filters – Parameter sharing – Regularization, Popular CNN Architectures: ResNet, AlexNet.

UNIT 3 RECURRENT AND RECURSIVE NETS - SEQUENCE MODELLING 9 Hrs.

Recurrent Neural Networks, Bidirectional RNNs, Encoder-decoder sequence to sequence architectures - BPTT for training RNN, Long Short-Term Memory Networks

UNIT 4 AUTO ENCODERS AND DEEP GENERATIVE MODELS 9 Hrs.

Introduction to Android, Creating Android Activities, Android User interface design, Access Wi-fi and Bluetooth with mobile applications-Web based App for e-health applications.

UNIT 5 RECENT TRENDS IN DEEP LEARNING 9 Hrs.

Recent Models of Deep Learning, Genomics, Predictive Medicine, Clinical Imaging, Lip Reading, Visual Reasoning.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Ability to differentiate the concept of machine learning with deep learning techniques
CO2 - Understand and visualize Convolutional Neural Networks for real-world applications
CO3 - Demonstrate the use of Recurrent Neural Networks and Transformer based for time series prediction
CO4 - Illustrate autoencoder and deep generative models to solve problems with high dimensional data
CO5 - Design and develop an application-specific deep-learning model
CO6 - Analyse the latest trends in deep learning

TEXT BOOK / REFERENCE BOOK

1. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017
2. Wei Di, Anuragh Bharadwaj, “Deep Learning Essentials”, Jianing Wei, Packt Publishers, 2018.
3. Nikhil Buduma, Nicholas, “Fundamentals of Deep Learning”, O Reilly Media, 2017.
4. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2016.
5. Suraj Sawant. “Deep Learning”, IGI Global, 2018.
6. Umberto Michelucci “Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks” A press, 2018.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

S24BPB75	PYTHON FOR SIGNAL AND IMAGE APPLICATIONS	L	T	P	EL	Credits	Total Marks
		2	0	2	0	3	100

COURSE OBJECTIVE

- To gain the knowledge necessary to launch a biomedical start-up
- To implement the concepts into practice and copyright the Inventions
- To understand the significance of sales and marketing.

UNIT 1 INTRODUCTION TO PYTHON, DATA TYPES, EXPRESSIONS, LOOPS 9 Hrs.

Introduction to Python Programming - Running Code in the Interactive Shell, Input, Processing and Output, Editing, Saving and Running a Script - Data Types, String Literals, Escape Sequences, String Concatenation, Variables, and the Assignment Statement - Numeric Data Types Module, The Main Module, Program Format, and Structure and Running a Script from a Terminal Command Prompt, Conditional loops, and iterations.

UNIT 2 STRINGS AND TEXT FILES 9 Hrs.

Strings - Accessing Characters and Substrings in Strings, Data Encryption, Strings and Number Systems and String Methods - Text Files - Text Files and Their Format, Writing Text to a File, Writing Numbers to a File, Reading Text from a File, Reading Numbers from a File and Accessing and Manipulating Files and Directories on Disk.

UNIT 3 LISTS AND DICTIONARIES 9 Hrs.

Lists - List Literals and Basic Operators, Replacing an Element in a List, List Methods for Inserting and Removing Elements, Searching and Sorting a List, Mutator Methods and the Value None, Aliasing and Side Effects, Equality, and Tuples - Defining Simple Functions - Syntax, Parameters and Arguments, return Statement, Boolean Functions, and main function, DICTIONARIES - Dictionary Literals, Adding Keys and Replacing Values, Accessing Values, Removing Keys and Traversing a Dictionary.

UNIT 4 DESIGN WITH FUNCTIONS AND DESIGN WITH CLASSES 9 Hrs.

Design with Functions and Design with Classes - Functions as Abstraction Mechanisms, Problem Solving with Top-Down Design, Design with Recursive Functions and Managing a Program's Namespace -DESIGN WITH CLASSES - Objects and Classes, Data Modeling and Structuring Classes with Inheritance and Polymorphism.

UNIT 5 CASE STUDIES IN BIOMEDICAL ENGINEERING 9 Hrs.

Medical Imaging, Speech Recognition, Genomics, Drug Discovery, Patient Health Monitoring, Virtual Assistance, and Predictive Analytics in Healthcare.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand the overview of NLP and modeling of Language
CO2 - Describe various word-level analysis
CO3 - Analyse Grammar and NLP Models
CO4 - Explore various methods of speech processing and Discourse analysis
CO5 - Apply the principles of NLP in Biomedicine
CO6 - Develop NLP for biomedical application

TEXT BOOK / REFERENCE BOOK

1. Richard M Reese, ―Natural Language Processing with Java, OReilly Media, 2015.
2. Nitin Indurkhya and Fred J. Damerau, ―Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.
3. Daniel Jurafsky, James H. Martin―Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech, Pearson Publication, 2014
4. Doan S, Conway M, Phuong TM, Ohno-Machado L. Natural language processing in biomedicine: a unified system architecture overview. Methods Mol Biol. 2014; 1168:275-94. doi: 10.1007/978-1-4939-0847-9_16. PMID: 24870142.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

S24BPB76	MEDICAL BIG DATA ANALYTICS	L	T	P	EL	Credits	Total Marks
		2	0	2	0	3	100

COURSE OBJECTIVE

- To understand the underlying concepts of Big Data.
- To study the various tools used for Big Data Analytics
- To apply Big Data in the field of health care systems and Biomedical Data.

UNIT 1 INTRODUCTION 9 Hrs.

Introduction to Big Data – Issues and Challenges in the traditional systems - Evolution of Big Data – Four V's of Big Data – Big Data Use Cases and Characteristics – Intelligent Data Analysis – Data Analytic Tools – Big Data Storage Statistical Concepts: Sampling Distributions - Re-Sampling - Statistical Inference - Prediction Error – Random Sampling.

UNIT 2 HADOOP AND NoSQL 9 Hrs.

Introduction to Hadoop – Hadoop Distributed File System – Analyzing data with Hadoop – Scaling – Streaming – Clustering: Single Node and Multi-Node – Working with Hadoop Commands – Working with Apache Oozie- Introduction to NoSQL- NoSQL business drivers-; NoSQL data architecture patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores - Variations of NoSQL architectural patterns; Big data NoSQL solution- Understanding the types of big data problems; Analyzing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer.

UNIT 3 BIG DATA TOOLS AND MAP REDUCE 9 Hrs.

Big Data Applications using Pig and Hive – Fundamentals of HBase and ZooKeeper – IBM Infosphere Big Insights – Introduction to FLUME – KAFKA. Algorithms using map-reduce - Matrix-Vector – Multiplication – Word Count - Understanding inputs and outputs of MapReduce, Data Serialization – Introduction to YARN – MapReduce Vs YARN – YARN Architecture – Scheduling in YARN – Fair Scheduler – Capacity Scheduler.

UNIT 4 MINING DATA STREAM AND FRAMEWORKS 9 Hrs.

Mining Data Stream: Introduction to Streams Concepts, Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, estimating moments, counting oneness in a Window, Decaying Window, Real-time Analytics Platform (RTAP) applications, - Using Graph Analytics for Big Data: Graph Analytics.

UNIT 5 SOURCES AND TECHNIQUES FOR BIG DATA IN HEALTHCARE 9 Hrs.

Motivation for Big data analytics in Health care-Structured EHR Data – Unstructured Clinical Notes – Medical Imaging Data – Genetic Data – Epidemiology & Behavioral data analysis.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - Understand the fundamentals of Big Data
CO2 - Analyze the usage of HADOOP and NoSQL in Big data
CO3 - Familiarize tools used for Big Data
CO4 - Comprehend the data mining concepts and Frameworks.
CO5 - Apply the concepts of Big Data in the field of healthcare
CO6 - Develop Big data solutions for healthcare applications

TEXT BOOK / REFERENCE BOOK

1. Chris Eaton, Dirk deroos et al., “Understanding Big data”, McGraw Hill, 2012.
2. Tom White, “HADOOP: The Definitive Guide”, O Reilly 2012.
3. Vignesh Prajapati, “Big Data Analytics with R and Hadoop”, Packet Publishing 2013.
4. Jimeng Sun, Chandan K. Reddy, Big Data Analytics for Healthcare, IBM Wayne State, http://dmkd.cs.wayne.edu/TUTORIAL/Healthcare.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

LIST OF MANAGEMENT ELECTIVES

SBAB4001	PRINCIPLES AND PRACTICES OF MANAGEMENT	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

COURSE OBJECTIVE

- To analyse how the field of Management has evolved and its significant contributions
- To analyse and apply the critical role of managers in modern organizational settings.
- To illustrate and evaluate the importance of planning, organizing, directing and controlling in decision making.

UNIT 1 INTRODUCTION 9 Hrs.

Definition, Functions, Process, Scope and Significance of Management. Nature of Management, Managerial Roles, Managerial Skills and Activities, Difference between Management and Administration. Significance of Values and Ethics in Management.

UNIT 2 SCHOOLS OF MANAGEMENT 9 Hrs.

Evolution of Management Thought - Contributions of F.W. Taylor, Henry Fayol, Elton Mayo, Approaches of Management Thought (including MBO & MBE) Functions of Management. Concept of Leadership- Theories and Styles.

UNIT 3 PLANNING AND ORGANIZING 9 Hrs.

Nature, Scope, Objective and Significance of Planning, Elements and Steps of Planning, Decision Making Organizing Principles, Span of Control, Line and Staff Relationship, Authority, Delegation and Decentralization. Effective Organizing, Organizational Structures, Formal and Informal Organizations, Staffing.

UNIT 4 DIRECTING 9 Hrs.

Effective Directing, Supervision, Motivation: Different Theories of Motivation - Maslow, Herzberg, Mc Clelland, Vroom, Porter and Lawler, Job Satisfaction. Communication Process, Channels and Barriers, Effective Communication.

UNIT 5 CONTROLLING AND COORDINATING 9 Hrs.

Elements of Managerial Control, Control Systems, Management Control Techniques, Effective Control Systems. Coordination Concept, Importance, Principles and Techniques of Coordination, Concept of Managerial Effectiveness.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - To provide an understanding of basic management concepts, principles, and practices.
CO2 - To develop planning and decision-making strategies in an organization.
CO3 - To summarize the concept and complete the process of organizing.
CO4 - To develop an understanding of staffing, leadership, directing and motivation in an organization.
CO5 - To predict the dynamics of controlling and its emerging issues in management.
CO6 - Assess managerial practices and choices relative to ethical principles and standards

TEXT / REFERENCE BOOKS

1. Stephen P. Robbins, David A. Decenzo, Fundamentals of Management, Pearson Education, 9th Edition
2. Harold Koontz, O'Donnell and Heinz Weihrich, Essentials of Management. New Delhi, 9th edition, Tata McGraw Hill

3. Management Fundamentals: Concepts, Applications, & Skill Development, 6th edition, Sage.
4. Richard L. Daft, Principles Of Management, Cengage Learning.
5. Prasad, L.M. Principles and Practice of Management, Sultan Chand
6. Jhunjhunwala J Mohanty, Management Principles and Applications, Himalaya Publishing House

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A :	10 Questions of 2 marks each - No choice	**20 Marks**
PART B :	2 Questions from each unit with internal choice, each carrying 16 marks	**80 Marks**

S41BPB41	VENTURE CREATION	L	T	P	EL	Credits	Total Marks
		2	0	0	3	3	100

COURSE OBJECTIVE

- To develop an entrepreneurial mindset, understand the concept of entrepreneurship and identify personal strengths and weaknesses
- To understand the design thinking process and apply design thinking to real-world problems
- To identify problems and opportunities and develop ideas for new ventures by assessing market potential
- To develop a value proposition, business model canvas, build MVP to create sustainable differentiation for the venture with a well-structured business plan, unit economics, go-to-market strategies and funding plan for managing business growth
- To build an idea pitch and deliver it with confidence to potential stakeholders.

UNIT 1 INTRODUCTION TO ENTREPRENEURSHIP 9 Hrs.

Defining Entrepreneurship, evolution the concept & Emerging Trends in Entrepreneurship (Domain specific), understanding the unique opportunities; Why be an Entrepreneur? Entrepreneurship in Indian Scenario &Its role in economic development; Success stories of Entrepreneur (Domain specific);Entrepreneurial style assessment tool; Developing the Entrepreneurial mindset- Attributes & skills, recognizing your sweet spot for starting up; Principles of Effectuation; Myths about Entrepreneurship; Types of Entrepreneurs; Entrepreneur vs Intrapreneur; Role of Entrepreneurial Teams.

UNIT 2 DESIGN THINKING &OPPORTUNITY DISCOVERY 9 Hrs.

Introduction to Design Thinking for startups; Design Thinking principles & process; Define the problem using Design thinking principles and validate Problem; Generation of ideas, Idea generation techniques and evaluating creative ideas; Identify problem worth solving; Sharpen your Problem Pitch.

UNIT 3 CUSTOMER, MARKETS AND CREATING A SUSTAINABLE DIFFERENTIATION 9 Hrs.

Differentiate between a customer and a consumer; Who is your customer and what is your segment ; Customer Job, Pains, and Gains using Value proposition Canvas; Build solution using Value Proposition Canvas; Market Estimation-TAM,SAM,SOM; Competitive analysis; Minimum viable product – what is MVP: Build - Measure - Learn, differentiate between solution Demo & MVP; How to validate MVP- Achieve a Product – Market fit.

UNIT 4 BUSINESS MODEL, BUSINESS PLANNING AND GO TO MARKET STRATEGIES 9 Hrs.

Introduction to Business model, Business plan ; Lean approach 9 block lean canvas model; Financial feasibility: Costs, revenue streams, Pricing, Financial Projections, Key Financial Metrics using financial template, Managing growth & targeting scale, Unit economics; Selecting the Right Channel; Introduction to Digital Marketing and tools; Branding strategy.

UNIT 5 FUNDING STRATEGY 9 Hrs.

Sources of funds: Debt & Equity ; Map the Start-up Lifecycle to Funding Options; Build an Investor ready pitch deck.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 - To define entrepreneurship and explain emerging trends in entrepreneurship.

CO2 - To identify and evaluate business opportunities and assess market potential

CO3 - To conduct customer discovery, market research, build a lean canvas, develop a business plan and marketing strategies

CO4 - To identify sources of funding and develop a funding strategy, understand basic legal requirement for starting and running a business

CO5 - To build an idea pitch and deliver it with confidence to various stakeholders To develop planning and decision-making strategies in an organization.

TEXT / REFERENCE BOOKS

1. Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2017). Entrepreneurship (10th ed.). McGraw-Hill Education.
2. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business.
3. Blank, S. G., &Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch.
4. Roy, R. (2017). Indian Entrepreneurship: Theory and Practice. New Delhi: Oxford University Press.
5. Chandan, J. S., & Rana, S. S. (2019). Entrepreneurship Development and Management. New Delhi: McGraw Hill Education.
6. Sinek, S. (2011). Start with Why: How Great Leaders Inspire Everyone to Take Action. Portfolio.
7. Choudhary, R., & Mehta, N. (2019). From Zero to One: How to Build a Successful Startup in India. Notion Press.
8. Osterwalder, A., &Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons.