SHRI G.S. INSTITUTE OF TECHNOLOGY & SCIENCE

(An Autonomous Institute Established in 1952)

BACHELOR OF TECHNOLOGY

BIOMEDICAL ENGINEERING

Syllabus

Session 23-24

Institute Vision
A front-line institute in science and technology making significant contributions to human resource development envisaging dynamic needs of the society.
Institute Mission
To generate experts in science and technology akin to society for its accelerated socioeconomic growth in a professional and challenging environment imparting human values.

Department Vision
To contribute to teaching excellence to generate human resources to cater the needs of industries and hospitals for affordable healthcare through research and innovation.
Department Mission
To bridge the engineering, science and healthcare sectors for indigenous development and to impart community services for mass healthcare through continuous research.

Program Outcomes – Competencies – Performance Indicators

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.

Competency	Performance Indicators
1.1 Demonstrate competence in mathematical modeling	1.1.1 Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems 1.1.2 Apply advanced mathematical techniques to model and solve Biomedical engineering problems
1.2 Demonstrate competence in basic sciences	1.2.1 Apply laws of natural science to an engineering problem
1.3 Demonstrate competence in engineering fundamentals	1.3.1 Apply fundamental engineering concepts to solve engineering problems
1.4 Demonstrate competence in specialized engineering knowledge to the program	1.4.1 Apply integrated engineering concepts to solve engineering problems.

PO 2: Problem analysis: Identify, formulate, research literature, and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Competency	Performance Indicators
2.1 Demonstrate an ability to identify and formulate complex engineering problem	2.1.1 Articulate problem statements and identify objectives 2.1.2 Identify engineering systems, variables, and parameters to solve the problems 2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 Reframe complex problems into interconnected sub-problems 2.2.2 Identify, assemble and evaluate information and resources. 2.2.3 Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions 2.2.4 Compare and contrast alternative solution processes to select the best process.

2.3 Demonstrate an ability to formulate and interpret a model	2.3.1 Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy. 2.3.2 Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required.
2.4 Demonstrate an ability to execute a solution process and analyze results	2.4.1 Apply engineering mathematics and computations to solve mathematical models 2.4.2 Produce and validate results through skillful use of contemporary engineering tools and models 2.4.3 Identify sources of error in the solution process, and limitations of the solution. 2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3: Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.	
Competency	**Performance Indicators**
3.1 Demonstrate an ability to define a complex/ open-ended problem in engineering terms	3.1.1 Recognize that need analysis is key to good problem definition 3.1.2 Elicit and document, engineering requirements from stakeholders 3.1.3 Synthesize engineering requirements from a review of the state-of-the-art 3.1.4 Extract engineering requirements from relevant engineering Codes and Standards such as, DCA, FDA, BIS, ISO and ASTM. 3.1.5 Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural and societal issues 3.1.6 Determine design objectives, functional requirements and arrive at specifications
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.1 Apply formal idea generation tools to develop multiple engineering design solutions 3.2.2 Build models/prototypes to develop a diverse set of design solutions 3.2.3 Identify suitable criteria for the evaluation of alternate design solutions

3.3 Demonstrate an ability to select an optimal design scheme for further development	3.3.1 Apply formal decision-making tools to select optimal engineering design solutions for further development 3.3.2 Consult with domain experts and stakeholders to select candidate engineering design solution for further development
3.4 Demonstrate an ability to advance an engineering design to defined end state	3.4.1 Refine a conceptual design into a detailed design within the existing constraints (of the resources) 3.4.2 Generate information through appropriate tests to improve or revise the design
PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	
Competency	Performance Indicators
4.1 Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.1 Define a problem, its scope and importance for purposes of investigation 4.1.2 Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation 4.1.3 Apply appropriate instrumentation and/or software tools to make measurements of physical quantities 4.1.4 Establish a relationship between measured data and underlying physical principles.
PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	
Competency	Performance Indicators
5.1 Demonstrate an ability to identify/ create modern engineering tools, techniques and resources	5.1.1 Identify modern engineering tools such as computer-aided drafting, modeling and analysis; techniques and resources for engineering activities 5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2 Demonstrate an ability to select and apply discipline-specific tools, techniques and resources	5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs. 5.2.2 Demonstrate proficiency in using discipline-specific tools
5.3 Demonstrate an ability to evaluate the suitability and limitations of tools used to solve an engineering problem	5.3.1 Discuss limitations and validate tools, techniques and resources 5.3.2 Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	
Competency	**Performance Indicators**
6.1 Demonstrate an ability to describe engineering roles in a broader context, e.g. pertaining to the environment, health, safety, legal and public welfare	6.1.1 Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level
6.2 Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.	
Competency	**Performance Indicators**
7.1 Demonstrate an understanding of the impact of engineering and industrial practices on social, environmental and in economic contexts	7.1.1 Identify risks/impacts in the life-cycle of an engineering product or activity 7.1.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
7.2 Demonstrate an ability to apply principles of sustainable design and development	7.2.1 Describe management techniques for sustainable development 7.2.2 Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline
PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	
Competency	**Performance Indicators**
8.1 Demonstrate an ability to recognize ethical dilemmas	8.1.1 Identify situations of unethical professional conduct and propose ethical alternatives
8.2 Demonstrate an ability to apply the Code of Ethics	8.2.1 Identify tenets of the BMES professional code of ethics. 8.2.2 Examine and apply moral & ethical principles to known case studies
PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	
Competency	**Performance Indicators**

9.1 Demonstrate an ability to form a team and define a role for each member	9.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team 9.1.2 Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
9.2 Demonstrate effective individual and team operations-- communication, problem-solving, conflict resolution and leadership skills	9.2.1 Demonstrate effective communication, problem-solving, conflict resolution and leadership skills 9.2.2 Treat other team members respectfully 9.2.3 Listen to other members 9.2.4 Maintain composure in difficult situations
9.3 Demonstrate success in a team-based project	9.3.1 Present results as a team, with smooth integration of contributions from all individual efforts
PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	
Competency	**Performance Indicators**
10.1 Demonstrate an ability to comprehend technical literature and document project work	10.1.1 Read, understand and interpret technical and non-technical information 10.1.2 Produce clear, well-constructed, and well-supported written engineering documents 10.1.3 Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
10.2 Demonstrate competence in listening, speaking, and presentation	10.2.1 Listen to and comprehend information, instructions, and viewpoints of others 10.2.2 Deliver effective oral presentations to technical and non-technical audiences
10.3 Demonstrate the ability to integrate different modes of communication	10.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations 10.3.2 Use a variety of media effectively to convey a message in a document or a presentation
PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	
Competency	**Performance Indicators**

11.1 Demonstrate an ability to evaluate the economic and financial performance of an engineering activity	11.1.1 Describe various economic and financial costs/benefits of an engineering activity 11.1.2 Analyze different forms of financial statements to evaluate the financial status of an engineering project
11.2 Demonstrate an ability to compare and contrast the costs/benefits of alternate proposals for an engineering activity	11.2.1 Analyze and select the most appropriate proposal based on economic and financial considerations.
11.3 Demonstrate an ability to plan/manage an engineering activity within time and budget constraints	11.3.1 Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks. 11.3.2 Use project management tools to schedule an engineering project, so it is completed on time and on budget.
PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	
Competency	**Performance Indicators**
12.1 Demonstrate an ability to identify gaps in knowledge and a strategy to close these gaps	12.1.1 Describe the rationale for the requirement for continuing professional development 12.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap
12.2 Demonstrate an ability to identify changing trends in engineering knowledge and practice	12.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current 12.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
12.3 Demonstrate an ability to identify and access sources for new information	12.3.1 Source and comprehend technical literature and other credible sources of information 12.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

B. Tech Biomedical Engineering (4 YDC)

ASSESSMENT

THEORY ASSESSMENT

1. Internal Assessment for continuous evaluation, 2 mid-term tests, quiz, attendance, class performance,tutorials etc. (30%).
2. End semester Theory Exam (70%).

PRACTICAL ASSESSMENT

A. Continuous evaluation of laboratory journals with a weightage of 40%. It includes lab attendance as well as experiments performed in the lab.
B. The end-term practical examination weightage is 60%.

B. Tech II[nd] Year Sem A (4 YDC)
BM- 29007: Bioelectricity and Transducers

Course Outcomes: -

At the end of this course students will be able to:

CO1: Identify sources of biopotential generation and their propagation in the human body.
CO2: Classify different electrodes based on their working principle.
CO3: Illustrate selection procedure of transducer for various medical applications.
CO4: Describe the various temperature and pressure transducers.
CO5: Demonstrate the working of reference electrodes and chemical electrodes.
CO6: Remember and understand the concepts, types, working and practical applications of important biosensors and optical sensors.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-29007	Bioelectricity and Transducers	3	-	2	3	1	4	70	30	40	60	200

Unit 1. Bioelectric Signals & Biopotential Electrodes

Sources of Bioelectric potentials, Propagation of Action potential. Bioelectric potentials ECG, EEG and EMG responses. Development of bioelectric potential measurement electrode theory and recording issues: electrode-tissue interface, metal-electrolyte interface, electrode-skin interface and motion artifact, electrode impedance, electrical conductivity of electrodes: jellies and creams, body surface electrodes. Internal electrodes: needle and wire electrodes, micro-electrodes: metal, micropipette.

Unit 2. Transducers and Applications

Transducer, transduction principles, active and passive transducers, transducers for biomedical applications. Displacement and pressure measurement: (with applications) resistive: potentiometers, strain gauges, bridge circuits, inductive: variable inductance and LVDT, capacitive type, piezoelectric transducers**.**

Unit 3. Temperature and Pressure Measurement

Different types of temperature transducers: thermistor, thermocouple, resistive temperature detector, IC based measurement temperature. Different types of pressure transducers: types of diaphragms, bellows, bourdon tubes.

Unit 4. Bio- Chemical Electrodes

Blood gas and acid−base physiology, potentiometric sensors, ion selective electrodes, ISFETs, amperometric sensors, Clark's electrode with examples − pH, pO_2, pCO2 electrodes, reference electrodes.

Unit 5. Biosensors and Optical Sensor

Classifications: Biological phenomenon, transduction phenomenon i.e. enzyme sensor and electrode based: affinity sensors (catalytic biosensors), two examples of each biosensors and immunosensors, optical sensors, photo detectors, pyrometers, optical sources.

Text books

1. A.K. Sawhney, *A course in Electrical and Electronic Measurement and Instrumentation*, Dhanpat Rai, 2005.
2. R.S. Khandpur, *Handbook of Biomedical Instrumentation*, 2nd ed., Tata McGraw Hill, 2003.

References books

1. Tatsuo Togawa, Toshiyo Tamura and P. Ake Oberg, *Biomedical Transducers and Instruments*, 1st ed., CRC Press, 1997.

2. Joseph J. Carr and John M. Brown, *Introduction to Biomedical Equipment Technology*, 4th ed., Prentice Hall, 2001.
3. B. C. Nakra and K. K. Chaudhry, *Instrumentation, Measurement and Analysis*, Tata McGraw-Hill, 2003.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	2	1	2	-	-	-	-	1
CO2	2	2	3	2	3	-	2	-	-	-	-	2
CO3	3	3	3	2	3	-	3	-	-	-	-	3
CO4	3	2	3	2	3	-	1	-	-	-	-	1
CO5	3	2	3	2	2	-	1	-	-	-	-	2
CO 6	2	2	2	2	2	-	1	-	-	-	-	2
Average	2.5	2.0	2.5	1.8	2.5	1.0	1.7	-	-	-	-	1.8

LABORATORY

List of Experiments:

1. To measure strain using strain gauge cantilever-based assembly.
2. To measure displacement using LVDT.
3. Angular measurement using rotary pot.
4. Strain gauge as a displacement transducer.
5. Humidity measurement.
6. To measure temperature using a thermistor.
7. To understand the working of RTD.
8. To understand the working of Thermocouple.
9. To perform temperature measurement using IC based temperature sensor.

LABORATORY OUTCOMES

1. Understand the concepts of measurement, error and uncertainty.
2. Understand the static and dynamic characteristics of measuring instruments
3. Gain knowledge about the principle of operation and characteristics of different types of resistance, capacitance and inductance transducers.
4. Ability to interpret the results and draw meaningful conclusions
5. Ability to work as a member of a team while carrying out experiments.

Lab Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	3	-	-	-	-	-	-	-	3	-	-
2	2	3	-	-	3	-	-	2	-	3	-	-
3	3	3	-	1	-	-	-	-	-	3	-	-
4	-	-	-	-	3		-	2	2	-	-	1
5	-	-	-	-	-	-	-	2	2	3	-	1
Average	2.7	3.0	-	1.0	3.0	-	-	2.0	2.0	3.0	-	1.0

B. Tech IInd Year Sem A (4 YDC)
BM- 29003: Human Anatomy and Physiology

Course Outcomes: -

At the end of this course students will be able to:

CO1: Classify different types of cell based on their structure and functionality.

CO2: Explain physiology of cardiovascular and respiratory systems and their implications.

CO3: Describe the interdependence and interactions of nervous and musculoskeletal systems.

CO4: Describe the physiology and anatomy of digestive and excretory systems..

CO5: Recognise organs of the reproductive system and other special organs.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-29003	Human Anatomy and Physiology	3	-	2	3	1	4	70	30	40	60	200

Unit 1. Introduction to Human Body

Cell, overview of organ systems, basic terminologies (directional, regional, planes, feedback). cell:- different types of cells, cell structure and its organelles, functions of each component in the cell membrane, transport across membrane, origin of cell membrane potential, action potential and propagation, blood composition:- RBC, WBC and platelets.

Unit 2. Cardiovascular and Respiratory Systems

Structure of heart, circulation types, cardiac cycle, volume and pressure changes, ECG, heart sounds, blood pressure, regulation of BP, parts of respiratory system, mechanics of respiration carbon dioxide and oxygen transport, regulation of respiration, volumes and capacities of lung, types of hypoxia.

Unit 3. Nervous System and Musculoskeletal System

Nerve cell anatomy, functions of nervous system, brain anatomy and hemispheres, meninges, cerebrospinal fluid, circulation and absorption, spinal cord anatomy, reflex action, PNS, skeletal system -functions -anatomy of long bone –formation, growth and repair, structural and functional classification of joints, functions of muscular system, types of muscles - sliding filament model, neuromuscular junction, physiology of muscle contraction**.**

Unit 4. Digestive and Excretory System

Digestive system, organization, movements of GI tract, digestion at various parts (mouth to large intestine), accessory organs of digestion (salivary glands, liver, pancreas, gallbladder), defecation, excretory system, functions of urinary system, microanatomy and functions of nephron, physiology of urine formation, micturition.

Unit 5. Reproductive System, Special Organs and Endocrine Glands

Human Reproductive System (Male & Female); Physiology and functionsEyes-retina layers, visual pathway, internal ear, physiology, auditory pathway, sense of taste, sense of smell, touch, endocrine glands, different glands and their hormones, pituitary, thyroid parathyroid glands-secretions, maintenance of calcium homeostasis, maintenance of glucose homeostasis.

Text books

1. Charles Herbert Best and Burke Taylor, *Living body*, Chapman & Hall Ltd, 1944.
2. Dr. T. S. Ranganath, *Textbook of Human Anatomy*, S. Chand & Company, 2000.
3. W.G. Sears and R. S. Winwood, *Anatomy and Physiology for Nurses and Students of Human Biology*, Hodder & Stoughton Educational, 1974.

References books

1. Anantha Narayana and R. Jeyaram Panickar, *Textbook of Microbiology*, Orient Longman, 2009.
2. Paul and Reich, *Hematology, Physio Pathological Basis for Clinical Practice*, Little Brown, 1978.
3. Warrick C. K, *Anatomy and Physiology for Radiographers*, Oxford University Press, 1977.
4. Cyril A. Keele and Eric Neil, *Samsons Wright's Applied Physiology*, Oxford University Press, 1979.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	-	-	-	3	-	-	-	2	-	2
CO2	2	2	-	-	-	3	-	-	-	3	-	2
CO3	2	2	-	-	-	3	-	-	-	2	-	2
CO4	1	1	-	-	-	3	-	-	-	3	-	2
CO5	1	1	-	-	-	3	-	-	-	2	-	2
Average	1.4	1.6	-	-	-	3	-	-	-	2.4	-	2

LABORATORY

List of Experiments:

1. To study various physiological models.
2. To study Cardiopulmonary Resuscitation (CPR).
3. To measure the systolic and diastolic blood pressure value of the human heart.
4. To measure the Heart-Rate/Pulse-Rate of the human body.
5. To study abnormalities (Tachycardia, Bradycardia) present in the human cardiovascular system using ECG simulator.
6. To measure respiration rate of human body
7. To record the changes in pulmonary volume and capacities by using a spirometer.
8. To determine the blood group of the subject.
9. To understand the basic concept of blood cell differentiation

LABORATORY OUTCOMES

1. To get acquainted with anatomy and physiology of the human body.
2. To set up biomedical instruments and measure the key human body parameters such as temperature, blood pressure etc.
3. To analyze the blood group of the subject.
4. To understand the working of a microscope and observe the blood cell differentiation.

Lab Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	1	-	-	-	-	-	-	2	3	-	-
2	3	1	-	-	2	-	-	-	2	3	-	-
3	3	1	-	-	1	-	-	-	2	3	-	-
4	3	1	-	-	3	-	-	-	2	3	-	-
Average	3	1	-	-	3	-	-	-	2	3	-	-

B. Tech IInd Year Sem A (4 YDC)
MA- 29024: Mathematics- III

Course Outcomes:-

At the end of this course students will be able to:

CO1: Modeling of biological systems through ordinary differential equations, solution of differential equations.
CO2: Calculus of finite differences, different rules.
CO3: Formation of partial differential equations of different orders.
CO4: Euler's Equation.
CO5: Fourier series & Integral Transforms.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
MA- 29024	Mathematics-III	3	1	-	4	-	4	70	30	-	-	100

Unit 1. Calculus of Finite Differences and Difference equations

Difference operator, shift operator, Newton's forward & backward interpolation, Lagrange's interpolation, numerical differentiation and integration, difference equations.

Unit 2. Modeling of Biological Systems through ordinary differential Equations

Growth and decay, dynamics of tumor growth, radioactivity and carbon data, temperature rate of change, biological growth, a problem in epidemiology, detection of diabetes.

Elements of Partial Differential equations:

Formation of partial differential equations, partial differential equation of first order and first degree, i.e., $Pp + Qq = R$, linear homogeneous partial differential equation of n^{th} order with constant coefficient, separation of variables, applications to simple problem.

Unit 3. Statistics

Modern view of probability theory, random experiments, sample space, random variables, distribution function and density function, random variables of discrete and continuous type, functions of two random variables, bivariate probability with conditional and marginal probability distribution.

Unit 4. Fourier Analysis

Euler's formula, Dirichlet's condition, function having point of discontinuity, change of intervals, odd and even functions, half-range series, Fourier integrals, Fourier sine and cosine integrals, complex form of Fourier integral, Fourier transform and its application..

Unit 5. Laplace Transform

Laplace Transform (LT), LT of elementary and periodic functions, properties of LT, inverse Laplace transform, convolution theorem. Application of Laplace transform to the solution of ordinary differential equations.

Text books

1. Ramana B. V., *Higher Engineering Mathematics*, Tata McGraw Hill, 2006.
2. Jain, R.K. and S.K. Iyengar, *Advanced Engineering Mathematics*, Narosa Publishing House, 2006.

References

1. Erwin. Kreyszig, *Advanced Engineering Mathematics*, 8th ed., John Willy and sons Publications, 1999.
2. Balagurusamy, *Numerical Methods*, Tata McGraw-Hill Publishing Company Ltd., 1999.
3. H.K. Das, *Higher Engineering Mathematics*, S. Chand, 2014.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	-	-	-	-	-	-	-	-	3
CO2	3	3	3	-	-	-	-	-	-	-	-	3
CO3	3	3	3	-	-	-	-	-	-	-	-	3
CO4	3	3	3	-	-	-	-	-	-	-	-	3
CO5	3	3	3	-	-	-	-	-	-	-	-	3
Average	3	3	3	-	-	-	-	-	-	-	-	3

EE- 29011: Network Analysis

Course Outcomes:-

After completing the subject student will be able to:

CO1: Apply the knowledge of basic physics and mathematics to develop an approximate circuit model of practical elements. Formulation of circuit equations using Kirchhoff's law and network topology

CO2: Infer and evaluate transient response, steady state response in time and frequency domain, determine different network functions.

CO3: Develop and evaluate two-port model and its parameters.

CO4: To perform Steady state analysis, and analyze the series and parallel resonant circuit.

CO5: Analysis of polyphase circuits, neutral shift concept and power factor improvement.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
EE-29011	Network Analysis	3	-	2	3	1	4	70	30	40	60	200

Unit 1. Lumped circuits and Kirchhoff's Laws, Circuit elements, physical components v/s circuit elements, Power and energy, Passivity, Network Topology, Loop and Nodal equations, State equations.

Unit 2. First and second order networks, zero state, zero input, transient and steady state response, Solution of network equations using Laplace transform, Network functions, their pole zero description.

Unit 3. Two port networks, various two port network parameters and their interrelationships.

Unit 4. Sinusoidal steady state analysis, frequency response, resonance, complex power, power factor improvement, maximum power transfer theorem, locus diagram, Superposition, Reciprocity, Thevenin's and Norton's theorem.

Unit 5. Magnetically coupled circuit, analysis of circuits with controlled sources, analysis of balanced and unbalanced poly-phase circuits, Fourier analysis of periodic waveforms, frequency spectrum, Power and energy of complex waveforms.

Text books

1. M.E Van Valkenburg, *Network Analysis*, Third Edition, PHI, New Delhi, 1998.
2. Desoer and Kuh, *Basic circuit theory*, Tata McGraw Hill Edition 2009.
3. William Hart Hayt, Jack E. Kemmerly, Steven M. Durbin, *Engineering Circuit Analysis*, Eight Edition, McGraw-Hill Higher Education, 2012.

References books

1. Ronald E. Scott, *Linear circuits Vol.I and II*, Addison-Wesley Publication, 2007.
2. Joseph A Edminister, *Electric circuits Schaum's outlines*, Fifth Edition, Tata McGraw Hill Education Private Limited 2009.
3. G K Mithal, *Network Analysis*, Khanna Publication, edition 2011.
4. Robert L. Boylestad, *Introductory Circuit Analysis*, Twelfth Edition, Pearson Education Limited, 2012.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	1	-	-	-	-	-	-	-
CO2	3	3	2	2	1	-	-	-	-	-	-	-
CO3	3	-	2	-	1	-	-	-	-	-	-	-
CO4	3	3	2	2	1	-	-	-	-	-	-	-

CO5	3	-	2	-	1	-	-	-	-	-	-	-
Average	3	3	2	2	1	-	-	-	-	-	-	-

LABORATORY

List of Experiments:

1. To determine equivalent network by application of thevein's theorem.
2. To determine an equivalent network by application of Norton's theorem.
3. Study of transients in RC circuits.
4. Study of series and parallel resonance phenomenon.
5. To verify the voltage and current relations in the star and delta connection system.
6. To verify open circuit and short circuit parameters for two port networks.
7. Verification of superposition theorem.
8. Verification of reciprocity theorem.
9. Verification of maximum power transfer theorem.
10. Passive Filter: Design of passive low pass and high pass filter.

LABORATORY OUTCOMES

1. Analyze complicated circuits using different network theorems.
2. Apply the knowledge of basic circuital law and simplify the network.
3. Infer and evaluate transient response, Steady state response, and network functions.
4. Obtain the maximum power transfer to the load, and analyze the series resonant and parallel resonant circuit.
5. Evaluate two port network model and its parameters

Lab Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
1	2	3	3	-	3	-	-	-	-	3	-	-
2	2	3	3	-	3	-	-	-	-	3	-	-
3	-	3	3	3	3	-	-	-	-	3	-	-
4	-	3	3	-	3	-	-	-	-	3	-	-
5	-	-	3	3	3	-	-	-	-	3	-	-
Average	2	3	3	3	3	-	-	-	-	3.0	-	-

B. Tech IInd Year Sem A (4 YDC)
EE-xxxxx: Electrical Workshop

Course Outcomes:-

After completing the subject student will be able to:

CO1: The main objective is to make the students able to understand, design and prepare electrical circuit using basic concepts.

CO2: To focus on Electrical safety and equipment earthing.

CO3: To address the underlying concepts of wiring of various electrical installations.

CO4: In this lab, students are expected to get hands-on experience in using the electrical tools and develop communication skills through manual with written descriptions of procedure, result and analysis

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
EE-xxxxx	Electrical Workshop	-	-	2	-	1	1	-	-	40	60	100

LABORATORY

List of Experiments:

1. Introduction of tools, Electrical materials, Symbol and Abbreviation.
2. To make a T joint and straight joint.
3. To Study Staircase wiring.
4. To Study and estimate House wiring
5. To Study Fluorescent tube light
6. To Study high pressure mercury vapour lamp (H.P.M.V)
7. To Study Sodium vapour lamp
8. To study different types of earthing systems and measure the earth resistance.
9. To study repairing of Home Appliances such as Heater, Electric iron, Fans etc

LABORATORY OUTCOMES

The student will able to:

1. To get acquainted with various tools, symbols used in the electrical system.
2. Prepare estimates for electrical wiring in domestic applications.
3. Provide effective earthing solutions in domestic as well as industrial domain.
4. Suggest suited illumination devices as per application requirement.
5. Repair and maintain electrical appliances and make robust joint in electrical connection**.**

Lab Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	1	-	-	-	-	-	-	-	-	-	-
2	3	-	3	-	-	-	-	-	-	-	-	3
3	3	-	-	3	-	-	-	-	-	-	-	3
4	3	-	3	-	-	-	-	-	-	-	-	-
5	3	1	-	3	1	-	-	-	1	-	-	3
Average	3	1	3	3	1	-	-	-	1	-	-	3

B. Tech IInd Year Sem B (4 YDC)
EI 29572: Fundamentals of Measurement System

Course Outcomes:-

At the end of this course students will be able to:

CO1: Demonstrate fundamentals of measuring instruments theoretically as well as practically.
CO2: Study of cathode ray oscilloscope in detail with its applications and probe compensation.
CO3: Attain basic knowledge about analog instruments.
CO4: Study measurement of low resistances, voltage, current, phase frequency etc.
CO5: Demonstrate compensation, calibration and testing of measuring instruments.
CO6: Gain knowledge about A.C. bridges and its applications.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
EI-29572	Fundamentals of Measurement System	3	-	2	3	1	4	70	30	40	60	200

Unit 1. Fundamentals of Measuring Instruments

Fundamental methods of measurement, classification of measuring instruments, static and dynamic characteristics, error classification and analysis, standards for displacement, force, time, frequency, temperature and electrical standards. IEEE standards.

Unit 2. Cathode Ray Oscilloscope

Construction and operation, measurement of amplitude, phase and frequency with CRO, lissajous patterns. Fundamentals of EMI, RF measurements techniques, network analysers, noise reduction techniques, compatibility of measuring instruments.

Unit 3. Analog Instruments

Analog indicating type instruments based on various operating principles, ammeters, voltmeters, ohmmeters. Extension of instrument range, instrument transformers.

Unit 4. Calibration and Testing of Instruments

Measurement of low resistances, voltage, current, phase, frequency, power and energy, Q factor, resistance, noise etc., compensation, calibration and testing of measuring instruments.

Unit 5. A.C. Bridges

A.C bridges for measurement of inductance, capacitance, Q factor and loss angle, universal impedance bridge. Design aspects. Design aspects of digital multimeter and panel meters. Distortion and spectrum analysis.

Text book

1. A.k. Sawhney, *electrical & electronic measurement & instrumentation*, dhanpat rai, 2015.

References books

1. W. D. Cooper, *Electronic Instrumentation and Measurement*, Prentice Hall, 1985.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO7	PO8	PO9	PO10	PO11	PO6	PO12
CO1	3	2	2	-	-	-	-	-	-	-	-	-
CO2	3	2	3	-	2	-	-	-	-	-	-	-
CO3	3	2	1	3	-	-	-	2	-	-	-	-
CO4	3	3	3	2	2	2	-	-	-	-	-	-
CO5	2	2	3	2	1	-	-	2	-	-	-	-
CO6	3	3	3	2	2	-	-	-	-	-	-	-
Average	2.8	2.3	2.5	2.3	1.8	2.0	-	2.0	-	-	-	-

LABORATORY

List of Experiments:

1. Study of Cathode Ray Oscilloscope (CRO).
2. To measure Amplitude and Frequency of unknown signals using CRO.
3. To measure Phase and Frequency of unknown signal using Lissajous pattern.
4. Study of PMMC Instruments (Analog Ammeter and Voltmeter).
5. To measure current and voltage in a circuit using Analog Ammeter and Voltmeter respectively.
6. To measure medium range resistance using Wheatstone bridge
7. To find percentage limiting error in the measurement of value of a given resistor and study the colour coding system of resistor for 4 band, 5 band and 6 band.
8. Study of A.C Bridges (Maxwell's, Inductance Bridge, Hay's Bridge, Anderson's Bridge, Owen's Bridge, De- Sauty's Bridge, Schering's Bridge).
9. To measure unknown inductance of a coil using Maxwell's Inductance Capacitance Bridge.
10. Study of Digital Storage Oscilloscope.

B. Tech IInd Year Sem B (4 YDC)
EC- 29562/EC-29509- : Digital Electronics

Course Outcomes

At the end of this course students will be able to:

CO1: Analyze the digital circuits through basic logic gates.

CO2: Analyse and design computational digital circuit which can perform logical and arithmetic operation.

CO3: Analyze and design finite state machines and data storage elements.

CO4: Analyse and design digital integrated circuits.

CO5: Analyse and design converters which facilitate the conversion of real world analog signals to digital and vice versa.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
EC-29562/EC-XXXXX	Digital Electronics	3	-	2	3	1	4	70	30	40	60	200

Unit 1. Introduction to Digital Logic

Review of semiconductor devices as a switch, wave shaping circuits, time base generators. Number system, number base conversion, binary codes, boolean algebra, boolean functions, logic gates. Simplification of boolean functions, combinational logic, Karnaugh map methods, SOP-POS simplification, NAND-NOR implementation, variable mapping.

Unit 2. Combinational Logic

Half adder, full adder, carry look ahead, multiplexer - demultiplexer, encoder - decoder, arithmetic circuits, ALU.

Unit 3. Sequential Logic

Flip flops, D, T, S-R, J-K, Master-Slave, racing condition, edge & level triggered circuits, shift registers, asynchronous and synchronous counters, their types and state diagrams. Semiconductor memories, introduction to digital ICs 2716, 2732 etc. & their address decoding. Modern trends in semiconductor memories such as DRAM, FLASH RAM etc.

Unit 4. Comparison of N-MOS, P-MOS, C-MOS, H-MOS etc.

Logic families : TTL, ECL, CMOS, IIL and their comparison on the basis of Fan in, Fan out, speed, propagation delay and noise margin, interfacing between ICs of different logic families.

Unit 5. Applications of Digital Circuits:

Introduction to A/D & D/A conversion & their types, sample and hold circuits, voltage to frequency & frequency to voltage conversion. Multivibrators: bistable, monostable, astable, schmitt trigger, IC555, IC565 & their applications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO7	PO8	PO9	PO10	PO11	PO6	PO12
CO1	3	3	2	-	-	-	-	1	1	-	-	-
CO2	3	2	3	-	2	-	-	1	1	-	-	-
CO3	3	3	2	3	-	-	-	1	1	-	-	-
CO4	3	3	2	2	2	2	-	1	1	-	-	-
CO5	3	2	1	2	1	-	-	1	1	-	-	-

CO6	3	2	2	2	2	-	-	1	1	-	-	-
Average	3.0	2.5	2.0	2.3	1.8	2.0	-	1.0	1.0	-	-	-

Text books

1. Morris Mano, *Digital Circuits & Logic Design*, PHI, 2000.
2. Floyd, *Digital Fundamentals*, Pearson, 2001.

References book

1. Tocci, *Digital Electronics*, PHI, 2004.
2. Malvino & Leach, *Digital Principles & Applications*, TMH, 2011
3. Taub and Schilling, *Digital Integrated Electronics*, McGraw Hill, 1977.

LABORATORY

List of Experiments:

1. To study various logic gates.
2. To verify properties of NAND and NOR Gates as universal building blocks.
3. Simplification and implementation of boolean function.
4. Implementation of basic boolean arithmetic logic circuit
5. Implementation of even and odd parity generator and checker.
6. Conversion from binary to grey and grey to binary code.
7. To verify a two bit magnitude comparator for all possible conditions.
8. Connection of various logical functions using 8 to 1 Multiplexer.
9. Construction of a 4 bit ripple counter and study of its operation.
10. Design and implement various types of flip flop using JK flip flop.
11. Design of a 3-bit synchronous counter and study of its operation.

LABORATORY OUTCOMES

1. Learn the basics of gates and implement logic functions.
2. Construct basic combinational circuits such as arithmetic circuits, code converter circuits and parity generator & checker and verify their functionalities.
3. Learn about Magnitude Comparator and multiplexers.
4. Apply the design procedures to design basic sequential circuits

Lab Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
1	2	1	-	-	-	-	-	-	-	3	-	-
2	3	3	2	-	-	-	-	-	-	3	-	-
3	3	3	2	3	-	-	-	-	-	3	-	-
4	3	3	2	-	-	-	-	-	-	3	-	-
Average	2.5	2.8	2	2	-	-	-	-	-	3	-	-

B. Tech II[nd] Year Sem B (4 YDC)
BM- 29508/BM-29551: Analog Electronics

Course Outcomes: -

At the end of this course students will be able to:

CO1: Analyse and design different BJT Circuits i.e amplifiers and oscillator circuits.
CO2: Explain concepts and applications of power amplifiers and Tuned amplifiers.
CO3: Compare and apply different concepts of feedback methods in practical circuits.
CO4: Classify different OP-Amp configurations based on their design and working.
CO5: Design of different Op- Amp circuits for practical electronic project design.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-29508	Analog Electronics	3	-	2	3	1	4	70	30	40	60	200

Unit 1. Transistor Amplifiers

Small-signal high-frequency hybrid-π model of a BJT, Frequency Response of Amplifiers – low-frequency, mid, and high-frequency Power supplies- review of regulators using zener-diode and series and shunt regulators, switching regulators, calculation and measurement of regulation characteristics. Over current protection using limiting fold-back and crowbar protection, regulators using ICs.

Unit 2. Power Amplifiers and Tuned Amplifiers

Power Amplifiers: Classification of power amplifiers, Class A, B, AB, C & D. Efficiency of power amplifiers.

Tuned Amplifiers: General behaviour of tuned amplifiers, series and parallel resonant circuit, calculations of circuit impedance at resonance. Variation of impedance with frequency. Q-factor of a circuit & coil, bandwidth of series & parallel resonant circuit. Advantages and disadvantages of tuned amplifiers. Single tuned amplifiers, voltage gain & frequency response of single tuned amplifiers, double tuned amplifiers.

Unit 3. Feedback Amplifiers

Basic Feedback concept, Effect of positive and negative feedbacks. Properties of negative feedback. Basic feedback topologies & their properties.

Analysis of positive feedback amplifiers, Sinusoidal Oscillators, Barkhaussen criterion, Wien-bridge and phase shift oscillators, Colpitt, Hartley crystal oscillator.

Unit 4. Operational Amplifiers

Operational Amplifier Fundamentals. Ideal characteristics, OP-AMP parameters, characteristics of the practical op amp (IC 741), the input differential amplifier and other stages of the IC 741 op amp. Basic OP-Amp configurations.

Unit 5. Operational Amplifiers Applications

Circuits with Resistive Feedback: voltage to current, current to voltage converter, current amplifiers, difference amplifier, Instrumentation amplifier, Summer circuits.

Non Linear Circuits: Voltage comparators, Schmitt trigger, integrator and differentiator, logarithmic and antilogarithmic amplifier.

Text books

1. J. Millman & A. Grabel,*Microelectronics*,TataMcGraw-Hill, 2001.
2. Millman and Halkias, *Integrated Electronics*, Tata McGraw-Hill, 2001.
3. R. A. Gayakwad, *Op amp and Linear Integrated Circuits*, Prentice-Hall (India), 1983.

References books

1.B. S. Sonde, *Power Supplies and Regulators*, Tata Mc-Graw Hill,1980.
2. Schilling and Belove, *Electronics Circuits*, Tata Mc-Graw Hill, 2002.
3. Robert Boylestad, *Electronics Devices and Circuits*, 9th ed., Dorling Kindersley (India) Pvt Ltd, 2009.
4. David Bell, *Electronics: Devices and Circuits*, 4th ed., Prentice-Hall (India), 1999.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	--	1	--	--	-	-	-	-	-
CO2	2	3	3	1	-	-	-	-	-	-	-	1
CO3	3	2	3	2	--	-	-	-	-	-	-	-
CO4	2	3	1	-	-	-	-	-	-	--	-	1
CO5	3	2	2	2	1	-	-	-	1	1	-	1
Average	2.6	2.4	2.2	1.7	1	-	-	-	1	1	-	1

LABORATORY

List of Experiments:

1. To study the operation of single-stage and multi-stage RC-Coupled Amplifier
2. To calculate Av, AI, Zin and Zout of CE RC-Coupled amplifier with potential divider biasing
3. To plot the frequency response of RC-Coupled amplifier
4. Observing Open-Loop Gain as a function of frequency
5. Measuring the Common Mode Rejection Ratio
6. Observing a Non-inverting Amplifier
7. Observing the functioning of voltage follower i.e. buffer.
8. Observing Op amp as inverting Summer.
9. Observing Op amp as inverting Averager .
10. Observing Op amp as non–inverting Summer.
11. Observing Op amp as non-inverting Averager.
12. Observing Op amp as Integrator, Differentiator
13. Observing Op amp as To study the operation of a class A Amplifier
14. To study the operation of a class B, class C Amplifier
15. To study the operation of a Differential Amplifier

LABORATORY OUTCOMES

1. Operate CRO, Function generator and digital multimeter effectively.
2. Understand the concept of external circuit parameters and their importance.
3. Understand the concept of BJT and OP AMP based circuits.
4. Acquire enough understanding to build a comprehensive foundation for later higher-level courses such as Major & Minor Projects
5. Construct meaning from oral, written and graphical plotting through the experiments.

Lab Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	1	-	-		1	-	-	1	1	-	-	-
2	1	-	1		-	-	-	-	1	-	-	-
3	1	-	2		-	-	-	-	2	-	-	-
4	-	1	-		-	2	-	2	1	-	-	1

5	-	-	-		2	-	-	2	1	3	-	2
Average	1	1	1.5	-	1.5	2	-	1.7	1.2	3	-	1.5

B. Tech IInd Year Sem B (4 YDC)
MA- 29501: Mathematics-IV

Course Outcomes:-

At the end of this course students will be able to:

CO1: To perform the contour integration.
CO2: Identify random variables and classify stochastic processes .
CO3: Solve various stages of the Markov chain.
CO4: Demonstrate the basic concepts of reliability.
CO5: Demonstrate the basic concepts of graph theory

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
MA-29501	Mathematics - IV	3	1	-	4	-	4	70	30	-	-	100

Unit 1. Functions of Complex Variables

Analytic function, Cauchy-Riemann equations and Harmonic functions: Conjugate functions and their applications. Complex integrals. Cauchy's integral theorem and integral formula. Singularities, poles residues, residue theorem, Contour integration for simple cases, conformal mapping and its application to two-dimensional problems in electric fields.

Unit 2. Stochastic Process

Modern Definition of Probability, Random Experiments, Sample Space, Random variables. Distribution Function and Density Function, Concept of stochastic process. Mean, Auto Correlation and Covariance. Classification of Stochastic Process.

Unit 3. Markov Chain

Probability Vector, Stochastic Matrix, Fixed Point of a Matrix, and Definition of Markov Chain, Transition Matrix. Some Theorems and problems. Queuing Theory, Birth and Death Process.

Unit 4. Reliability

Basic concepts, Failure law, BathTub Curve, Evaluation of Reliability of a component from test data, System Reliability, Components in series and parallel, Redundancy, Non-series parallel system. A brief idea of software reliability.

Unit 5. Graph Theory and Combinatorial Optimization

Graphs – Definitions and basic properties. Isomorphism, Euler Circuits and Hamiltonian cycle. Digraphs. Trees- properties, spanning trees, Planar graphs. Shortest path problem, Dijkstra algorithm, spanning tree-Kruskal and Prim algorithm, Flow augmented paths-Ford-Fulkerson algorithm, cut sets. Max. Flow min. cut Method theorem.

Text books

1. Ramana B V, *Higher Engineering Mathematics*, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2006
2. Jain, R.K. and S.K. Iyengar, *Advanced Engineering Mathematics*, Narosa Publishing House, New-Delhi, 2006.

References books

1. Baisnab A, and M Jas, *Elements of Probability and Statistics*, Tata McGraw Hill, New Delhi, 1993.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	-	-	-	-	-	3
CO2	3	3	3	3	-	-	-	-	-	-	-	3
CO3	3	3	3	3	-	-	-	-	-	-	-	3
CO4	3	3	3	3	-	-	-	-	-	-	-	3
CO5	3	3	3	3	-	-	-	-	-	-	-	3
Average	3	3	3	3	-	-	-	-	-	-	-	3

B. Tech IInd Year Sem B (4 YDC)
BM-29502 Programming Tools & Techniques

Course Outcomes: -

At the end of this course students will be able to:

CO1: To understand the basic concepts of OOPS and various programming platforms.
CO2: To get acquainted with basic Python and MATLAB programming.
CO3: To apply the concepts of OOPs in Python.
CO4: To apply Python programming and MATLAB for solving standard engineering problems.
CO5: To evaluate and compare the performance of different existing platforms.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-39254	Programming Tools and Techniques	3	-	2	3	1	4	70	30	40	60	200

Unit 1. Introduction to Object Oriented Programming

Comparison with procedural programming, features of object oriented paradigm– merits and demerits of Oops methodology, object model. Concept of classes and objects in OOPs programming.

Unit 2. Introduction to Python Programming

Python Data Types, Python Program Flow Control, Functions, Modules and Packages, Python String, List and Dictionary Manipulations.

Unit 3. Object Oriented Programming using Python

Python Object Oriented Programming: Classes, Methods, Objects and the Standard Objective Features; Exception Handling and Working with Files. Python File Operation, python programming.

Unit 4. Getting Started With MATLAB

Introducing MATLAB and its applications, MATLAB interface, data files and data types, understanding the MATLAB math syntax, loops and conditional statements, M files, operations on matrix, understanding plotting basics, writing user defined functions.

Unit 5. GUI, SIMULINK and Image Processing with MATLAB

Introduction of Graphical User Interface, GUI function property, GUI component design, GUI Container, writing the code of GUI Callback, dialog box, menu designing, introduction of SIMULINK, SIMULINK environment & interface, some examples of image processing.

Text books

1. Timothy Budd, *An Introduction to Object-Oriented Programming*, 3rd ed., Addison-Wesley Publication, 2002.
2. Rudra Pratap, *Getting Started with MATLAB*, Oxford University Press, 2002.
3. Mark Summerfield, *Programming in Python 3: A Complete Introduction to the Language*,1st Edition, 2008.

References books

1. Booch, *Object Oriented Analysis & Design*, Addison Wesley, 2006.
2. James Martin, *Principles of Object-Oriented Analysis and Design*, Prentice Hall/PTR, 1992.
3. Peter Coad and Edward Yourdon, *Object Oriented Design*, Prentice Hall/PTR, 1991.
4. David Beazley, *Python Essential Reference*, 4th Edition 2009.G

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	3	-	1	-	1	1	-	1
CO2	-	3	3	-	3	-	1	-	1	1	-	1
CO3	-	-	-	-	3	-	1	-	1	1	-	1
CO4	-	-	-	-	3	-	1	-	1	1	-	1
CO5	-	-	-	-	3	-	1	-	1	1	-	1
Average	3	3	3	-	3	-	-	-	1	1	-	1

LABORATORY

List of Experiments:

1. Creating Class and Object in Python.
2. Creating Methods in Python.
3. Use of Inheritance in Python.
4. Data Encapsulation in Python.
5. Using Polymorphism in Python.
6. Create Matlab GUI and Simulink Introduction.

LABORATORY OUTCOMES

1. To develop basic concepts scripting and the contributions of scripting language
2. Write, Test and Debug Python Programs, Implement Conditionals and Loops for Python Programs
3. Use functions and represent Compound data using Lists, Tuples and Dictionaries
4. Read and write data from & to files in Python and develop Applications.
5. Ability to explore python especially the object oriented concepts, and the built in objects of Python.

Lab Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	2	3	-	2	-	-	-	-	-	-	2
2	3	3	3	-	2	-	-	-	-	-	-	2
3	3	3	3	-	2	-	-	-	-	-	-	2
4	3	2	2	-	2	-	-	-	-	-	-	2
5	3	3	3	-	3	-	-	-	-	-	-	2
Average	3	2.6	2.8	-	2.25	-	-	-	-	-	-	2

B. Tech IInd Year Sem A (4 YDC)
EI-XXXX: Electronic Workshop

Course Outcomes:-

After completing the subject student will be able to:

CO1: To gain knowledge of characteristics of basic electronic componentS.
CO2: To apply a color coding scheme for resistance (Band 4, Band 5 & band 6)
CO3: To implement methodology for designing PCB (Etching, Drilling & Soldering)
CO4: To design an electronics circuit using basic components like BJT,FET, timers, amplifiers.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
EI-29998	Electronic Workshop	-	-	4	-	2	2	-	-	40	60	100

Prerequisite: Knowledge of Basic Components

Course Content:

Mini Project design based on:
1. Regulated Power Supplies
2. KVL / KCL based circuits
3. Design based on A.C. bridges
4. Designing using various diodes
5. Designing using operational amplifier
6. Design using various logic families & gates.

LABORATORY

List of Experiment:

1. Introduction and Precautions for the laboratory providing SAFETY to users.
2. Study and Hands-on Tools required in the Laboratory.
3. Briefing about Electronic components for their ON/OFF condition and testing their working status and values.
4. Introduction about soldering process and soldering practice on a general purpose PCB with Soldering Iron, Soldering wire, flux and connecting wires.
5. Design and Implementation of DC power supply unit in working condition on BreadBoard.
6. Construction of DC power supply unit on Printed circuit Board
7. Design and Implementation of Minor Project in working condition on BreadBoard.
8. Construction of Minor Project in Working condition on Printed circuit Board
9. Industrial Visit. S.G.S.I.T.S/E & I/ UG Syllabus/ 2022-23 w. e. f. 2022

Session 2023-24
Semester A-Syllabus

Biomedical Engineering

B.E. IIIrd Year

BM- 39011/BM-39001: Signals and Systems

Course Outcomes: -

CO1: To familiarize students with different types of signals & systems and their applications

CO2: To make students aware of the problems in analysis and manipulation of various signals and their processing through linear shift invariant systems.

CO3: To make students understand the concept of different types of systems and their applications and relate to real world problems.

CO4: To make students understand the techniques of using specific transforms for different signals,their importance and applications.

CO5: To equip students with convolution and correlation techniques applicable in Biomedical Signal Processing Course.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th	CW	SW	Pr.	
BM-39001	Signals and Systems	4	1	2	4	1	5	70	30	40	60	200

Unit 1. Introduction to Signals & Systems

Continuous-time and discrete-time signals, signal classification, transformations of the independent variable, continuous-time and discrete-time systems, system classification, sampling and reconstruction of signals.

Unit 2. Linear Time-Invariant Systems

Discrete-time LTI systems: convolution sum, continuous-time LTI systems: convolution integral, properties of linear time-invariant systems, causal LTI systems- described by differential and difference equations, singularity functions.

Unit 3. Fourier series Representation of Periodic Signals

The response of LTI systems to complex exponentials, Fourier series representation of continuous-time periodic signals, convergence of the Fourier series (Dirichlet's conditions), properties of continuous-time Fourier series, Fourier series representation of discrete-time periodic signals, properties of discrete-time Fourier series, Fourier series and LTI systems. Case study: frequency analysis of ECG signals.

Unit 4. Continuous-Time and Discrete-Time Fourier Transform

Continuous-time Fourier transform: Fourier transform for periodic signals, properties of the continuous-time Fourier transform, systems characterized by linear constant-coefficient differential equations.

Discrete-Time Fourier Transform: Fourier transform for periodic signals, properties of the discrete-time Fourier transform, systems characterized by linear constant-coefficient difference equations.

Unit 5. Laplace and Z - Transform

Laplace Transform: Region of convergence for Laplace transform, properties of the Laplace transform, inverse Laplace transform, system function algebra and block diagram representations, the unilateral Laplace transform.

Z-Transform: Region of convergence for the z-transform, inverse z-transform, properties of the z-transform.

Practicals

List of Experiments

1. Waveform Generation.
2. Basic Operation on Signals.
3. Properties of Discrete Time Systems
4. Discrete Convolution
5. Discrete Fourier Transform
6. Time Domain Response of LTI Systems
7. Frequency Response of LTI Systems

** Some experiments will be conducted using Virtual Lab Platform

Text books

1. Alan Oppenheim, Alan Willsky & Hamid, *Signals and Systems*, Pearson, 2015.
2. R.F. Ziemer, W.H. Tranter and D.R. Fannin, *Signals and Systems: Continuous and Discrete*, 4th ed., Pearson, 1998.

References

1. A.V. Oppenheim, A.S. Willsky and I.T, *Signals and Systems*, Prentice Hall, 1983.
2. R. Gopal, *Problems and Solutions in Signals and Systems*, 1st ed., CBS, 2006.

Session 2023-24
Semester A-Syllabus

Biomedical Engineering

B.E. IIIrd Year

BM-39013: Biomedical Instrumentation I

Course Outcomes: -

CO1: Describe origin of various bioelectric signals and technical specifications of various bioelectric electrodes required for their analysis. Outline basic functional components of medical Instrumentation systems.

CO2: Explain the fundamental concepts of Biomedical recorders and be able to select the bio-amplifiers based on application.

CO3: Identify and describe various techniques/Instruments for measuring physiological parameters.

CO4: To be able to compare and distinguish between cardiac output measurement techniques.

CO5: Analyse, classify and select various analytical techniques and Instruments as per requirement of biomedical applications.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-39013	Biomedical Instrumentation-I	4	1	2	4	1	5	70	30	40	60	200

Unit 1. Bio signal generation and analysis

Fundamentals/origin of Bioelectric signals: generation of action potential and effect of electric field on various muscles. Sources of Bio-signals and evoked potential. Basics of Medical Instrumentation: Basic functional components (measurand, sensor, conditioner, display) and block diagram of medical instrumentation system. Electrodes-tissue interface, skin contact impedance. Half-cell potential, bio-electrodes. Design constraints and safety aspects of medical instruments.

Unit 2. Biomedical recorders and Bio amplifiers

Introduction of Biomedical recorders: Basics of ECG, VCG, PCG, EEG, EMG, EOG, ERG, Significance of Einthoven triangle in ECG recording. Introduction of Bio amplifiers and biosensors: carrier amplifier, isolation amplifier, differential amplifier, chopper amplifier, instrumentation amplifier.

Unit 3. Patient Monitoring Systems

Measurement of temperature, Measurement of respiration rate, Measurement of heart rate, Measurement of pulse rate. Introduction of oximeter: Basics of oximetry, Pulse oximeter, Ear oximeter. Introduction of blood flow meters: Electromagnetic, ultrasound and laser doppler blood flow meter. Heart lung machine (HLM), computerized patient monitoring system.

Unit 4. Cardiac output Measurement

Dye dilution method, Thermal dilution method, BP method, Measurement of blood pressure: Direct and indirect methods, Plethysmography, Pacemaker, ambulatory monitoring

instruments.

Unit 5. Analytical techniques and instruments

Fundamentals of analytical instruments: Types of chemical analysis, sensors, display systems, Methods of analysis and calibration techniques. Introduction of colorimeters and spectrophotometers: spectrophotometer, colorimeters, sources of error in spectrophotometers. Fundamentals of flame photometers. chemical biosensors, Fundamentals of fluorescence sensors and glucose sensors. Introduction of blood cell counters: electrical conductivity method, optical method. Coulter counter, Fundamentals of chromatography, Fundamentals of mass spectrometer, pH meter, blood gas analysers. Performance requirements of analytical instruments.

Practicals

List of experiments (Offline)

1. To observe ECG waveforms generated by ECG simulator in different leads configuration.
2. To observe Phonocardiogram waveforms (PCG) of the subject (Human body).
3. To measure the systolic and diastolic blood pressure of the human heart.
4. To study abnormalities (Tachycardia, Bradycardia) present in the Human cardiovascular System using ECG simulator.
5. To study EEG waveforms in unipolar recording and average recording mode.
6. To study EMG waveforms generated by built-in EMG simulators.
7. To measure the respiration-rate of a subject (Human body).
8. To understand the transmission and reception of biological signals using a telemetry system.
9. To study the pacemaker system using simulator kits**.**
10. Defibrillator Simulator @Virtual Lab.

List of experiments (Online)

1. Basics of Bio potential: To simulate Nernst and Goldman Equation.
2. Pulse rate measurement: To simulate performance of pulse rate sensor.
3. To Simulate electrocardiogram waveforms
4. 12 LEAD ECG Simulator: To simulate 12 LEAD ECG signal.
5. To simulate Biopotential Amplifier.
6. EEG Scalp potential Simulation
7. To Simulate EMG Waveform and analyze the same.
8. Demonstration of Uv-vis spectrophotometer
9. Lab Assignment: To Study and compare medical device on basis of technical specification, cost and functionality

Text books

1. John G. Webster, *Medical Instrumentation: Application and design*, 3rd ed., John Wiley, 2012.

2. Khandpur R.S, *Hand-book of Biomedical Instrumentation*, Tata McGraw Hill, 2nd Edition, 2003.

References

1. Stuart R, MacKay, *Bio-Medical Telemetry: Sensing and Transmitting Biological Information from Animals and Man*, 2nd ed., Wiley, 1998.
2. L. Cromwell, Fred J et al., *Biomedical Instrumentation and Measurements*, Prentice Hall, 1973.

Session 2023-24
Semester A-Syllabus

Biomedical Engineering
B.E. IIIrd Year
IP-39021: Industrial Engineering and Management

Course Outcomes:-

CO1: Basic knowledge of method engineering.
CO2: Introduction to operational management.
CO3: Introduction to organization & management.
CO4: Decision making techniques.
CO5: Introduction to quality control.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
IP-39021	Industrial Engineering and Management	4	1	-	4	-	4	70	30	-	-	100

Unit 1. Methods Engineering

Introduction to methods engineering and productivity, method study, recording techniques work measurement tools and techniques.
Workplace design, fundamentals of workplace design.
Introduction to job evaluation and wage incentive schemes.

Unit 2. Operational Management

Introduction to production planning and control, function, tools and techniques, types of production systems.
Facilities planning, introduction to plant layout and material handling, tools and techniques.

Unit 3. Organization and Management

Principles of management and management functions.Organization principles, structures, span of control, delegation, centralization and decentralization, formal and informal organization.Personnel management- introduction, communication, motivation and leadership.

Unit 4. Quantitative techniques for decision making

Introduction to operations research, linear programming, transportation and assignment models and its application, network techniques and its application.

Unit 5. Quality control

Quality planning and quality control operation, economics of quality control process capability studies and control charts for variables and attributes.

Text book

1. Koontz and O' Donnel, *Principles of Management: An Analysis of Managerial Functions*, McGraw Hill, 1972.

References

1. Sharma, *Operational Research: Theory and Application*, Laxmi Pub., 2009.

Session 2023-24
Semester A-Syllabus

Biomedical Engineering
B.E. IIIrd Year
BM-39254: Programming Tools & Techniques (Elective I)

Course Outcomes: -

CO1: To understand the basic concepts of OOPS and various programming platforms.
CO2: To get acquainted with basic Python and MATLAB programming.
CO3: To apply the concepts of OOPs in Python.
CO4: To apply Python programming and MATLAB for solving standard engineering problems.
CO5: To evaluate and compare the performance of different existing platforms.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-39254	Programming Tools and Techniques	4	-	2	3	1	4	70	30	40	60	200

Unit 1. Introduction to Object Oriented Programming

Comparison with procedural programming, features of object oriented paradigm– merits and demerits of Oops methodology, object model. Concept of classes and object in OOPs programming.

Unit 2. Introduction to Python Programming

Python Data Types, Python Program Flow Control, Functions, Modules and Packages, Python String, List and Dictionary Manipulations.

Unit 3. Object Oriented Programming using Python

Python Object Oriented Programming: Classes, Methods, Objects and the Standard Objective Features; Exception Handling and Working with Files. Python File Operation, python programming.

Unit 4. Getting Started With MATLAB

Introducing MATLAB and its applications, MATLAB interface, data files and data types, understanding the MATLAB math syntax, loops and conditional statements, M files, operations on matrix, understanding plotting basics, writing user defined functions.

Unit 5. GUI, SIMULINK and Image Processing with MATLAB

Introduction of Graphical User Interface, GUI function property, GUI component design, GUI Container, writing the code of GUI Callback, dialog box, menu designing, introduction of SIMULINK, SIMULINK environment & interface, some examples of image processing.

Practicals

List of Experiments

1. Creating Class and Object in Python.
2. Creating Methods in Python.
3. Use of Inheritance in Python.
4. Data Encapsulation in Python.
5. Using Polymorphism in Python.

6. Matlab GUI and Simulink Introduction.

Text books

1. Timothy Budd, *An Introduction to Object-Oriented Programming*, 3rd ed., Addison-Wesley Publication, 2002.
2. Rudra Pratap, *Getting Started with MATLAB*, Oxford University Press, 2002.
3. Mark Summerfield, *Programming in Python 3: A Complete Introduction to the Language*,1st Edition, 2008.

References

1. G. Booch, *Object Oriented Analysis & Design*, Addison Wesley, 2006.
2. James martin, *Principles of Object-Oriented Analysis and Design*, Prentice Hall/PTR, 1992.
3. Peter Coad and Edward Yourdon, *Object Oriented Design*, Prentice Hall/PTR, 1991.

David Beazley, *Python Essential Reference*, 4th Edition 2009.

Session 2023-24

Semester A- Syllabus

Biomedical Engineering

B.E. III Year

BM-39251: Embedded Systems (Elective I)

Course Outcomes:-

After completion of course, students will be able to:

CO1: Describe & understand the fundamental concepts of 8085 Microprocessor

CO2: Categorize the difference between Microprocessors and Microcontrollers and understand the architecture and programming of 8051 Microcontroller

CO3: Demonstrate the Architecture and Processors of Embedded systems

CO4: Explain & learn the Memory system architecture of embedded systems

CO5: Illustrate the fundamentals of embedded communication protocols

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM- 39251	Embedded Systems	4	-	2	3	1	4	70	30	40	60	200

Unit 1. Advanced Hardware Fundamentals

Introduction to Microprocessors: 8085 Microprocessor, Programming model, Buses, Instruction set classification, Microprocessor architecture and its operations, Direct Memory Access, Interrupts, Comparison of 8085 and 8086 microprocessors.

Unit 2. Microcontroller and Programming

Microcontroller versus General-purpose microprocessor, 8051 Microcontroller: Architecture, Block diagram, Memory organization, Special function registers, I/O Ports, Timers/Counters, Interrupts, Programming in Embedded C.

Unit 3. Embedded System Architecture

Definition of Embedded system, Embedded system vs General computing system, Classification, Major application areas, Purpose of Embedded system, CISC and RISC architecture, General purpose processor, Application specific processor, Single purpose processor, Basic embedded processor.

Unit 4. Memory System Architecture

Memory management schemes in embedded systems: Memory hierarchy, Cache, Virtual memory and MMU, Advanced RAM, Memory write ability and Storage permanence, Common memory types, Composing memory, Memory Interfacing.

Unit 5. Embedded Communication Protocols

Introduction to communication protocols: Communication basics and Baud rate concept, Serial bus communication protocols, Parallel bus communication protocols, Network protocols & Wireless and mobile system protoc*ols*.

TEXT BOOKS

1. F Vahid, T Giogarvis, *Embedded systems: A unified hardware/software approach*, Wiley, 1999.
2. Raj Kamal, *Embedded Systems Introduction*, 2nd Ed., TMH publication, 2015.
3. Operating system Principles, Galvin Silberschatz, 7th edition, Wiley Publication
4. Muhammad Ali Mazidi, *The 8051 Microcontroller and Embedded Systems*, 2nd Ed., Pearson
5. Ramesh Gaonkar, *Microprocessor Architecture, Programming and Applications with 8085*, 5th Ed. Penram International Publishing, 2011.
6. Pethuru Raj Anupama C. Raman, *The Internet of Things Enabling Technologies, Platforms, and Use Cases*, CRC Press, 2017

REFERENCES

1. David E Simons, *An Embedded Software Primer*, Pearson, 1999.
2. Perry Xiao, *Designing Embedded Systems and the Internet of Things (IoT) with the ARM® Mbed™*, Wiley Publication, 2018

Session 2023-24
Semester B-Syllabus

Biomedical Engineering
B.E. IIIrd Year
BM-39501: Biomedical Signal Processing

Course Outcomes:-

CO1: Introduction to signals, systems and fundamentals of signal processing.
CO2: Transform analysis of LTI systems.
CO3: Study of various algorithms of DFT.
CO4: Designing of filters and their realizations.
CO5: Developments of algorithms and visualizations of various elements and processes of BSP.

Subject -Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-39501	Biomedical Signal Processing	4	1	2	4	1	5	70	30	40	60	200

Unit 1. Introduction to Signal Processing

Signals and systems, signal processing, concept of frequency in continuous time and discrete time signals, analog to digital and digital to analog conversion, sampling and reconstruction of signals.

Unit 2. Frequency Domain Analysis of Signals and Systems

Analysis of linear time invariant systems in the z-Domain, analysis and characterization of LTI systems using the Laplace transform, correlation functions and spectra at the output of LTI systems, linear time-invariant systems as Frequency-Selective filter, inverse systems and deconvolution, linear filtering methods based on the DFT, frequency analysis of signals using the DFT, discrete cosine transform.

Unit 3. Efficient Computation of the DFT: Fast Fourier Transform Algorithms

Fast Fourier transform, decimation in time FFT algorithms, decimation in frequency FFT algorithms, FFT algorithms for N composite number- Spectrum analysis of bio signals. Quantization effects in the computation of the DFT. Case study: frequency analysis of ECG signals.

Unit 4. Design of FIR Digital Filter

FIR digital filters realizations, direct, cascade, lattice forms, FIR filter design using Fourier series, use of window functions like rectangular, raised cosine, kaiser.

Unit 5. Design of IIR Digital Filter

IIR digital filters realizations, direct, cascade, parallel forms, analog filter approximations, and Butterworth and Chebyshev approximations, frequency transformation techniques. Case study: PCA and ICA for biomedical signals.

Practicals

List of Experiments

1. Introduction to MATLAB.
2. Study of sampling theorem and the effects of under sampling.
3. Study of quantization of continuous amplitude, discrete time analog signals.
4. Study of properties of linear time invariant system.

5. Study of convolution: series and parallel system.
6. Study of discrete Fourier transform and it's inverse.
7. Study of transform domain properties and their applications.
8. Study of FIR filter design using windowing technique.
9. A case study on principal component analysis.
10. A case study on independent component analysis.

Text books

1. Oppenheim & R W Schafer, *Digital Signal Processing*, Prentice Hall, 2008.
2. R Rabiner & B. Gold, *Theory & Application of Digital Signal Processing*, Prentice Hall (India), 1975.

References

1. Andreas Antonion, *Digital Filters Analysis & Design*, Prentice Hall (India), 2007.

Session 2023-24
Semester B-Syllabus

Biomedical Engineering
B.E. IIIrd Year
BM-39512: Biomedical Instrumentation II

Course Outcomes: -

CO1: Discuss various pulmonary aid equipment's with working principle, their design specifications and requirements.

CO2: Describe various Electrotherapeutic equipment and their technical and functional specifications.

CO3: Analysis design of artificial kidney that imitates the role of health kidney and perform mathematical analysis of techniques used in BMD.

CO4: Review various instruments used for monitoring and diagnosis of sensory organs.

CO5: Design and application of various types of special equipment such as endoscope, drug delivery systems, etc.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-39512	Biomedical Instrumentation II	4	1	2	4	1	5	70	30	40	60	200

Unit 1. Pulmonary Analyzers and Aid Equipment's

Regulation of breathing - pulmonary gas flow measurements, pulmonary volume measurements, respiratory gas analysers, nitrogen gas analyser, oxygen analyser, humidifier, nebulizer, ventilators, IPPB unit, and anaesthesia machine.

Unit 2. Physiotherapy and Electrotherapy Equipments

Tissue response, short wave diathermy, microwave diathermy, ultrasonic therapy unit, electrotherapy - FES, TENS, bladder stimulator, lithotripter system, extra corporeal shock wave therapy.

Unit 3. Instruments Dealing with Kidney and Bones

Regulation of water and electrolyte balance, artificial kidney, hemodialysis, Grafts for dialysis, peritoneal dialysis, dialyzers. BMD measurements – SXA – DXA, quantitative ultrasound bone densitometer-LASERS.

Unit 4. Sensory Instrumentation

Mechanism of hearing, sound conduction system, basic audiometer- pure tone audiometer, audiometer system Bekesy, hearing aids, ophthalmoscope, tonometer, , experimental analysis of behaviour. Electrical safety.

Unit 5. Special Equipments

Endoscopy, laparoscopy, cryogenic equipment, automated drug delivery system, components of a drug infusion system, implantable infusion systems. Defibrillator

Practicals

List of Experiments (Offline)

1. Study of ventilator machine.
2. Demo of anaesthesia machine.
3. Study of ultrasound diathermy machine.

4. Application and physiotherapy of muscles and effect of different modes in ultrasound Machine.

5. To measure the respiration-rate of subject (Human body).
6. Designing a galvanic skin response meter.
7. Course project/presentations notes.

List of Experiments (Online)

1. Demonstration of manual ventilation and concept of PEEP using adult resuscitator bag with peep valve.
2. Online demonstration of Spirometry.
3. Understanding the design and modes of operation of Ventilator machine
4. To simulate the working of electrosurgical unit and analyse the effects of AC current on tissues.
5. To simulate Haemodialysis Machine
6. To Simulate Pacemaker
7. Defibrillator Simulator @Virtual Lab.
8. Term paper

Text books

1. Geoddes L.A, and Baker L.E, *Principles of Applied Biomedical Instrumentation*, John Wiley, 3rd Edition, 1975.

2. John G. Webster, *Medical Instrumentation: Application and design*, 3rd ed., John Wiley, 2012.

References

1. Khandpur R.S, *Hand-book of Biomedical Instrumentation*, Tata McGraw Hill, 2nd Edition, 2003.

Session 2023-24
Semester B- Syllabus

Biomedical Engineering
B.E. IIIrd Year
EE-39508: Control System

Course Outcomes:-

CO1: Modeling & simulation of dynamic systems. Feedback control systems
CO2: Time domain analysis of feedback control systems
CO3: Frequency domain analysis of feedback control systems.
CO4: Compensation Techniques to achieve desired frequency response.
CO5: State space method of analysis of feedback control systems.

Subject Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
EE-39508	Control Systems	4	1	2	4	1	5	70	30	40	60	200

Unit 1. Modeling of Dynamic Systems and Simulation

Integro-differential equation of linear systems such as mechanical, hydraulic, pneumatic and electrical systems. Block diagram and Signal flows graph method of representing the dynamic equations, analogue simulation, linearity, impulse response and concept of transfer function, Mason's gain formula, control system components: errors detectors ac and dc servomotors, servo amplifier(ac & dc) using operational amplifiers, gyro, resolver. Typical study of characteristics of these components. Concept of feedback as control theory-Mathematical theory of feedback, return ratio, return difference, open and closed loop, understanding the necessity of feedback as real control action supplemented by a small example.

Unit 2. Time-Domain Analysis of Feedback Control Systems

Typical references test signals and their significance, transient behavior of closed loop systems under feedback control. Proportional plus derivative and rate feedback control actions for improving the transient response. Steady state behavior of closed loop feedback control systems. Types of open loop transfer functions. Steady state errors. Proportional plus integral control action for the improvement of steady state errors.

Unit 3. Frequency-Domain Analysis of Feedback Control Systems

Concept of frequency-domain analysis, Bode plots, polar plots. Bode of closed loop transfer function and bode plots of error transfer functions, principle of argument, Nyquist criteria. Conditionally stable closed loop systems, transportation lag, constant M and constant N loci, Loci of closed loop poles (root loci).

Unit 4. Compensation Techniques

Need for frequency-domain compensation, different types of compensation, phase lead and phase lag compensation, design of compensating networks for the desired frequency-domain close loop performance.

Unit 5. State Space Method of Analysis

Fundamentals of state space: Concept of state variables. Representation of linear system through state dynamics, calculation of Eigen values and Eigen vectors, modal matrix, modal transformation, elementary understanding of controllability and observability, state feedback control. Stability analysis of feedback.

Control system-concept of stability: BIBO stability, asymptotic stability, Routh-Hurwitz analysis. Nyquist stability analysis and relative stability, gain margin and phase margin.

Practicals

List of Experiments

1. To determine the performance characteristics of an angular position error detector using potentiometers.
2. To determine the characteristics of a Synchro Transmitter Receiver pair and use as a torque synchro and angular error detector.
3. To find the transfer function of an A.C. Servomotor.
4. To find the transfer function of a D.C. Servomotor.
5. To control the angular position of an AC servo motor as a carrier control system.
6. Determination of the time response characteristics of a DC Servo angular position control system.
7. To perform closed loop speed control of a D.C Servomotor.
8. To determine the performance characteristics of a DC motor speed control with PWM type power driver.
9. To determine the performance characteristics of a DC motor speed control with SCR type power driver.
10. Analysis of Proportional + Integrator + Derivative (PID) control actions for first and second order systems.

Text books

1. B.C. Kuo, *Automatic Control system*, Prentice Hall, 1975.
2. K Ogata, *Modern Control Engineering*, Prentice Hall of India Ltd., 2010.

References

1. J.L. Melsa and D.G. Schultz, *Linear Control Systems*, McGraw Hill, 1970.
2. I.J. Nagrath and M. Gopal, *Control systems Engineering*, New Age International (P) Ltd., 1999.

Session 2023-24
Semester B-Syllabus

Biomedical Engineering
B.E. IIIrd Year
EC-39602: Analog and Digital Communication (Elective II)

Course Outcomes:-

CO1: Review of basic signals, different types of categorization of signals.
CO2: Study of amplitude modulation in communication.
CO3: Study frequency modulation.
CO4: Study of Noise associated with receivers and elimination /reduction techniques.
CO5: Introduction to digital communication.

Subject -Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th	CW	SW	Pr.	
EC-39602	Analog and Digital communication	4	-	-	3	-	3	70	30	-	-	100

Unit 1. Signals and Random Variables

Types of signals: deterministic & random, periodic & non-periodic, analog & discrete, energy & power signals. Fourier series, Fourier transform and its properties, Gaussian and Rayleigh probability density function, mean, variance and standard deviation, central limit theorem, voltage & power decibel scales.

Unit 2. Amplitude Modulation

Need of modulation in a communication system, block schematic of a typical communication system. AM modulation system, modulation index, generation & detection of AM wave, side bands & power content in an AM wave, DSB-SC, SSB, their methods of generation & detection, AM transmitter block diagram.

Unit 3. Frequency Modulation

Relationships between phase & frequency modulation, FM wave & its spectrum, phasor diagram of narrowband FM signal, wideband FM, methods of generation & detection of FM, discriminators, pre-emphasis & de-emphasis.

Unit 4. Receivers and Noise

TRF receiver & its limitations, necessity of heterodyning, super heterodyne radio receivers, IF amplifiers & selection of intermediate frequency, RF amplifiers, detectors. Sources of noise, noise figure, noise bandwidth, effective noise temperature.

Unit 5. Introduction to Digital Communication

Nyquist sampling theorem, time division multiplexing, pulse modulations and PCM, quantization error, introduction to BPSK & BFSK, Shannon's theorem for channel capacity.

Text books

1. Lathi B.P., *Anolog and Digital Communication Systems*, Oxford Press, 2009.
2. Singh R.P. & Sapre, *Communication Systems Analog & Digital*, TMH, 2017.

References

1. Haykin Simon, *Communication Systems*, John Willey & Sons, 2013.
2. Taub & Schilling, *Principles of Communication Systems*, McGraw Hill, 1986.

Session 2023-24
Semester B -Syllabus

Biomedical Engineering
B.E. IIIrd Year
BM-39603: Biomedical Statistical Signal Processing (Elective II)

Course Outcomes:-

CO1: Describe and illustrate data collection and sampling, hypothesis testing
CO2: Define and understand the concept of random variables.
CO3: To solve various distribution and density functions.
CO4: Analyse and Evaluate statistical tests using SPSS software
CO5: Design signal processing unit for Biomedical Applications

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Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-39603	Biomedical Statistical Signal Processing	4	-	-	3	-	3	70	30	-	-	100

Unit 1. Data Collection and Sampling Methods

Concepts of population and sample and need for sampling methods of collecting data. Types of sampling- simple random sampling with and without replacement, errors in sampling and data acquisition. Statistical tests of hypotheses, box plots of a data sample, distribution & scatter plots.

Unit 2. Random Variables

Discrete and continuous variables, probability mass function, probability density function and cumulative distribution function, jointly distributed random variables: marginal and conditional distributions, independence of random variables. Expectation of a random variable and its properties

Unit 3. Distributions of Function of Random Variables

expectation of sum of random variables, product of independent random variables, conditional expectation and related problems, moments, moment generating function & their properties, random vectors and central limit theorem.

Unit 4. Statistical Tests

correlation, regression, multiple and partial correlation, one-way and two-way analysis of variance (ANOVA**),** $\chi 2$ (chi-square), t and F distributions (central cases only) and their limiting forms, bivariate normal distribution and its properties, tests of goodness of fit, tests of independence.

Unit 5. Case Studies for Biomedical Application

Processing of biomedical signals like ECG, EMG, EEG etc.**,** removal of high frequency noise (power line interference), motion artefacts (low frequency) and power line interference in ECG**,** cancellation of ECG from EMG signal.

Text books

1. Wayne W. Daniel Chad L. Cross, *BIOSTATISTICS: A Foundation for Analysis in the Health Sciences,*
2. Statistical Package for the **S**ocial **S**ciences (SPSS) Software.

References

1. Rangaraj M Rangayyan, *Biomedical Signal Analysis* case study approach, PHI, 2004.

Session 2023-24
Semester A-Syllabus

Biomedical Engineering
B.E. IVth Year
BM-49004: Biomechanics

Course Outcomes:-

CO1: Apply the knowledge of joint mechanics to day to day human movement.
CO2: Examine the principles of bio-fluid dynamics.
CO3: Explain the fundamentals of biosolid mechanics.
CO4: To visualize the biomechanics principles and gait analysis of human locomotion
CO5: Derive the joint force and muscle force for various biomechanical systems in human

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
3	1	2	3	1	4	70	30	40	60	200

Prerequisite: -PH 10006, CE 10003, MA 10001, MA 10501

Unit 1. Biomechanics of Joints

Biomechanics of Joints: Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, free body diagrams, types of joint, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle.

Unit 2. Hard Tissue Mechanics

Hard Tissues: Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, and Maxwell&Voight models – anisotropy.

Unit 3. Soft Tissue Mechanics

Structure and functions of Soft Tissues: Cartilage, Tendon, Ligament, and Muscle; Material Properties: Cartilage, Tendon, Ligament, and Muscle; Modelling of soft tissues: Cartilage, Tendon, Ligament, and Muscle, Hills's muscle model.

Unit 4. Bio-fluid Mechanics

Introduction, viscosity and capillary viscometer, Rheological properties of blood, laminar flow, Couette flow and HagenPoiseuille equation, turbulent flow.

Unit 5. Gait Analysis

Gait analysis, measurement of gait parameters, techniques for recording and measuring movements and forces - force platforms and motion analysis system, Applications of these equipment in biomechanics, performance improvement and injury prevention. Centre of gravity.

Text Books

1. NihatOzkaya and Margareta Nordin, *Fundamentals of biomechanics: Equilibrium, Motion and deformation*, 2nd Edi. Springer 1999.
2. (Undergraduate Lecture Notes in Physics) EmicoOkuno, Luciano Fratin (auth.) - *Biomechanics of the Human Body*-Springer-Verlag New York (2014)

References

1. D. Dowson and V. Wright, *An introduction to Biomechanics of joints and joint replacements*, Mechanical Engineering Publications, 1980
2. George L. Lucas M.D., Francis W. Cooke Ph.D., Elizabeth A. Friis Ph.D. (auth.) - *A Primer of Biomechanics*-Springer-Verlag New York (1999)

Session 2023-24
Semester A- Syllabus

Biomedical Engineering
B.E. IVth Year
BM- 49003/BM-49305: Medical Imaging Systems

Course Outcomes: -

CO1: To learn principles of sectional imaging in X-Ray, CT scanner configuration and 2D image reconstruction techniques.
CO2: Recognize basic physics of MRI, its instrumentation and areas of application.
CO3: Interpret basic physics of ultrasound, the instrumentation involved and modes of operation.
CO4: To classify Emission Computed Tomography with emphasis on SPECT and PET imaging.
CO5: To explain basic knowledge of IR imaging, its advantages and application.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4	1	-	4	-	4	70	30	40	60	200

Prerequisite:- PH 10006, MA 10001, MA 10501, MA-29024, MA-29501

Unit 1. X-Ray Computed Tomography

Principles of sectional imaging, scanner configuration, data acquisition system, image formation principles, conversion of X-ray data into scan image, 2D image reconstruction techniques - iteration and Fourier transform methods.

Unit 2. Magnetic Resonance Imaging (MRI)

Principles of MRI, pulse sequence, image acquisition and reconstruction techniques, MRI instrumentation: magnets, gradient system, RF coils, receiver system, functional MRI, applications of MRI.

Unit 3. Ultrasound in Medicine

Introduction, production of ultrasonic - properties - principles of image formation, capture and display, principles of A-mode, B-mode and M-mode display, principles of scan conversion, Doppler ultra sound and colour flow mapping, application of diagnostic ultrasound.

Unit 4. Radio Isotope Imaging

Rectilinear and scanners, SPECT, PET, gamma camera, radionuclide for imaging, emission computed tomography, Biomarkers.

Unit 5. Infra-Red Imaging

Physics of thermography, imaging systems, pyro-electric vidicon camera, clinical thermograph, liquid crystal thermography.

Text Books

1. Jerry L Prince, Jonathan Links, *Medical Imaging Signals and Systems, 2016, Pearson Publication.*
2. P. Allisy-Roberts, J. Williams and R.Farr, *Farr's physics for medical imaging*. Edinburgh: Saunders Elsevier, 2008.

References

1. S. Webb, *The Physics of Medical Imaging*, 2nd ed. CRC Press, 1999.
2. A.C.Kak,*Principle of Computed Tomographic Imaging*, IEEE PressNewYork, 1988.
3. G. A. Hay, *Medical Image Formation Perception and Measurement*, John Wiley & Sons, 1977.
4. W. Hendee and E. Ritenour, *Medical Imaging Physics*. Hoboken: Wiley, 2003.

Session 2023-24
Semester A- Syllabus

Biomedical Engineering
B.E. IVth Year
BM-49005: Biological Control Systems

Course Outcomes:-

CO1: Interpreting physiological systems in terms of control systems and summarizing their properties**.**
CO2: Developing a simple respiratory model.
CO3: Developing a simple cardiovascular model.
CO4: Summarizing various physiological models.
CO5: Interpreting different system identification techniques.

L	T	P	Theory Credits	Practical Credits	Total credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4	-	2	3	1	4	70	30	40	60	200

Prerequisite: - EE -39508, BM-29003, BM 39254

Unit 1. Control Systems Perspective for Biological Systems:
Introduction to physiological control systems, examples of a physiological control system, differences between engineering and physiological control systems, art of modelling physiological systems, distributed parameters versus lumped parameter models, simple models of muscle stretch reflex action, across and through variables, generalized system properties (viz., impedance, compliance and inertance).

Unit 2. Human Respiratory Modeling
Respiratory mechanism, linear model of respiratory mechanics, gas exchange and ventilation–perfusion relationships in the lung, chemical regulation of ventilation.

Unit 3. Cardiovascular System Modeling
Theoretical basis- cardiac cycle & pressures-volume loops, cardiac pressure versus time graph, the cardiac output curve, the venous return curve, closed-loop analysis: heart and systemic circulation combined.

Unit 4. Various Physiological Models
The Hodgkin-Huxley model. Westheimer's Saccadic eye model, compartmental models, integrated cardiopulmonary model.

Unit 5. Art of Modeling the Biological Control System
Basic problems in physiological system analysis, nonparametric and parametric identification: numerical deconvolution, least square estimation, estimation using correlation functions, estimation in the frequency domain, optimization techniques. Problems in parameter estimation.

Text Books

1. Michael C.K. Khoo, *Physiological control systems: Analysis, Simulation and Estimation,* 2nd ed. Wiley-IEEE press, 2018.
2. Frank C., Hoppenstead, Charles,*Modelling and Simulation in Medicine and the Life Sciences*, Springer, 2002.

Reference

1. John H. Milsum, *Biological Control System analysis*, McGraw hill, 1966.

Session 2023-24

Semester A- Syllabus

Biomedical Engineering
B.E. IVth Year
BM-4XXXX: Artificial Intelligence and Machine Learning for Medical Applications
Elective III.1

Course Outcomes: -

CO1: Understand and describe the basics of Artificial Intelligence and Machine Learning.
CO2: Learn and reframe the machine learning algorithm and its classification.
CO3: Understand, describe and practise various training models of machine learning.
CO4: Learn, classify and examine the process of decision trees and dimensionality reduction in machine learning.
CO5: Practice and infer the different medical applications of AI & ML.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
3	-	2	3	1	4	70	30	40	60	200

Prerequisite: - Nil

Unit 1. Introduction to Artificial Intelligence (AI) & Machine Learning (ML)

AI Fundamentals: - Definition, Comparison between Human Intelligence and Artificial Intelligence, Types of AI techniques, State Space Search and Heuristic Search Techniques. Predicate Logic and Representing Knowledge as Rules, Non-monotonic Reasoning and its logic, Statistical Reasoning.

Introduction to Machine Learning: - What is Machine Learning? Importance of Machine Learning, Types of Machine Learning systems, Main Challenges of Machine Learning.

Unit 2. Steps of Machine Learning (ML) & Its Classification

Various Steps of Machine Learning, Classification of ML:- MNIST, Training a Binary Classifier, Performance Measures : Measuring Accuracy Using Cross-Validation, Confusion Matrix, Precision and Recall, Precision/Recall Tradeoff, The ROC Curve; Multiclass Classification, Error Analysis, Multilabel Classification, Multi output Classification.

Unit 3. Training Models of ML & Support Vector Machines (SVM)

Training Models: - Linear Regression, Gradient Descent, Polynomial Regression, Learning Curves, Regularized Linear Models, Logistic Regression.

Support Vector Machines: - Linear SVM Classification, Nonlinear SVM Classification, SVM Regression, Decision Function and Predictions, Training Objective, Quadratic Programming, The Dual Problem, Kernelized SVM. Case Study 1 - Predicting Atrial Fibrillation/Flutter.

Unit 4. Decision Trees &Dimensionality Reduction

Decision Trees:- Training and Visualizing a Decision Tree, Making Predictions, Estimating Class Probabilities, The CART Training Algorithm, Computational Complexity, Regularization Hyper parameters, Regression, Instability, Random Forests and its classification.

Dimensionality Reduction: - Approaches of Dimensionality Reduction – Projection and Manifold learning, PCA, Kernel PCA. Case Study 2 – Prediction of Infection in Human lungs from CT/MRI Image.

Unit 5. Applications of AI & ML in Medical Systems

Neural Networks, Pattern Imaging Analytics, Drug Discovery & Manufacturing, Clinical Trial Research, Predicting Epidemic Outbreaks, Maintaining Healthcare Records.

Practicals:

List of Experiments

1. To study some basic neuron models and learning algorithms by using Matlab's neural network toolbox.
2. Prediction of First degree Cardiac Block.
3. Classification of heart sound recording.
4. Detection and analysis of T-wave in ECG recording.
5. Prediction of Cancer/Tumour in Human lungs from CT scan.

Text Book

1. AurélienGéron, *Machine Learning with Scikit-Learn&TensorFlow*, O'ReillyUSA, 2017.

References

1. Stuart Russell and Peter Norvig, *Artificial Intelligence - A Modern Approach,* Third Edition, Prentice Hall Series, 2010.

2. Keith Frankish and William M. Ramsey, *The Cambridge Handbook of Artificial Intelligence*, Cambridge University Press, 2014.

Session 2023-24
Semester A- Syllabus

Biomedical Engineering
B.E. IVth Year
EE-47002: Power Electronics
Elective III.2

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
3	-	2	3	1	4	70	30	40	60	200

Prerequisite: - Basic knowledge of Electronics and semiconductor devices.

Course Objectives:

- To provide students a deep insight in to the operational behaviour of practical power switching devices with respect to their static and dynamic characteristics
- To learn the working principle of classified topologies of Thyristor based AC/DC, AC/AC, DC/DC and DC/AC converters.
- To design and analyze the operation of above converters considering their applications.
- To understand design of firing circuits for Thyristor based line commutated converters.

Course Outcomes:

EE47002 (T). CO1: Acquire knowledge about fundamental concepts and switches used in power electronics.
EE47002 (T). CO2: Ability to analyze various single phase and three phase line commutated power converter circuits and understand their applications.
EE47002 (T). CO3: Nurture the ability to identify basic requirements for line commutated converter based design application.
EE47002 (T). CO4: To develop skills to build, and troubleshoot power electronics circuits.
EE47002 (T). CO5: Understand the firing circuit design for line commutated converters.
EE47002 (T). CO6**:** Foster ability to understand the use of line commutated converters in professional engineering.

Course Contents:

Theory:

Unit 1.

Static power devices: Thyristor family, two transistor analogy of SCR, construction, characteristics, parameters, turn on and turn off methods, firing circuits, isolation and amplifier circuits, synchronization circuits.

Unit 2.

Converters: AC to DC converters, single phase rectifier circuits with different load, various quadrant operation, basic principle and power circuits of dual converter and cycloconverter.

Unit 3.

DC to DC converter: Basic principle of chopper circuits, various chopper circuits and their working, stepup chopper, performance analysis.

Unit 4.

Inverters: CSI and VSI inverters, single phase inverters, principle of operation, voltage and frequency control techniques.

Unit 5.

Industrial Application of Power Electronics, SMPS, UPS, AC and DC drives, Power Supplies.

Assessment:

A. Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the coursetopics.

B. The end-term theory examination weightage is70%.

Practicals:

List of Experiments

1. Verification of steady state characteristics of different staticswitches.
2. Phase control of TRIAC using DIAC and RC circuit in light dimmingcircuit.
3. Firing pulse generation using UJT based relaxationoscillator.
4. Firing pulse generation for SCR using TCA 785IC.
5. Performance evaluation of single phase uncontrolled converter for R, RLload.
6. Performance evaluation of single phase controlled converter for R, RLload.
7. Performance Analysis of step downchopper
8. Performance evaluation of current commutation circuit forSCR
9. Performance evaluation of voltage commutation circuit forSCR.
10. Effect of duty cycle on the output voltage of buck-boostconverter.

Assessment:

A. Continuous evaluation of laboratory journals with a weightage of 40%. It includes lab attendance as well as experiments performed in thelab.

B. The end-term practical examination weightage is60%.

Text Books

1. M H Rashid, ―Power Electronics Circuits, Devices, and Applications‖, third edition Pearson/Prentice Hall, 2009.
2. NedMohan,―PowerElectronics:Converters,Applications,andDesign‖,thirdedition,John Wiley & Sons Inc, 2007.
3. Joseph Vithayathil, ―Power Electronics Principles and applications‖, Tata McGraw-Hill, 1995.

References

1. C.M.Pauddar, ―SemiconductorPowerElectronics (DevicesandCircuits)‖,firstedition,Jain Brothers New Delhi, 1999.
2. M.H.Rashid,―Handbook of Power Electronics‖,PearsonEducationIndia,2008.
3. M.D.Singh, K.B.Khanchandani, ―PowerElectronics‖, TataMcGraw-Hill, 2008.

Session 2023-24
Semester A- Syllabus

Biomedical Engineering
B.E. IVth Year
BM-49261: Hospital Management and Information Systems
Elective III.3

Course Outcomes:

CO1: To write algorithms for linear data structures & their application.
CO2: To develop algorithms for nonlinear data structure-trees & graphs.
CO3: Learn basic concepts, components & applications of database system as well as ER model to use efficiently to improve performance of hospital databases.
CO4: Write SQL queries for solving problems related to current scenarios in hospital database.
CO5: Design of HIS and its integration in a networked hospital scenario.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
3	-	2	2	1	3	70	30	40	60	200

Prerequisite: - Nil

Unit 1. Introduction to Data Structures, Linear Data Structures

Concepts of data and information, Classification of data structures. Introduction to linear data structures- Array, Linked List.Representation of linked list.Implementation of linked list, circular linked list. Stacks and Queues. Implementation and different types of Stacks and Queues.

Unit 2. Non-Linear Data Structures

Tree: Definitions – Height, depth order, degree etc. Binary Search Tree - Operations. Graphs: Introduction, classification of graph: Directed and Undirected graph. Application of Trees and Graphs.

Unit 3. Introduction to Database Models

Basic concepts of data and information.Introduction to DBMS-characteristics of DBMS, DBMS architecture, components of DBMS. Relational data model: domains, tuples, attributes, relation keys and type of keys.

Unit 4. Relational Database Design- Normalization

Normalization theory and database methodologies- Relational schemas, functional dependency.1NF, 2NF and 3NF indexing and hashing. Query Language: SQL-Basic SQL queries, functions, constraints, joins.

Unit 5. Hospital Information System

Role of database in HIS. Need of networking in HIS, overview of networking, topologies and its configuration. Detailed study of picture archiving and communication systems (PACS).

Practicals:

List of Experiments

1. Write a program to perform push and pop operations on stack using array or linked list.
2. Write a program to perform different operations on queue such as insert, delete and display.
3. Insert and delete a node at the beginning of a linear linked list.
4. Write a Program to implement Bubble sort using array.
5. Create table “Patient” with following details and constraints*.
6. List the name, address and phone number of all the patients who have taken a medical test in a medical lab outside Indore.
7. Find the name and clinic address of all doctors who have prescribed at least three "CTscan" to a patient during the year 2011.
8. List the name, address and phone number of all the patients who may take "bone marrow check "
9. List the name, address and phone of all the patients who took more tests than the average in one year.
10. List the name and address of all patients who have taken exactly one non X-ray test in the last one year.

Text Books

1. H. Dominic Covvey, *Computer in practice of medicines*, Addison Wesley, 1980.
2. Edward Shortlife, *Computer based medical consultation*, Elsevier Scientific, 1976.
3. Date C. J, *An introduction to database systems*, 8th ed., Pearson, 2003.

References

1. Ramez Elmasri, Shamkant B. Navathe, *Fundamentals of Database Systems*, 7th ed., Pearson, 2017.

Session 2023-24
Semester A- Syllabus

Biomedical Engineering
B.E. IV Year
BM-49204 : Internet of Things for Medical Applications
Elective III.4

Course Outcomes: -

CO1: To understand the fundamentals of Internet of Things
CO2: To learn about the basics of IoT protocols
CO3:To build a small low cost embedded system using Raspberry Pi.
CO4:To learn various designing components of IoT
CO5:To apply the concept of Internet of Things in smart healthcare.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4		2	3	1	4	70	30	60	40	200

Unit 1. Introduction to IoT

Basic IoT concepts, technologies that led to evolution of IoT, physical design, logical design, IoT levels & deployment templates, relevance of IOT for the future, challenges in IOT implementation: big data management, connectivity challenges.

Unit 2. IoT Protocols:

Development of prototypes, protocol standardization for IoT.Efforts, M2M and WSN Protocols, SCADA and RFID protocols, issues with IoT standardization, unified data standards,protocols: IEEE802.15.4, BACNet protocol, Modbus, KNX, Zigbee network layer, APS layer.

Unit 3. Building IoT with RASPBERRY Pi Vs Arduino

Building IoT with Raspberry Pi, logical design using Python, IoT physical devices & endpoints, IoT device building blocks: Raspberry Pi-board,Raspberry Pi interfaces, programming Raspberry Pi with Python,other IoT platforms - Arduino.

Unit 4. Design and implementation of IoT devices:

Components of IoT system, design of IoT systems,operating platforms /systems,hardware and software used, networking and the internet, internet protocol, local networks of IoT devices: Mobile Ad Hoc Network (MANET)

Unit 5. IoT in Healthcare Applications:

IoT based health care: physiological parameter monitoring system, future challenges in health care, health care echo system with IoT, IoT for personalized healthcare-wearable device characteristics.

Text Books

1. Ovidiu Vermesan & Peter Friess, *Internet of Things Applications - From Research and Innovation to Market Deployment*, River Publishers Series in Communications, 2014

References

1. Olivier Hersent, David Boswarthick, Omar Elloumi, ―*The Internet of Things – Key applications and Protocols,* Wiley, 2012

2. Vijay Madisetti and Arshdeep Bahga, *"Internet of Things (A Hands-On-Approach)"*,1st Edition, VPT, 2014

Practicals:

1. Study of various connection policies for Wi-Fi connectivity.
2. Setting up a Raspberry Pi.
3. Interfacing various sensors with Raspberry Pi.
4. Configure IPv6 on Raspberry Pi
5. Hosting a Website on Raspberry Pi
6. Wireless Sensor Network using Raspberry Pi

Session 2023-24
Semester B- Syllabus

Biomedical Engineering
B.E. IVth Year
BM-49612: Rehabilitation Engineering
Elective IV.1

Course Outcomes:-

CO1: Understand the need and concepts of rehabilitation engineering in general.
CO2: Understand the concept of mobility and functioning of sensory augmentation.
CO3: Identify the key components and design of universal accessibility.
CO4: Analyse the design of orthotics and prosthetics of upper and lower extremities.
CO5: Design manual and power wheelchair.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4	-	-	3	-	3	70	30	-	-	100

Prerequisite: -BM-29003

Unit 1. Engineering Concepts in Rehabilitation Engineering

Anthropometry: methods for static and dynamic measurements. Area measurements-measurement of characteristics and movement, measurement of muscular strength and capabilities. Measurement tools and processes in rehabilitation engineering: fundamental principles, structure, function. Measurement systems for performance and behaviour.

Unit 2. Sensory Rehabilitation Engineering

Sensory augmentation and substitution, visual system, visual augmentation, tactual vision substitution, and auditory vision substitution. Auditory system: auditory augmentation, audiometer, hearing aids, cochlear implantation, visual auditory substitution, tactual auditory substitution. Tactual system: tactual augmentation, tactual substitution.

Unit 3. Universal Design and Accessibility

Design Considerations, Total Quality Management in Rehabilitation Engineering, Steel as a Structural Material, Aluminium for Assistive Technology Design, Use of Composites for Assistive Technology Design, Design with Engineering Materials, Fabrication, Basic Electric Circuits. Barrier-Free Design, Elemental Resource Model, Factors Affecting Barrier-Free Design, Interior Space Design, Design for People with Disabilities, Accessible Transportation

Unit 4. Orthopaedic Prosthetics and Orthotics

Upper-Extremity Prostheses, Upper-Extremity Orthoses, Lower-Extremity Prostheses, Lower-Extremity Orthoses, Functional Neuromuscular Stimulation, Ambulation Aids, Aids to Daily Living.

Unit 5. Wheelchair Safety Standards and Testing

Standard Tests, Normative Values, Static Stability, A Geometric Approach to Static Stability, Stability with Road Crown and Inclination, Impact Strength Tests, Fatigue Strength Tests, Finite-Element Modelling Applied to Wheelchair, Design/ Testing, Test Dummies, Power Wheelchair Range Testing, Power Wheelchair Controller Performance, Designing for Safe Operation. Design of manual and powered wheelchairs.

Text Books

1. Bronzino, Joseph, *Handbook of Biomedical Engineering*, 2nd ed., CRC Press, 2000
2. Robinson C.J, *Rehabilitation Engineering*, CRC press, 1995.
3. (Medical science series) Rory A Cooper - Rehabilitation engineering applied to mobility and manipulation _ Rory A. Cooper-Institute of Physics Pub (1995)

References

1. H N Teodorecu, L.C.Jain, *Intelligent Systems and Technologies in Rehabilitation Engineering*, CRC, 2000.
2. Etienne Grandjean, H. Oldroyd, *Fitting the task to the man*, Taylor & Francis, 1988.

Session 2023-24
Semester B- Syllabus

Biomedical Engineering
B.E. IVth Year
BM-49611: Hospital Technology Systems
Elective-IV.2

Course Outcomes:-

CO1: To classify hospital's & understand the architecture of various departments.
CO2: Understand the requirement of electrical power systems in hospitals.
CO3: Design of Air-conditioning and gas supply system, its criticality
CO4: Analyse and implement maintenance protocols of hospital equipment.
CO5: Identify the need and application of hospital information systems.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4	-	-	3	-	3	70	30	-	-	100

Prerequisite: -Nil

Unit 1. Classification of Hospital & Architecture

General hospital, specialized hospital, primary health care – their role and 8L functions. Aspects of hospital services – inpatient, outpatient and emergency. Location and environment of hospital, Hierarchy of medical and paramedical staff & their functions and responsibilities. Modern Hospital Architecture- space in a hospital building, design of ward, intensive care units, air conditioning, plumbing & sanitation, gas supply, waste disposal, cleaning, dietary, sterilizing, laundry, storage and operation theatre systems, Radiology, Central labs, Blood banks, OPD, Casualty, et**ls**c

Unit 2. Electrical Power Systems in Hospital

Safety of electrical systems, Protective systems - interference of patient's protection grounding. Design of substations, breakers, Surge protectors, EMI filters, voltage stabilizers, generator sets and UPS. 8L Uninterrupted power supply for ICU and computerized monitoring units. Specification & estimation for hospital wiring.

Unit 3. Air Conditioning & Gas Supply Systems

Air conditioning and refrigeration systems for small and large areas. Air changes, filtering and sterility. Deodorization, disinfection, dehumidification and cryogenic systems. Centralized supply of air, 6L oxygen, nitrous oxide & vacuum - Principle of production of liquid oxygen. Management lifts fire fighting equipment.

Unit 4. Hospital Engineering & Management

Definition of biomedical Engineering, clinical engineering & hospital engineering. Importance of BME department – servicing and maintenance, testing, acceptance & maintenance protocols, Computerized preventive maintenance planning, MROs. Training of men for medical equipment preventive and periodical maintenance 10L procedures. Preparation of estimates, specifications, tender details etc. Importance of ISO 9000 Certificates - Obtaining ISO certificates in hospitals.Proposed protocols.

Unit 5. Hospital Information system

Role of database in HIS. Need of Networking in HIS. Overview of Networking, topologies and its configuration. Structuring medical records to carry out functions

like admissions, discharges, treatment history etc. Computerization in pharmacy & billing. Automated clinical laboratory systems & radiology information system.

Text Books

1. Harold E. Smalley, "*Hospital Management Engineering – A guide to the improvement of hospital management system"*
2. L. C. Redstone ,"Hospital and Health Care Facilities
3. PHI. C. A. Caceras ,"Clinical Engineering"
4. Ward,"Anesthetics Equipment".
5. BIS, "ISO Certification details"

References

1. Bhaumick and Bhattachary," EHV Substation equipments"
2. Alexander Kusko," Emergency and Standby Power Systems"
3. Balagune Swamy,"Reliability Engineering"
4. Anantha Narayanan,"Basic Refrigeration and Air Conditioning"

Session 2023-24
Semester B- Syllabus

Biomedical Engineering
B.E. IVth Year
BM-XXXXX: Medical Image Processing
Elective-IV.3

Course Outcomes: -

CO1: Understand the concept of 2D signal and apply it on image
CO2: Evaluate the techniques for image enhancement.
CO3: Analyze images in the frequency domain using various transforms.
CO4: Apply and compare various image segmentation techniques on images.
CO5: Interpret Image the output of morphological operations on images.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4	-	-	3	-	3	70	30	-	-	100

Prerequisite: -Nil

Unit 1. Two-dimensional systems

Linear systems and shift invariance. Fourier transform - Z - transform - Block matrices, Toeplitz and Kronecker product. Luminance, brightness and contrast. Color representation, color matching and reproduction, color vision model.Image sampling and quantization. Two dimensional sampling theory, reconstructions of images from its samples. Image acquisition.

Unit 2. Image Enhancement in the Spatial and Frequency Domain

Gray level transformations, Histogram processing, Arithmetic and logic operations, Spatial filtering: Introduction, Smoothing and sharpening filters. Frequency domain filters

Unit 3. Image Transforms

Completeness and orthogonality property of image transforms. Introduction to Fourier transform, DFT and 2-D DFT, Properties of 2-D DFT, FFT, IFFT, Walsh transform, Hadamard transform, Discrete cosine transform, Slant transform: Karhunen - Loeve transform

Unit 4. Morphological Image Processing

Introduction, Dilation, Erosion, Opening, closing, Hit -or-miss transformation, Morphological algorithm operations on binary Images, Morphological algorithm operations on gray-scale Images.

Unit 5. Feature extraction algorithms

Image Segmentation, Representation and Description: Detection of discontinuities, Edge linking and Boundary detection, Thresholding region based segmentation, Image Representation schemes, Boundary descriptors, and Regional descriptors.

Text Books

1. R.C Gonzalez and R. Woods *:-Digital Image Processing*, (Indian reprint: Pearson publication, 2001)
2. Anil K. Jain *:- Digital Image Processing* (Prentice-Hall, India)

Reference

1. W. K. Pratt *:- Digital Image Processing*, - 2nd Edition, (John Wiley & Sons).
2. B. Chanda& D. DuttaMajumder, *Digital Image Processing and Analysis*, (Prentice-Hall, India)
3. M. A. Sid-Ahmed :- *Image Processing- Theory, Algorithms & Architecture*, (McGraw-Hill).

Biomedical Engineering
B.E. IVth Year
BM-XXXXX-Design and Manufacturing of Medical Devices
Elective-IV.4

Course Outcomes: -

CO1: Provides an overview of design and manufacturing techniques for medical devices development.

CO2: Able to understand the technical and business aspects of the medical device development process.

CO3: Apply creative process techniques in synthesizing information, problem-solving and critical thinking.

CO4: Strategically apply technical skill, knowledge and craftsmanship to prove feasibility of their concepts.

CO5: Build confidence in students to create a new health care product and enhanced team working skills.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4	-	-	3	-	3	70	30	-	-	100

Prerequisites:-

Introduction to basic medical Science for engineers, Introduction to principles of design and product development, Basic Mechanical Engineering, Introduction of Finite Element Method

Objectives:

1. Provides an overview of design and manufacturing techniques for medical devices development.
2. Define the equipment, instrumentations and control systems used in bio manufacturing.
3. Explain standard design and manufacturing programs, validation practices and regulatory requirements used in the biomedical industry.

Unit 1.

Generating Ideas and Concepts, Design Process versus Design Control, Implementation of Design Procedures, Material selection and Biocompatibility, Design Specification, Quality in Design, Detailed Design (hardware/ Software design), Computer-Aided Design, Design Evaluation (Validation and Verification), Obtaining Regulatory Approval to Market.

Unit 2.

Introduction to Finite Element Method, Finite element modelling of cells, tissues and organs Medical device design and prototyping, Customized and universal design of Implants and prosthesis.

Unit 3.

Design of orthopaedic Implants, orthoses and Assistive devices.

Unit 4.

Additive manufacturing processes; Machining, forming, electro-discharge machining (EDM) and electrochemical machining (ECM), laser-based processing, casting and molding, and others.

Unit 5.

Machines and equipment including tooling, fixturing, sensors systems, and control; Metrology, material handling, joining, and assembly; Implants, Prostheses and orthoses manufacturing; Assistive technology

Text Books

1. The Design and Manufacture of Medical Devices by Paulo Davim, Woodhead Publishing
2. Medical Device Design: Innovation from Concept to Market, by Peter J. Ogrodnik, Academic Press is an imprint of Elsevier
3. Handbook of Medical Device Design by Richard C. Fries, CRC Press
4. Introduction to Bio manufacturing, Margaret Bryans, Northeast Bio Center

Session 2023-24
Semester B- Syllabus

Biomedical Engineering
B.E. IV Year
BM-49701: Biomaterials
Elective V.1

Course Outcomes:-

CO1: Illustrate the fundamental concepts of biomaterials, its classification and detailed understanding of different implant materials.

CO2: Demonstrate and test the bulk and surface properties of biomaterials.

CO3: Describe the biological testing of biomaterials & fundamentals of tissue engineering

CO4: Explain detailed understanding of practical applications of biomaterials in medicine and dentistry.

CO5: Identify and predict the host reaction on application of biomaterials.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4	1	-	4	-	4	70	30	-	-	100

Prerequisite: -BM 29003

Unit 1. Introduction

Definition and classification of biomaterial, Types of bonds in material, Introductory overview of some existing prosthetic devices, Fundamentals of biocompatibility, Metallic, Ceramic and Polymeric implant material, Sterilization of implants & devices.

Unit 2. Mechanical Behaviour & Surface Characterization of Materials

Stress-Strain curve characteristics, Viscoelasticity, Mechanical properties & Mechanical testing of materials, Surface characterization of biomaterials.

Unit 3. Testing of Biomaterials & Tissue Engineering

Introduction, In- Vitro and In-Vivo assessment of tissue compatibility, Overview of tissue engineering.

Unit 4. Application of Material in Medicine and Dentistry

Sutures, Basic fundamentals of Drug delivery systems, Orthopedic application, Cardiovascular application & Dental application.

Unit 5. Host Reaction to Biomaterial and Their Evaluation

Introduction: Biomaterials-Tissue interactions, Systemic toxicity and Hypersensitivity, Biofilms & Device-related Infections.

Text Books

1. Joseph Bronzino, *The Biomedical Engineering Handbook*, 2nd ed., CRC Press, 2000.
2. Joon Park, R.S. Lakes, *Biomaterials An Introduction*, Springer, Third Edition, 2007.
3. Joo L. Ong, Appleford, and Mani, *Introduction to Biomaterials*, Cambridge University Press, 2014

References

1. Buddy D. Ratner, *Biomaterials Science-An Introduction to Materials in Medicine*, 2nded. Elsevier Academic Press, 2004.

Session 2023-24
Semester B- Syllabus

Biomedical Engineering
B.E. IVth Year
BM-49702: Telemedicine
Elective V.2

Course Outcomes:-

CO1: Demonstrate the basic knowledge of telemedicine and telehealth
CO2:Understand the technology of Telemedicine Systems.
CO3:Interpret the clinical applications, standards, and guidelines in telemedicine
CO4:Design of integrated telemedicine architecture with sub systems
CO5:Describe the often complex legal, ethical, regulations and laws in telemedicine.

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4	1	-	4	-	4	70	30	-	-	100

Prerequisite: - BM39013

Unit 1. History, Definitions and Current Applications

History of Telemedicine, Definition of telemedicine, Telehealth, Tele care, origins and Development of Telemedicine, Block diagram of telemedicine system, Scope, Benefits and limitations of Telemedicine.

Unit 2. Technology of Telemedicine Systems

Network technologies: topologies, LAN, WAN, MAN, OSI model, physical layer, data link layer, network layer, transport layer, TCP/IP model, and comparison of OSI & TCP/IP model.

Types of information: Audio, Video, still Images, text and data, Fax. Types of Communication and Network: PSTN, POTS, ATM, ISDN,wireless transmission, wireless technologies, 802.11, 802.16, satellite communication.

Unit 3. Clinical Applications

Clinical parameters, Tele-cardiology Tools and Devices, Tele-dermatology, Tele-radiology, homecare, neurology, Tele-oncology, Tele-ophthalmology, Tele-rehabilitation, Tele-pathology & Tele-surgery.

Unit 4. Telemedicine Equipments

Data Exchanges: Network Configuration, Circuit and packet switching, H.320 series (Video phone based ISBN) T.120, h.324 (Video phone based PSTN), Video Conferencing Network equipments – Telemedicine workstations, DSL, ADSL, SDSL, cable modems, VoIP modem, Fast switched ethernet, routers, switches, hubs, multi point conferencing units. Monitoring devices –electronic stethoscope, vital sign monitoring devices. Respiratory monitoring devices, neurological monitoring devices, video scopes, robotics and virtual reality devices.

Unit 5. Legal and Ethical Issues

Confidentiality, Patient Rights and Consent.Data Protection and Security.Ethical and Legal Aspects of the Internet. International and National protocols- HL7, HIPAA, DICOM, and Indian IT act.

Text Books

1. Andrew S Tanenbaum, *Computer Networks*, PHI, 2003.
2. Norris A.C., *Essential of Telemedicine and Telecare*, John Wiley & Sons, 2001.

References

1. M Marlene, W Pamela, A Allen, *E-Health, Telehealth, and Telemedicine: A Guide to Start-up & Success*, Wiley, 2001.

Session 2023-24
Semester B- Syllabus

Biomedical Engineering
B.E. IVth Year
BM-XXXXX: Nanosensors
Elective V.3

Course Outcomes: -

CO1: To understand the basics concepts of nanotechnology
CO2: To compare different materials used in the field of nanotechnology
CO3: To analyse and categorize the nanosensors
CO4: To apply the knowledge of nanomaterials in the development of nanosensors
CO5: To analyse and evaluate the performance of different nanosensors

L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
						Theory		Practical		Total
						Th.	CW	SW	Pr.	
4	1		4		4	70	30			100

Prerequisite: - Nil

Unit 1. Introduction to Nanotechnology

Basic properties of nanomaterials and the unusual behaviour at nanoscales, difference between bulk and nano materials, comparison of 0D, 1D, 2D and 3D materials Classification of nanomaterials, application of nanomaterials, nanomaterials for sensor applications.

Unit 2. Nanosensors

Properties of materials used for nanosensors, materials for nanosensors, synthesis techniques, characterisation of nanosensors: characterisation techniques.

Unit 3. Classification of Nanosensors

Classification of nanosensors: physical, chemical, and biological nanosensors. Mechanical nanosensors, thermal nanosensors, optical nanosensors, magnetic nanosensors, chemical nanosensors, nanobiosensors

Unit 4. Nanosensors for Chemical and Biological Applications

Chemical and biological sensing with carbon nanotubes, electrochemical nanosensors for blood glucose analysis, electropolymers for (nano-) imprinted biomimetic biosensors, nanoporous silicon biochemical sensors

Unit 5. Nanobiosensors

Biomolecular components of a biosensor: fundamentals**,** nanoparticle-based electrochemical biosensors, CNT-based electrochemical Biosensors, functionalization of CNTs for biosensor fabrication, quantum dot-based electrochemical biosensors, nanotube- and nanowire-based FET nanobiosensors, cantilever-based nanobiosensors, optical nanobiosensors, microarrays

Text Books

1. Bharat Bhushan, *Handbook of Nanotechnology*, Springer 4th edition.
2. Vinod Kumar Khanna , *Nanosensors: Physical, Chemical, and Biological*, 1st Edition.
3. Joseph M. Irudayaraj, *Biomedical Nanosensors*, 1st Edition.
4. Kevin C. Honeychurch , *Nanosensors for Chemical and Biological Applications: Sensing with Nanotubes, Nanowires and Nanoparticles*.

References

1. CNR Rao, *Nanoworld : An Introduction To Nanoscience & Technology* .