



Second Year Curriculum

Admission Year 2026-27

**Bachelor of Technology
Biomedical Engineering**

Faculty of Engineering & Technology

Parul University

Vadodara, Gujarat, India

SEMESTER 3

- a. **Course Name:** Human Anatomy and Physiology-II
- b. **Course Code:** 03011103PC01
- c. **Prerequisite:** Basic knowledge of Biology and chemistry up to 12th Level.
- d. **Rationale:** The students need to learn fundamentals of anatomical structures and physiology of body organs. This knowledge is helpful to design any instrument. Students get to know about body composition, organs and systems.

e. Course Learning Objective:

CLOBJ 1	Explain the structures of different body parts.
CLOBJ 2	Describe the physiology of body organs.
CLOBJ 3	Demonstrate the ability to interpret how the nervous system controls various body parts.
CLOBJ 4	Apply their knowledge to point out and explain the processes of exchange and transportation of gases in the body
CLOBJ 5	Locate and identify anatomical structures through recalling their knowledge.
CLOBJ 6	Study the use of Anatomy in biomedical field

f. Course Learning Outcomes:

CLO 1	Explain the structures of different body parts.
CLO 2	Describe the physiology of body organs.
CLO 3	Able to interpret how the nervous system controls the body parts.
CLO 4	Able to point out the exchange and transportation of gases.
CLO 5	Locate and identify anatomical structures
CLO 6	Able to point out the exchange and transportation of gases.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<p>Respiratory System Structure and function of respiratory system, mechanism of respiration, regulation of respiration, principle of gas Exchange /transport between the lungs and tissues, pulmonary volumes and capacities, pulmonary function test, Spiro meter, artificial respiration.</p>	15%	5
2	<p>Nervous System Introduction, Functions of Nervous System, Central Nervous System: Neuron, Anatomy, Communication, Cerebrospinal Fluid, Functions of CSF, Brain-Parts, Anatomy and Physiology, Spinal Cord, Peripheral nervous system, Reflex Action and Reflex Arc, Parasympathetic & Sympathetic nervous system, Problems of the Nervous System.</p>	20%	10
3	<p>Special Senses Structure, function and physiology of vision, hearing, taste & smell. Mechanism of vision, color vision, mechanism of hearing, tests of hearing.</p>	15%	5
4	<p>Integumentary, Skeletal and Muscular System Integumentary System: Introduction, The Skin: Structure and Functions of Skin, Regulation of Body temperature, Skin Disorders, Wound Healing. Skeletal System: Introduction, Components and Functions of Skeletal system, Divisions of Skeletal system, Classification of Bone based of Shape, Axial Skeleton: Skull, Vertebral column (spinal column), Thoracic cage, Sternum. Appendicular skeleton: Pectoral Girdle, upper limbs, Pelvic Girdle, Lower Limbs. Muscular System: Introduction, types of Muscular tissue, Anatomical terms of movement, Physiology of muscle Contraction.</p>	25%	13
5	<p>Reproductive System Introduction, Asexual and Sexual Reproduction, Organs, Location and Functions of Female Reproductive System: Cyclical development of ovarian follicle, ovum and corpus luteum, Menstrual Cycle v/s Ovarian Cycle, Mechanism of Labor and Parturition, Stages of Labor, Organs, Location and Functions of Male Reproductive System: Composition of semen, Sperm Count and the factors involved in male fertility, Hormonal control of mammary gland development and lactation.</p>	25%	12
Total:		100 %	45

i. Text Book and Reference Book:

1. Anatomy and physiology in Health and Illness, By ROSS AND WILSON; Churchill Livingstone (Elsevier).
2. Textbook of Medical Physiology, By A.C.Guyton; Saunders
3. Human Anatomy, By B.D Chaurasia.
4. Human anatomy and Physiology with Health Education, By Padma B Sanghani; McGrawHill.
5. Atlas of Human Anatomy by Frank H. Netter.

- a. **Course Name:** Human Anatomy and Physiology-II Laboratory
- b. **Course Code:** 03011103PC02
- c. **Prerequisite:** Basic knowledge of Biology and chemistry up to 12th Level.
- d. **Rationale:** The students need to learn fundamentals of anatomical structures and physiology of body organs. This knowledge is helpful to design any instrument. Students get to know about body composition, organs and systems
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with biological systems.
CLOBJ 2	Solve problems related to the various tissues and organs of different systems of human body
CLOBJ 3	Acquire knowledge of the gross morphology, structure and functions of various organs of the human body.
CLOBJ 4	Understand different anatomical structures

f. **Course Learning Outcomes:**

CLO 1	Locate and identify anatomical structures
CLO 2	Identify the various tissues and organs of different systems of human body
CLO 3	Able to interpret the gross morphology, structure and functions of various organs of the human body.
CLO 4	Illustrate the knowledge of biological systems.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
0	-	2	1	-	-	20		30	50

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. **List of Experiments:**

Sr. NO.	Experiment List
1	To study the Skeletal system
2	To identify different joints in the human body
3	To study the structure and function of different components of eyes

4	To study the structure and function of different components of ears
5	To study the structure and function of different components of Taste
6	To study the Nervous system
7	To study the respiratory system
8	To study the human male reproductive system
9	To study the human female reproductive system
10	To study the integumentary system
11	To study the muscular system

- a. **Course Name:** Biomedical Control Theory
- b. **Course Code:** 03011103PC03
- c. **Prerequisite:** Knowledge of Linear differential equations, Different equations and its solution and Laplace transform.
- d. **Rationale:** The course explores the fundamentals of control systems, understanding and predicting system behaviour and design and analysis of closed loop control systems.
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with systems theory to complex real world problems in order to obtain models that are expressed using differential equations, transfer functions, and state space equations.
CLOBJ 2	Solve problems system behavior based on the mathematical model of that system.
CLOBJ 3	Acquire knowledge of the behavior of closed loop systems using tools such as root locus, Routh Hurwitz, Bode, Nyquist plots.
CLOBJ 4	Understand different single phase and three phase circuits.
CLOBJ 5	Demonstrate a clear understanding of the models of dynamic systems in transfer function and state space forms.

f. **Course Learning Outcomes:**

CLO 1	Apply systems theory to complex real world problems in order to obtain models that are expressed using differential equations, transfer functions, and state space equations.
CLO 2	Predict system behavior based on the mathematical model of that system where the model may be expressed in time or frequency domain.
CLO 3	Analyze the behavior of closed loop systems using tools such as root locus, Routh Hurwitz, Bode, Nyquist plot.
CLO 4	Obtain models of dynamic systems in transfer function and state space forms.
CLO 5	Design of PID Controllers with Frequency-Response Approach.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. **Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	Introduction to Control Systems Introduction, Examples of Control Systems, Closed-Loop Control versus n-Loop Control, Digital Computer Control, The Control Problem.	5%	3
2	Mathematical Modeling of Control Systems Introduction, Transfer Function and Impulse-Response Function, Automatic Control Systems, Transformation of Mathematical Models with MATLAB. Mathematical Modeling of Mechanical Systems, Mathematical Modeling of Electrical Systems, and Block diagram Model, Signal flow graph.	15%	6
3	State Variable Models Concept of State Variable, State equation, State-Space Representations of Transfer-Function Systems, Transformation of System Models with MATLAB, Solving the Time-Invariant State Equation, Some Useful Results in Vector-Matrix Analysis.	15%	6
4	Feedback Characteristics of Control System Feedback and non-feedback Systems, Reduction of parameters variations by use of feedback, Control over System dynamics by use of feedback, Control of the effects of disturbance signal by use of feedback, Linearizing effect of feedback, Regenerative feedback.	5%	3
5	Time response analysis Design Specifications and Performance Indices: Standard Test signal, Time response of first order systems, Time response of second order systems, Steady-state errors and errors constants, Effect of adding zero to a system, Design specifications of second order systems, Design consideration of higher order systems, Performance Indices.	10%	5
6	Concept of Stability and algebraic Criteria The Concept of Stability, Necessary condition of stability, Hurwitz stability criterion, Routh stability criterion, Relative stability analysis.	5%	3
7	Control Systems Analysis and Design by the Root-Locus Method	10%	5

	Introduction, Root-Locus Plots, Plotting Root Loci with MATLAB, Root- Locus Plots of Positive Feedback Systems, Root-Locus Approach to Control-Systems Design.		
8	Control Systems Analysis and Design by the Frequency- Response Method Introduction, Correlation between time and frequency response, Polar plots, Bode plots, All pass and minimum phase systems, Log magnitude versus Phase plots.	15%	6
9	Stability in frequency domain Introduction, Mathematical Preliminaries, Nyquist stability criterion, assessment of relative stability using Nyquist criterion.	10%	4
10	PID Controllers and Modified PID Controllers Introduction, Ziegler'Nichols Rules for Tuning PID Controllers, Design of PID Controllers with Frequency-Response Approach, Modifications of PID Control Schemes, Two-Degrees-of-Freedom Control.	10%	4
Total:		100 %	45

i. Text Book and Reference Book:

1. Modern Control System, By Richarc C. Drof and Robert H. Bishop).
2. Modern Control Engineering, By Katsuhiko Ogata; Prentice Hall of India
3. Control Systems Engineering, By Nagrath and Gopal; New Age Publication.
4. Automatic Control Systems, By Benjamin C.Kuo; John Wiley & Sons.
5. Feedback and Control Systems, By Joseph J Distefano.

- a. **Course Name:** Biomedical Control Theory Laboratory
- b. **Course Code:** 03011103PC04
- c. **Prerequisite:** Knowledge of Linear differential equations, Different equations and its solution and Laplace transform.
- d. **Rationale:** The course explores the fundamentals of control systems, understanding and predicting system behaviour and design and analysis of closed loop control systems
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with the closed and open loop systems.
CLOBJ 2	Solve problems related to the stability of the closed and open loop system.
CLOBJ 3	Acquire knowledge of the stability of the closed and open loop system.
CLOBJ 4	Understand system behaviour based on the mathematical model of that system using MATLAB
CLOBJ 5	Demonstrate a clear understanding of the Analysis effect of PID controller on system

f. **Course Learning Outcomes:**

CLO 1	Understand and interpret the response of the closed and open loop systems.
CLO 2	Solve basic stability of the closed and open loop system.
CLO 3	Understand the stability of the closed and open loop system.
CLO 4	Discuss system behaviour based on the mathematical model of that system using MATLAB
CLO 5	Understanding the Analysis effect of PID controller on system.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50

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h. List of Experiments:

Sr. NO.	Experiment List
1	Introduction to MATLAB for Control System.
2	Introduction to Simulink and various block sets.
3	Analysis different input signals to control system
4	Analysis of linear time-invariant systems and representation
5	Write a MATLAB program for reduction of block diagrams.
6	Plotting response of first order circuit and second order circuits with the help of MATLAB programming.
7	Obtain the root locus plot for the system using MATLAB
8	Obtain the bode plot for the system using MATLAB
9	Obtain the Nyquist plot for the system using MATLAB
10	Basic concept of state space and its conversion using MATLAB
11	Simulation of control system represented in state space form.
12	Analysis effect of P, PD, PI, PID controller on system.

- a. **Course Name:** Biosensor and Transducers
- b. **Course Code:** 03011103PC07
- c. **Prerequisite:** Basics Principles of Physics, Human Anatomy & Physiology, Bio-Potentials.
- d. **Rationale:** Due to growing need in the area of Health care sector and Biomedical instruments Study of Bio Transducers as well as sensors will give insight to the Biomedical Engineers.
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with importance of the sensors and transducers for medical applications.
CLOBJ 2	Solve problems related to the importance of the sensors and transducers for medical applications.
CLOBJ 3	Acquire knowledge of the importance of the sensors and transducers for medical applications.
CLOBJ 4	Understand measuring temperature, pressure, force, flow and other important parameters in determining the circulation-, breathing- and excretory functions.
CLOBJ 5	Demonstrate engineering approach to develop biomedical measurement systems.

f. Course Learning Outcomes:

CLO 1	Interpret the importance of the sensors and transducers for medical applications.
CLO 2	Interpret the importance of the sensors and transducers for medical applications.
CLO 3	Present different methods for measuring temperature, pressure, force, flow and other important parameters in determining the circulation-, breathing- and excretory functions.
CLO 4	Describe how different measurement techniques are used to determine the vital parameters of diagnostic importance.
CLO 5	Provide an engineering approach to develop biomedical measurement systems.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<p>Basics of measurement physiological parameters Introduction, Basic Instrumentation System, Measurement, Measurand and Transducer, Accuracy, Precision and errors, Signal and Noise with its Ratio, Transducers Classification, Transducer Constituent Parts, Electrical Design Characteristics, Transduction Principles, Performance Characteristics.</p>	15%	7
2	<p>Piezo-Electric Force and Ultrasonic Transducers Introduction, Piezo-electric Phenomena and Materials, Expression of Piezoelectric Voltage, Piezoelectric Pressure Transducer, Advantage, Piezoelectric Ultrasonic Transducers: Introduction, Construction and design</p>	10%	5
3	<p>Temperature Transducers Introduction, basic Concepts, Construction and working principle of RTD, Thermistor and Thermocouple, Non-contact Temperature measurement, Principle of Infrared Radiation Thermometer, Non-contact Infrared Tympanic Thermometer Probe.</p>	15%	7
4	<p>Displacement Transducers Introduction, Displacement and Force Transducers, Theory of Resistance Strain Gauge, Types and Construction of Strain Gauge, Construction and working principle of LVDT, Basic Principle of RVDT, Potentiometric Displacement Transducer.</p>	10%	5
5	<p>Biological Pressure and Flow Transducers: Pressure Transducers: Introduction, Physiological Pressures, Blood Pressure measurement methods, Measurement of Vacuum. Flow Transducers: Introduction, Electromagnetic Blood flow probe, Ultrasonic Blood flow Transducers, Respiratory Gas Flow Transducers, Breathing Analyzer.</p>	20%	8
6	<p>Chemical and Enzyme Based Biosensors Introduction, Blood Gas Sensors, Blood pH-sensor, pCO₂ Sensor, Microbial Biosensors, Enzyme based Biosensor</p>	10%	5
7	<p>Bio-potential Electrodes Introduction, Electrode Theory, Polarizable and Nonpolarizable electrode, Types of Biopotential</p>	15%	6

	Electrodes, ECG Electrode, EMG Electrode, EEG Electrode, Glucose strip, Pregnancy Strip.		
8	Basics of SMART and MEMS Sensors	5%	2
Total:		100 %	45

i. Text Book and Reference Book:

1. Biomedical Transducers (TextBook), By H.T.Kasipara.
2. Transducers for Biomedical measurements, By Richard S.C. Cobbold.
3. Biomedical Sensors- Fundamentals and applications, By Harry.N. Norton.
4. Biomedical Instrumentation and Measurements (TextBook), By Leslie Cromwell.
5. Biomedical Transducers and Instruments, Tatsuo Togawa, Toshiya Tamora, and P. Ake Oberg.

- a. **Course Name:** Biosensor and Transducers Laboratory
- b. **Course Code:** 03011103PC08
- c. **Prerequisite:** Basics Principles of Physics, Human Anatomy & Physiology, Bio-Potentials.
- d. **Rationale:** Due to growing need in the area of Health care sector and Biomedical instruments Study of Bio Transducers as well as sensors will give insight to the Biomedical Engineers.
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with Electronics concepts for a range of problems in medical applications.
CLOBJ 2	Solve problems related to applications of various sensors and transducers available for physiological and cellular measurements.
CLOBJ 3	Acquire knowledge of the critically reviewing the literature in the application area and apply knowledge gained from the course to analyse simple bio-sensing and transduction problems.
CLOBJ 4	Understand biomedical instrumentation systems.

f. **Course Learning Outcomes:**

CLO 1	Apply Electronics concepts for a range of problems in medical applications.
CLO 2	Interpret the applications of various sensors and transducers available for physiological and cellular measurements.
CLO 3	Capable of critically reviewing the literature in the application area and apply knowledge gained from the course to analyse simple bio-sensing and transduction problems.
CLO 4	Design biomedical instrumentation systems.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. **Experiment List:**

Sr. NO.	Experiment List
1	To study and perform resistive transducers.

2	To study and perform capacitive and inductive transducers.
3	To study and perform displacement transducers.
4	To study and understand the working of proximity transducers.
5	To study and perform resistance strain gauge
6	To study and understand the industrial weighing system.
7	To study and perform hall effect sensors.
8	To study and understand the tachometer.
9	To study and perform ph measurement.
10	To study and understand working of viscosity measurement
11	To study and understand working of turbidity measurement
12	To study and understand chromatography.
13	To study and understand infrared analysers.
14	To study and understand acceleration measurement.
15	To study and perform conductivity measurement.

- a. **Course Name:** Fabrication Workshop for Biomedical
- b. **Course Code:** 03011103PC06
- c. **Prerequisite:** Basic understanding of tools, machines, and hand instruments used in fabrication.
- d. **Rationale:** This course is designed to provide students with foundational practical skills in mechanical, electrical, and electronics workshop practices, enabling them to understand industrial processes, safety norms, tools, and basic fabrication, measurement, and electrical systems essential for engineering applications.
- e. **Course Learning Objective:**

CLOBJ 1	To provide fundamental practical knowledge of mechanical, electrical, and electronics workshop practices relevant to biomedical engineering applications.
CLOBJ 2	To develop hands-on skills in the use of workshop tools, measuring instruments, fabrication techniques, and basic electrical/electronic systems.
CLOBJ 3	To familiarize students with industrial safety practices, maintenance procedures, and standard operating methods followed in engineering workshops.
CLOBJ 4	To enable students to understand and perform basic fabrication, assembly, testing, and troubleshooting processes used in biomedical equipment and healthcare-related devices.

f. **Course Learning Outcomes:**

CLO 1	Identify workshop layouts, tools, safety norms, and basic electrical/electronic components.
CLO 2	Apply safety practices and use measuring instruments for accurate measurements.
CLO 3	Perform basic workshop operations such as fitting, carpentry, sheet metal, welding, and plumbing.
CLO 4	Analyze basic electrical and electronic circuits using Multimeter, power supply, CRO, and function generator.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	4	2	-	-	20	-	30	50

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. Experiment List:

Sr. NO.	Experiment List
1	To study the workshop layout, tools, machines, and safety practices followed in an engineering workshop.
2	To study and use basic measuring instruments for linear and angular measurements.
3	To perform marking, cutting, filing, and finishing operations to produce a fitting job as per given dimensions.
4	To carry out drilling, reaming, and tapping operations using appropriate tools and machines.
5	To prepare simple wooden joints using basic carpentry tools and machines.
6	To perform layout, cutting, bending, and fabrication of a simple sheet metal component.
7	To perform basic forging operations such as drawing out, upsetting, bending, and cutting.
8	To perform basic welding and soldering operations for joining metal parts.
9	To carry out cutting, threading, and joining of pipes using standard plumbing fittings.
10	To estimate material, labor, and total cost involved in completing a simple workshop job.
11	Study of Digital Multimeter and Measurement of voltage, current, frequency, phase difference, power, power factor for single phase supply using Digital Millimeter.
12	To study about safety, Electric shock, First aid for electric shock and other Hazards of electrical Laboratories and Safety rules.
13	Identification and symbolic representation of basic passive components.
14	Understanding of working and specifications of CRO and Function generator.
15	Identification, symbolic representation and testing of various electronics components (including SMD).
16	To understand working and specifications of DC regulated Power supply.
17	Understanding soldering techniques and practicing proper soldering and de-soldering.
18	Overview of PCB layout designing and fabrication.
19	Study of different types of cables, wires, probes, connectors.
20	To understand series & parallel type of connections and to perform Bulb wiring, Fan wiring, Tube-light wiring.
21	To perform staircase wiring, double stair case wiring, and Go-down wiring.

22	Demonstration of Fuse, MCB along its operation and study of ELCB.
23	Prepare installation diagram for a newly built room, Simple room wiring with one fan, one tube-light and one bulb with switch board.

- a. **Course Name:** Functional Communication Skills
- b. **Course Code:** 03010003HM01
- c. **Prerequisite:** Knowledge of Advanced Communication and Interpersonal Skills.
- d. **Rationale:** This course develops workplace-oriented communication skills by bridging academic language competence with professional communication requirements.
- e. **Course Learning Objective:**

CLOBJ 1	Demonstrate the ability to communicate clearly and persuasively in oral presentations.
CLOBJ 2	Practice active listening techniques to enhance understanding in professional interactions.
CLOBJ 3	Write professional emails, memos, and reports with clarity and conciseness.
CLOBJ 4	Understand and practice time management strategies effectively.
CLOBJ 5	Demonstrate skills in resolving conflicts and negotiating effectively.
CLOBJ 6	Use digital communication tools and platforms effectively.

f. **Course Learning Outcomes:**

CLO 1	To develop advanced communication skills
CLO 2	To become more proficient in formal writing
CLO 3	To apply interpersonal communication skills to be more productive at the workplace
CLO 4	To identify, set and achieve the goals with the help of time management
CLO 5	To use with range of vocabulary to communicate effectively

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	2	-	2	-	100	-	-	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. **Course Content:**

Sr. No.	Content		Teaching Hours
1	Sentence Correction Error identification (grammar, usage, style)	10%	2

	Common workplace errors Contextual grammar usage		
2	Para Jumbles & Sentence Reordering Logical sequencing Cohesion markers Theme identification	8%	1
3	Statement and Assumptions Fact vs assumption Logical reasoning basics Workplace problem scenarios	10%	1
4	Reading Comprehension (Level of Difficulty - Advanced) Inferential questions Author's tone & intent Vocabulary in context	12%	2
5	Resume and Cover Letter Writing Resume formats Achievement-based bullet points Customizing cover letters	14%	2
6	Building a Professional LinkedIn Profile Professional headline Summary writing Digital networking ethics	8%	1
7	Just a Minute (JAM) Idea organization Fluency techniques Time management in speech	8%	1
8	Telephone and Video Call Etiquette Opening & closing calls Voice modulation Virtual meeting etiquette	8%	1
9	Email Writing Format Professional tone Subject lines Email etiquette	10%	2
10	Report Writing Report Writing Types of reports Structure & formatting Use of visuals & data	12%	2
Total:		100 %	15

i. Text Book and Reference Book:

1. Business Communication Today
By Bovee, Courtland L., and John V. Thill | Pearson Education, Pub. Year 2019
2. Essentials of Business Communication

- By Guffey, Mary Ellen, and Dana Loewy. | Cengage Learning, Pub. Year 2018
3. Advanced Grammar in Use
By Hewings, Martin. | Cambridge University Press, Pub. Year 2013
 4. English Vocabulary in Use: Advanced.
By McCarthy, Michael, and Felicity O'Dell | Cambridge University Press, Pub. Year 2017
 5. Personality Development and Soft Skills.
By Mitra, Barun K | Oxford University Press, Pub. Year 2011

- a. **Course Name:** Numerical Methods
- b. **Course Code:** 03019104BS02
- c. **Prerequisite:** Basic knowledge of Functions, Differential and Integral Calculus, and Elementary Algebra
- d. **Rationale:** Numerical Methods is an essential course that provides mathematical techniques for obtaining approximate solutions to complex engineering and scientific problems where analytical solutions are difficult or impossible to achieve.
- e. **Course Learning Objective**

CLOBJ 1	Understand the fundamental concepts of numerical methods and their importance in solving engineering and mathematical problems.
CLOBJ 2	Apply numerical techniques such as Bisection, Newton-Raphson, Regula-Falsi, Gauss-Jacobi, and Gauss-Seidel methods for solving algebraic equations and linear systems.
CLOBJ 3	Develop interpolation models using finite difference techniques, Newton's interpolation, divided difference, and Lagrange interpolation methods.
CLOBJ 4	Apply numerical integration techniques including Trapezoidal Rule, Simpson's Rules, and Gaussian Integration for approximate evaluation of definite integrals.
CLOBJ 5	Analyze and solve ordinary differential equations using Euler, Modified Euler, and Runge-Kutta methods.
CLOBJ 6	Interpret numerical results and evaluate accuracy, efficiency, and applicability of different numerical methods in real-world problems

f. **Course Learning Outcomes:**

CLO 1	Solve simultaneous algebraic equations arising in engineering problems.
CLO 2	Solve algebraic and transcendental equations arising in engineering problems.
CLO 3	Approximate functional values for equidistant and non-equidistant intervals using interpolation techniques.
CLO 4	Approximate integrals relevant to engineering applications using numerical integration.
CLO 5	Solve ordinary differential equations using standard numerical techniques applicable to engineering systems.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. **Course Content:**

Sr.	Topics	Weightage %	Teaching hours
1	Solution of Simultaneous Algebraic Equations and Solutions of Algebraic and Transcendental Equations: Solution of algebraic and transcendental equations – Bisection Method, Newton-Raphson Method, and Regula-Falsi Method, Gauss-Jacobi and Gauss Seidel Methods.	25%	12
2	Finite Differences and Interpolation: Finite Differences, relation between operators. Interpolation using Newton's forward and backward difference formulae. Newton's divided difference formula and Lagrange's interpolation formula for unequal intervals.	25%	11

3	Numerical Integration: Trapezoidal Rule, Simpson's 1/3- Rule, Simpson's 3/8- Rule, Gaussian Integration.	25%	11
4	Solution of Ordinary Differential Equations: Euler's method, Modified Euler's method, and Runge-Kutta method.	25%	11
Total:		100 %	45

i. Text Books:

- B. S. Grewal, "Numerical Methods in Engineering & Science with Programs in C and C++", Khanna Publishers.
- E. Kreyszig, Advanced Engineering Mathematics, Willey India Edition.
- Jain, Iyengar, Jain, Numerical Methods for Scientific & Engineering Computations, New Age International.
- S. S. Shastri, Introductory Methods of Numerical Analysis, Prentice Hall India Learning Private Limited.

j. Reference Books:

- C.E. Froberg, "Introduction to Numerical Analysis", Addison-Wesley.

SEMESTER 4

- a. **Course Name:** Biomaterial and Implants
- b. **Course Code:** 03011104PC03
- c. **Prerequisite:** Basic knowledge of human anatomy and physiology is must.
- d. **Rationale:** To understand the basic types of materials used in human body, to understand the importance of material selection in the implants the course contents will enable the students to study the effects of implants on human body required for Biomedical Engineers.
- e. **Course Learning Objective:**

CLOBJ 1	Understand the bio-materials and its mechanical properties.
CLOBJ 2	Compare and classify the various metallic and ceramic material used for manufacturing of the implants
CLOBJ 3	Analyze the method for testing and evaluating its biocompatibility.
CLOBJ 4	Discuss three phase-balanced circuits.
CLOBJ 5	Understands the basic properties of different biomaterials used and biological substitutes.
CLOBJ 6	Acquire knowledge about electrical device installations

- f. **Course Learning Outcomes:**

CLO 1	Give Classification of bio-materials and its mechanical properties.
CLO 2	Compare and classify the various metallic and ceramic material used for manufacturing of the implants
CLO 3	Understand the role for testing and evaluating biocompatibility.
CLO 4	Examine the properties of different biomaterials.
CLO 5	Understanding the basic properties of different biomaterials used and biological substitutes.
CLO 6	Acquire knowledge about electrical device installations

- g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

- h. **Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<p>Introduction Of Biomaterial And Types Definition and Classification of Bio-materials, Mechanical Properties, Viscoelasticity, Wound Healing Process, Body response to Implants, Types of Biomaterials: Metals, Ceramics and Polymers, Introduction of composite material.</p>	15%	7
2	<p>Metals And Ceramics Stainless steel, Cobalt-chromium based alloys, Titanium and titanium alloys, Nitinol: Shape memory effect. Dental Metals: Gold, Nickel. Corrosion of metals. Ceramics-types of ceramics: (i) Alumina as a Bioinert ceramics (ii) Bioglass as a Bioactive Ceramics and (iii) Calcium Phosphate as a Bioresorbable ceramics. Carbons: Different types of carbons.</p>	20%	9
3	<p>Polymers Polymerization: Types of Polymerization process, polymer chain, Polymers in biomedical use, types of polymer: Polyethylene, polypropylene, Per-fluorinated polymers, Acrylic polymers, Polyamides and Poly Methyl Methacrylate (PMMA), Silicon rubber, Prosthodontic polymers.</p>	10%	4
4	<p>Cardiac And Ophthalmic Implants: Vascular grafts, heart valves, cardiac assisting devices, stent, implantable pacemaker, Contact lens: soft and hard lenses, Disposable lenses, Intraocular lenses (IOLs), Viscoelastic solutions, Vitreous Implants, Eye shields, Drainage tubes in Glaucoma, Manufacturing process of cardiac and ophthalmic implant.</p>	15%	7
5	<p>Orthopaedic And Dental Implants Temporary fixation devices, Fracture healing, Repair of the ligaments, Joint Replacements; Total Hip replacement, Total Knee replacement Dental Implant modalities: Dentures, types of Dental Implants End osseous, Subperiosteal, Trans osseous Implants. Filling materials, Restoration and Impression materials used in Dental Implants, Manufacturing process of orthopaedic and dental implant.</p>	25%	11
6	<p>Biocompatibility And Sterilization Methods for testing and evaluating biocompatibility: In Vivo and In Vitro testing, Hemocompatibility, Osteocompatibility, Tissue response to external materials, Biodegradable materials and their</p>	15%	7

	applications. Sterilization Process: ETO, Gamma radiation, autoclave. Effects of sterilization.		
Total:		100 %	45

i. Text Book and Reference Book:

1. Biomaterials Second Edition, Narosa Publishing House, 2005., By Sujata V. Bhatt
2. Biomaterials - Principles and Applications – CRC Press, 2003, By JoonB.Park Joseph D. Bronzino
3. Biomaterials Science: An Introduction to Materials in Medicine" by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, and Jack E. Lemons.
4. "Fundamentals of Biomaterials: An Introduction" by Qizhi Chen.
5. "Implantable Neural Prostheses 1: Devices and Applications" edited by David Zhou.

- a. **Course Name:** Biomaterial and Implants Lab
- b. **Course Code:** 03011104PC04
- c. **Prerequisite:** Basic knowledge of human anatomy and physiology is must.
- d. **Rationale:** To understand the basic types of materials used in human body, to understand the importance of material selection in the implants the course contents will enable the students to study the effects of implants on human body required for Biomedical Engineers.
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with the different Biomaterials.
CLOBJ 2	Solve problems related to various metallic and ceramic material used for manufacturing of the implants.
CLOBJ 3	Acquire knowledge of the Methods for testing and evaluating biocompatibility.
CLOBJ 4	Understand different properties of different biomaterials used and biological substitutes.

f. Course Learning Outcomes:

CLO 1	Identify the different Biomaterials.
CLO 2	Interpreting of various metallic and ceramic material used for manufacturing of the implants.
CLO 3	Illustrate the Methods for testing and evaluating biocompatibility.
CLO 4	Awareness of properties of different biomaterials used and biological substitutes.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. List of Experiments:

Sr. NO.	Name of Experiments
1	To Study about Introduction of Biomaterials.
2	Identify various metals and alloys used in biomedical field.
3	Identify various ceramics used in biomedical field.

4	Identify various polymers used in biomedical field.
5	To Study about different dental implants.
6	To Study about cardiac valve implants.
7	To Study about cardiac pacemaker implantation
8	To Study about different Intra ocular implants.
9	To study about Total Hip Replacement.
10	To study about Total Knee Replacement.

- a. **Course Name:** Signals and Systems for Biomedical
- b. **Course Code:** 03011104PC01
- c. **Prerequisite:** Inclination to learn mathematics, basic knowledge of differential equations and difference equations, electrical circuits and networks.
- d. **Rationale:** The course will provide strong foundation on signals and systems which will be useful for creating foundation of communication and biomedical signal processing. The students will learn basic continuous time and discrete time signals and systems. Student will understand application of various transforms for analysis of signals and systems both continuous time and discrete time for biomedical systems. Students will also explore to power and energy signals and spectrum.
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with electrical current, potential difference, power and energy, sources of electrical energy and elements of electrical circuit.
CLOBJ 2	Solve problems related to various types of systems, classify them, analyse them and understand their response behaviour.
CLOBJ 3	Acquire knowledge of signals and systems for observing effects of applying various properties and operations.
CLOBJ 4	Understand a strong foundation of communication and biomedical signal processing to be studied in the subsequent semester.

f. **Course Learning Outcomes:**

CLO 1	Understand electrical current, potential difference, power and energy, sources of electrical energy and elements of electrical circuit.
CLO 2	Illustrate about various types of systems, classify them, analyse them and understand their response behaviour.
CLO 3	Carry simulation on signals and systems for observing effects of applying various properties and operations.
CLO 4	Create a strong foundation of communication and biomedical signal processing to be studied in the subsequent semester.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. **Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	Introduction to Signal Processing Signal, System, Analog signal processing, Digital signal processing, Digital system, Advantages of DSP over ASP, Applications of DSP.	15%	4
2	Signals and Systems Signal: Introduction, Classification of Signals, Characteristics of continuous and discrete time signal, Representation of discrete time signal, Standard test signals, Operating upon signals: Time-Shifting, Time-Scaling and Amplitude Scaling operations, Related Examples. System: Introduction, Classification of System and related examples, Symbols used in discrete time systems for block schematic representation.	20%	10
3	Sampling, Aliasing and Reconstruction A/D conversion process, Sampling theorem, Nyquist criteria, Examples related to sampling theorem, Aliasing: signal ambiguity in frequency domain, Anti-aliasing filter: Importance, Block-diagram of DSP system	15%	4
4	Linear Time Invariant (LTI) System: Convolution & Correlation Introduction of LTI System, Analysis of LTI System: Mathematical expression (Analytical), Graphical, Tabular and Multiplication method, Related examples to solve convolution sum, Properties of convolution sum. Concept of correlation, types: Autocorrelation and Cross correlation, Analysis of correlation: Mathematical expression and Tabular method, Related examples, Properties of Autocorrelation and Cross-correlation, Applications of correlation.	25%	15
5	Z Transform Introduction, Definition of Z-transform, Region of Convergence, Properties of Z-transform, Inversion of Z-transform, Evaluation of system frequency response, Applications of Z-transform..	25%	12
Total:		100 %	45

i. Text Book and Reference Book:

1. Signals and Linear Systems, By Gabel R.A. and Robert R.A; John Wiley and Sons, New York
2. Signals and System, By Oppenheim, Wilskey and Nawab; Prentice Hall India

3. Systems and Signal Analysis, By C.T.Chen; Oxford University Press, India.
4. Signals and Systems, By Simon Haykin and Bary Van Veen; Wiley.
5. Digital Signal Processing, By Salivahanan S. , Vallavaraj A., Gnanapriya C.; Tata McGraw-Hill, New Delhi, 2008; 2008

- a. **Course Name:** Signals and Systems for Biomedical Laboratory
- b. **Course Code:** 03011104PC02
- c. **Prerequisite:** Inclination to learn mathematics, basic knowledge of differential equations and difference equations, electrical circuits and networks.
- d. **Rationale:** The course will provide strong foundation on signals and systems which will be useful for creating foundation of communication and biomedical signal processing. The students will learn basic continuous time and discrete time signals and systems. Student will understand application of various transforms for analysis of signals and systems both continuous time and discrete time for biomedical systems. Students will also explore to power and energy signals and spectrum.
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with electrical current, potential difference, power and energy, sources of electrical energy and elements of electrical circuit.
CLOBJ 2	Solve problems related to various types of systems, classify them, analyze them and understand their response behavior.
CLOBJ 3	Acquire knowledge of signals and systems for observing effects of applying various properties and operations.
CLOBJ 4	Understand a strong foundation of communication and biomedical signal processing to be studied in the subsequent semester.

f. **Course Learning Outcomes:**

CLO 1	Understand electrical current, potential difference, power and energy, sources of electrical energy and elements of electrical circuit.
CLO 2	Illustrate about various types of systems, classify them, analyze them and understand their response behavior.
CLO 3	Carry simulation on signals and systems for observing effects of applying various properties and operations.
CLO 4	Create a strong foundation of communication and biomedical signal processing to be studied in the subsequent semester.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. List of experiments:

Sr. NO.	Experiment List
1	Introduction to MATLAB as a tool for signal processing.
2	Identify the nature of signals with their amplitude and phase.
3	To Generate the Following Waveforms Using MATLAB In Continuous And Discrete Time. 1) Sine 2) Cosine 3) Square 4) Saw-Tooth Wave.
4	To Generate the Following Waveforms Using MATLAB In Continuous and Discrete Time. 1) Unit Step 2) Unit Impulse 3) Unit Ramp 4) Exponential
5	Write a program in MATLAB to study the basic operations on the Discrete-time signals.
6	Implementation of Nyquist Criteria Using Sampling Theorem.
7	To Perform Linear Convolution of Two Discrete Time Sequences.
8	To Write A MATLAB Program to Plot Magnitude Response and Phase Response of Digital Butterworth Low Pass & High Pass Filter.
9	To Write A MATLAB Program to Plot Magnitude Response and Phase Response Of Digital Butterworth Band Pass & Band Stop Filter.
10	To Perform Z-Transform from Poles and zeros of a given system.

3	-	-	3	20	20	-	60	-	100
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L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage (%)	Teaching Hours
1	Introduction to 8051 Microcontroller: Microprocessor Vs. Microcontroller, 8051 Architecture Registers, Microcontrollers and embedded processors, Overview of 8051 family Architecture of 8051, 8051 Memory organization, Registers, Special Function Registers (SFRs), Program Status Word (PSW), Program counter & ROM space in 8051.	10%	5
2	8051 Instruction Set: Addressing Modes, Data Transfer Instructions, Arithmetic instructions, Logical instructions, Branch instructions, Bit manipulation instructions. Simple Assembly language program examples (without loops) to use these instructions.	15%	7
3	8051 Stack, I/O Port Interfacing and Programming: 8051 Stack, Stack and Subroutine instructions. Assembly language program examples on subroutine and involving loops. Interfacing simple switch and LED to I/O ports to switch on/off LED with respect to switch status.	20%	7
4	8051 Timers and Serial Port: 8051 Timers and Counters-Operation and Assembly language programming to generate a pulse using Mode-1 and a square wave using Mode-2 on a port pin. 8051 Serial Communication Basics of Serial Data Communication, RS232 standard, 9 pin RS232 signals, Simple Serial Port programming in Assembly and C to transmit a message and to receive data serially.	15%	10
5	8051 Interrupts and Interfacing Applications: 8051 Interrupts. 8051 Assembly language programming to generate an external interrupt using a switch, 8051 C Programming to generate a square waveform on a port pin using a Timer interrupt. Interfacing with 8051- LCD system – 4x4 keyboard – ADC and DAC – Stepper motor – DC motor – Water Level Indicator – Temperature control and their 8051 Assembly language interfacing programming.	40%	16
Total:		100 %	45

i. Text Book and Reference Book:

1. "8051 Microcontroller & Embedded system using assembly & C" by Muhammad Mazidi.
2. "8051 microcontroller & Embedded system using assembly & C" by K J Ayala.
3. "Programming and Customizing the 8051 Microcontroller" by Myke Predko. "The 8051 Microcontrollers, Architecture and programming and Applications" by K.Uma Rao, Andhe Pallavi.

-	-	2	1	-	-	20	-	30	50
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L- Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

a. List of Experiments:

Sr. NO.	Experiment List
1	Programming 8051 Micro controller using ASM and C, and implementation in flash 8051 microcontroller.
2	Programming with Arithmetic logic instructions [Assembly].
3	Program using constructs (Sorting an array) [Assembly].
4	Programming using Ports [Assembly and C].
5	Delay generation using Timer [Assembly and C].
6	Programming Interrupts [Assembly and C].
7	Implementation of standard UART communication (using hyper terminal) [Assembly and C].
8	Interfacing LCD Display. [Assembly and C].
9	Interfacing with Keypad [Assembly and C].
10	Programming ADC/DAC [Assembly and C].
11	Interfacing with stepper motor. [Assembly and C].
12	Pulse Width Modulation. [Assembly and C] Programming ARM Micro controller using ASM and C using simulator
13	Programming with Arithmetic logic instructions [Assembly].

- a. **Course Name:** Embedded System
- b. **Course Code:** 03011104PE03
- c. **Prerequisite:** Digital Electronics fundamentals, Microprocessors (8085), Micro controller (8051) and Basic knowledge of high-level languages like C
- d. **Rationale:** Course provides the concept of Embedded System Design using AVR Micro controllers, programming skills and various protocols. This subject covers sufficient knowledge in all aspects to design Small Scale Embedded Systems.
- e. **Course Learning Objective:**

CLOBJ 1	Understand the architecture and functioning of microcontrollers, including their memory, I/O ports, and instruction set.
CLOBJ 2	Acquire proficiency in programming microcontrollers using assembly language and high-level languages for embedded systems.
CLOBJ 3	Design and implement interfaces between microcontrollers and external devices, sensors, and actuators for practical applications.
CLOBJ 4	Apply microcontroller programming skills to develop real-time control systems for monitoring and regulating external processes.
CLOBJ 5	Investigate and apply communication protocols, such as UART and SPI, for data exchange between microcontrollers and external devices.
CLOBJ 6	Develop skills to troubleshoot and debug microcontroller-based systems, ensuring efficient and reliable operation in various applications.

f. **Course Learning Outcomes:**

CLO 1	Demonstrate a comprehensive understanding of microcontroller architecture and proficiently program in assembly language and high-level languages for embedded systems.
CLO 2	Design and implement effective interfaces between microcontrollers and external devices, sensors, and actuators for diverse applications.
CLO 3	Apply microcontroller programming skills to develop real-time control systems, showcasing the ability to monitor and regulate external processes.
CLO 4	Investigate, select, and apply communication protocols, such as UART and SPI, for efficient data exchange between microcontrollers and external devices.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<p>Introduction Embedded system and general-purpose computers, Embedded system components, Embedded System Design Process, Classification of an embedded system, Examples of an embedded system, and Applications of an embedded system.</p>	10%	4
2	<p>Overview of AVR and Related Software Introduction to AVR Studio 6, Introduction to BASSCOM, Introduction to AVR IDE/WINAVR, Overview of AVR family, AVR microcontroller architecture, Register, AVR status register, ROM space and other hardware modules, ATmega32 pin configuration & function of each pin, addressing modes of AVR, overview of instruction set of AVR.</p>	20%	8
3	<p>AVR Interfacing with peripherals and programming in C Data types, I/O programming, logic operations, Intel HEX file, Timer programming in Interrupt programming in C, Serial Port programming in C, LCD and Keyboard Interfacing, ADC, DAC and sensor interfacing, Stepper Motor Interfacing, PWM programming and DC motor control, SPI protocol and Display interfacing, I2C Protocol and RTC interfacing.</p>	30%	17
4	<p>Inter process Communication and Synchronization of processes, Thread and Task Multiple process and thread in application, Task and Task state, Task control block, Task coding, Task scheduling, Semaphores, Semaphores for synchronization, Data sharing and deadlocks, Inter process communication, Sockets and remote procedure call.</p>	20%	8
5	<p>RTOS Operating system service, Process management, Timer and Event function, Memory management, Device, File and I/O subsystem management, Interrupt routine in RTOS environment and handling of interrupt service calls, Basic design using RTOS, RTOS task scheduling models, Interrupt latency and response of tasks as performance metrics, OS security issue.</p>	20%	8

Total:	100 %	45
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i. Text Book and Reference Book:

1. Embedded Systems, Architecture, Programming and Design (Textbook), By Raj Kamal; TMH
2. The AVR Microcontroller and Embedded Systems Using Assembly and C, By Muhammad Ali Mazidi, Sarmad Naimi and Sepehr Naimi, Pearson Education
3. Introduction to Embedded Systems, By K. Shibu; TMH Edition.
4. Programming and Customizing the AVR Microcontroller, By Dhananjay Gadre; McGraw Hill Education.
5. AVR ATmega32 data sheet

- a. **Course Name:** Embedded System Lab
- b. **Course Code:** 03011104PE04
- c. **Prerequisite:** Digital Electronics fundamentals, Microprocessors (8085), Microcontroller (8051) and Basic knowledge of high-level languages like C.
- d. **Rationale:** Course provides the concept of Embedded System Design using AVR Microcontrollers, programming skills and various protocols. This subject covers sufficient knowledge in all aspects to design Small Scale Embedded Systems.
- e. **Course Learning Objective:**

CLOBJ 1	Understand the architecture and functioning of microcontrollers, including their memory, I/O ports, and instruction set.
CLOBJ 2	Acquire proficiency in programming microcontrollers using assembly language and high-level languages for embedded systems.
CLOBJ 3	Design and implement interfaces between microcontrollers and external devices, sensors, and actuators for practical applications.
CLOBJ 4	Apply microcontroller programming skills to develop real-time control systems for monitoring and regulating external processes.
CLOBJ 5	Investigate and apply communication protocols, such as UART and SPI, for data exchange between microcontrollers and external devices.
CLOBJ 6	Develop skills to troubleshoot and debug microcontroller-based systems, ensuring efficient and reliable operation in various applications.

f. Course Learning Outcomes:

CLO 1	Demonstrate a comprehensive understanding of microcontroller architecture and proficiently program in assembly language and high-level languages for embedded systems.
CLO 2	Design and implement effective interfaces between microcontrollers and external devices, sensors, and actuators for diverse applications.
CLO 3	Apply microcontroller programming skills to develop real-time control systems, showcasing the ability to monitor and regulate external processes.
CLO 4	Investigate, select, and apply communication protocols, such as UART and SPI, for efficient data exchange between microcontrollers and external devices.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50

L- Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

h. List of Experiments:

Sr. NO.	Experiment List
1	Familiarization with AVR simulator and trainer kit.
2	Assembly Code: Transfer, Arithmetic and Logical.
3	Assembly Code: Branch and Bitwise.
4	Assembly and Embedded C: Chip peripherals.
5	Installation of Arduino software and write program for blinking LED.
6	Read Push-button switch and display its status on LED using Arduino.
7	Interfacing Buzzer with AVR Board.
8	Serial Communication using AVR Board.
9	Interfacing of LED using AVR Board.
10	Interfacing 7-Segment LED Display with AVR Board.
11	Interfacing of 16x2 LCD with AVR board.
12	Interface 4x4 matrix keyboard with AVR microcontroller.
13	Read analogue voltage using AVR board.
14	Interfacing of Real Time Clock DS1307.
15	Interface DC Motor with AVR Microcontroller.

- a. **Course Name:** Bioinformatics
- b. **Course Code:** 03011104PE05
- c. **Prerequisite:** Basic knowledge of Biochemistry and computers is required.
- d. **Rationale:** Study of Bioinformatics is helpful to the Biomedical Engineers to understand Bioinformatics, data base management in biotechnology and DNA mapping and sequencing.
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with Basics of Bioinformatics.
CLOBJ 2	Solve problems related to Fundamentals Information theory for biomedical applications.
CLOBJ 3	Acquire knowledge of the DNA mapping.
CLOBJ 4	Understand DNA sequencing.

f. **Course Learning Outcomes:**

CLO 1	Interpret Basics of Bioinformatics
CLO 2	Interpret Fundamentals Information theory for biomedical applications.
CLO 3	Interpret DNA mapping
CLO 4	Interpret DNA sequencing

g. **Teaching & Examination Scheme: -**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. **Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	Introduction to Bioinformatics Bioinformatics and its relation with molecular biology. Examples of related tools (FASTA, BLAST), databases (GENBANK, PubMed, PDB) and software (RASMOL, Ligand Explorer).	20%	9

2	Data generation Generation of large-scale molecular biology data. (Through Genome sequencing, Protein sequencing, Gel electrophoresis, NMR Spectroscopy, X-Ray Diffraction, and microarray). Applications of Bioinformatics.	20%	9
3	Biological Database and its Types Introduction to data types and Source. Population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Protein databases (Primary, Composite, and Secondary). Specialized Genome databases:(SGD, TIGR) Structure databases (CATH, SCOP, and PDBsum)	20%	9
4	Data storage and retrieval Flat files, relational, object-oriented databases and controlled vocabularies. File Format (Genbank, DDBJ, FASTA, PDB, Swiss rot).	20%	9
5	Sequence Alignments and Visualization Introduction to Sequences, alignments and Dynamic Programming; Local alignment and Global alignment (algorithm and example), Pairwise alignment (BLAST and FASTA Algorithm) and multiple sequence alignment (Clustal Walgorithm).	20%	9
Total:		100 %	45

i. Text Book and Reference Book:

1. Bioinformatics sequence and genome analysis (TextBook) , By DAVID W MOUNT; Cold spring harbor laboratory press
2. Bioinformatics- Concepts, Skills, and Applications) , By S.C. Rastogi; CBS
3. Basic Bioinformatics , By S. Ignacimuthu; Narosa Publishing House.
4. "Introduction to Bioinformatics" by Arthur M. Lesk.
5. "Bioinformatics and Functional Genomics" by Jonathan Pevsner.

- a. **Course Name:** Bioinformatics Lab
- b. **Course Code:** 03011104PE06
- c. **Prerequisite:** Basic knowledge of Biochemistry and computers is required.
- d. **Rationale:** Study of Bioinformatics is helpful to the Biomedical Engineers to understand Bioinformatics, data base management in biotechnology and DNA mapping and sequencing.
- e. **Course Learning Objective:**

CLOBJ 1	Gain familiarity with Basics of Bioinformatics.
CLOBJ 2	Solve problems related to Fundamentals Information theory for biomedical applications.
CLOBJ 3	Acquire knowledge of the DNA mapping.
CLOBJ 4	Understand DNA sequencing.

f. **Course Learning Outcomes:**

CLO 1	Interpret Basics of Bioinformatics.
CLO 2	Interpret Fundamentals Information theory for biomedical applications.
CLO 3	Interpret DNA mapping.
CLO 4	Interpret DNA sequencing

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. **List of Experiments:**

Sr. No.	Experiment List
1	To view and use the various biological databases available on the World Wide Web with Reference to Expsy.
2	To view and use the various biological databases available on the World Wide Web with Reference to NCBI.
3	To browse Genomic databases using MapViewer & ensembl, viewing genetic, linkage maps for human and other model organisms.

4	To retrieve the sequence of the Human keratin protein from UniProt database and to interpret the results.
5	To retrieve the gene sequence in FASTA format corresponding to P00519.
6	To retrieve any one FASTA sequence of GABA transaminase in Human, mouse, pig and chick.
7	To determine the Secondary structure of P68871 AND P24071.
8	To determine the conserved domain present in Q8NFM4.
9	To find the gene sequences of Mouse origin similar to U80226.1.
10	To retrieve the sequence of the Human keratin protein from GenBank database and to interpret the results.
11	To retrieve the structure of a protein and viewing it in RASMOL viewer.
12	To align more than two sequences and find out the similarity between those sequences.
13	To study the phylogenic relationships of nucleotide and protein sequence(s) by using PHYLIP Package.
14	To model a protein sequence using Swiss model.
15	To perform the local alignment between the given sequences using any two variants of BLOSUM.

- a. **Course Name** Circuits and Networks
- b. **Course Code:** 03011104PE07
- c. **Prerequisite:** Basic understanding of mathematics, including linear algebra, differential equations, and complex numbers, for network and frequency analysis.
- d. **Rationale:** This course provides students with a comprehensive understanding of electrical circuits and network analysis, including basic concepts of node and mesh analysis, graph theory, and network theorems. It equips learners with the skills to apply Laplace transforms, Fourier analysis, and frequency-domain techniques to solve both DC and AC network problems. The course also covers network function synthesis, two-port networks, and filter design, enabling students to analyze transient and steady-state behavior, understand resonance, and characterize system responses.
- e. **Course Learning Objective:**

CLOBJ 1	Understand the fundamental concepts of electrical circuits and network elements.
CLOBJ 2	Apply circuit laws and network theorems to analyze DC and AC circuits.
CLOBJ 3	Analyze the transient and steady-state behavior of RL, RC, and RLC circuits.
CLOBJ 4	Develop problem-solving skills for modeling and analyzing electrical networks in engineering applications.

f. **Course Learning Outcomes:**

CLO 1	Apply basic circuit laws, node and mesh analysis, and network matrices to solve DC and AC circuits with voltage/current sources and coupled components.
CLO 2	Analyze networks using graph theory methods and apply Thevenin, Norton, Superposition, Maximum Power Transfer, and Tellegen's theorems for circuit simplification.
CLO 3	Use Laplace transform and Fourier analysis to study transient and steady-state responses of RC, RL, RLC, and three-phase circuits.
CLO 4	Characterize LTI two-port networks, determine transfer functions, poles and zeros, and analyze interconnections, symmetry, and reciprocity.
CLO 5	Analyze and design series/parallel resonant circuits and basic low-pass, high-pass, band-pass, and band-reject filters for desired frequency response.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				T	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. Course Content:

Sr. No.	Content		Teaching Hours
1	Basic Concepts: Node and mesh analysis, matrix approach of network containing voltage and current sources, and reactance, source transformation and duality, coupled Circuit Analysis: dot convention.	15%	07
2	Graph Theory: Graph of a network, definitions, tree, Co-tree, link, basic loop and basic cut set, Incidence matrix, Cut set matrix, Tie set matrix, Duality, Loop and Nodal methods of analyses.	10%	04
3	Network Theorems: Network theorems: Superposition, reciprocity, Thevenin's, Norton's, Maximum power Transfer, compensation and Tallegen's theorem as applied to AC. circuits.	15%	07
4	Laplace Transform and network analysis: Laplace transforms and properties: Partial fractions, singularity functions, waveform synthesis, analysis of RC, RL, and RLC networks with and without initial conditions with Laplace transforms evaluation of initial conditions.	15%	7
5	The Frequency domain Fourier analysis: Trigonometric and exponential Fourier series: Discrete spectra and symmetry of waveform, steady state response of a network to non-sinusoidal periodic inputs, power factor, effective values, Fourier transform and continuous spectra, three phase unbalanced circuit and power calculation.	15%	07
6	Network Function Synthesis and Two port Networks: Transient behavior, concept of complex frequency, Driving points and transfer functions poles and zeros of immittance function, their properties, sinusoidal response from pole-zero locations, convolution theorem, Characterization of LTI two port networks; Z, Y, ABCD, g and h parameters, Reciprocity and symmetry, Inter-relationships between the parameters, Interconnections of two port networks.	20%	09
7	Filters: Behaviors of series and parallel resonant circuits, Introduction to band pass, low pass, high pass and band reject filters.	10%	04
Total:		100 %	15

i. Reference Books:

1. Network Analysis
By M. E. Van Valkenburg | PHI Learning
2. Circuit Theory
By Chakrabarti | Dhanpat Rai & Co.
3. Networks and Systems
D. Roy Choudhary | Wiley Eastern Ltd

4. Engineering Circuit Analysis

By W H Hayt, S M Durbin | Tata McGraw-Hill Education

5. Engineering circuit analysis with PSPICE and probe

By Roger | Prentice Hall

- a. **Course Name** Circuits and Networks Laboratory
- b. **Course Code:** 03011104PE08
- c. **Prerequisite:** Students should have basic knowledge of electrical concepts such as voltage, current, resistance, Ohm's law, and power. They should also understand electrical components like resistors, capacitors, inductors, diodes, and transistors. Additionally, students should know how to use common lab instruments such as multimeters, oscilloscopes, function generators, and power supplies..
- d. **Rationale:** This laboratory provides students to apply theoretical knowledge in practical experiments, develop skills in using electrical instruments, and accurately measure circuit parameters. It helps them understand real-world effects such as component tolerances and signal variations, and prepares them for advanced courses and practical applications in circuit design, analysis, and troubleshooting.
- e. **Course Learning Objective:**

CLOBJ 1	Understand the fundamental concepts of electrical circuits and network elements.
CLOBJ 2	Apply circuit laws and network theorems to analyze DC and AC circuits.
CLOBJ 3	Analyze the transient and steady-state behavior of RL, RC, and RLC circuits.
CLOBJ 4	Develop problem-solving skills for modeling and analyzing electrical networks in engineering applications.

f. **Course Learning Outcomes:**

CLO 1	Apply KVL and KCL to verify loop and nodal analysis in electrical circuits.
CLO 2	Demonstrate and verify network theorems, including superposition, Thevenin's, maximum power transfer, and reciprocity theorems.
CLO 3	Analyze transient responses of RC, RL, and RLC circuits and determine time constants and step responses.
CLO 4	Determine two-port network parameters (Z-parameters and Y-parameters) experimentally.
CLO 5	Design and test passive filters (low-pass, high-pass, and band-pass) and verify their frequency response.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				T	CE	P	Theory	P	
0	0	2	1	0	0	20	0	30	50

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

h. List of Experiments:

Sr. No.	Experiment List
1	To Verify Loop Analysis and Nodal Analysis using KVL and KCL.
2	To verify superposition theorem.
3	To verify Thevenin's theorem.
4	To verify maximum power transfer theorem.
5	To verify reciprocity theorem.
6	To measure and calculate RC and RL time constant for a given RC circuit.
7	To measure and analyze step response of for a given series RLC circuit.
8	To measure and calculate Z-parameters for a given two-port system.
9	To measure and calculate Y-parameters for a given two-port system.
10	To Design Passive Low Pass filter and verify the Frequency Response.
11	To Design Passive High Pass filter and verify the Frequency Response.
12	To Design Passive Band Pass filter and verify the Frequency Response.