

**DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
KURUKSHETRA-136119**



SCHEME AND SYLLABI

OF

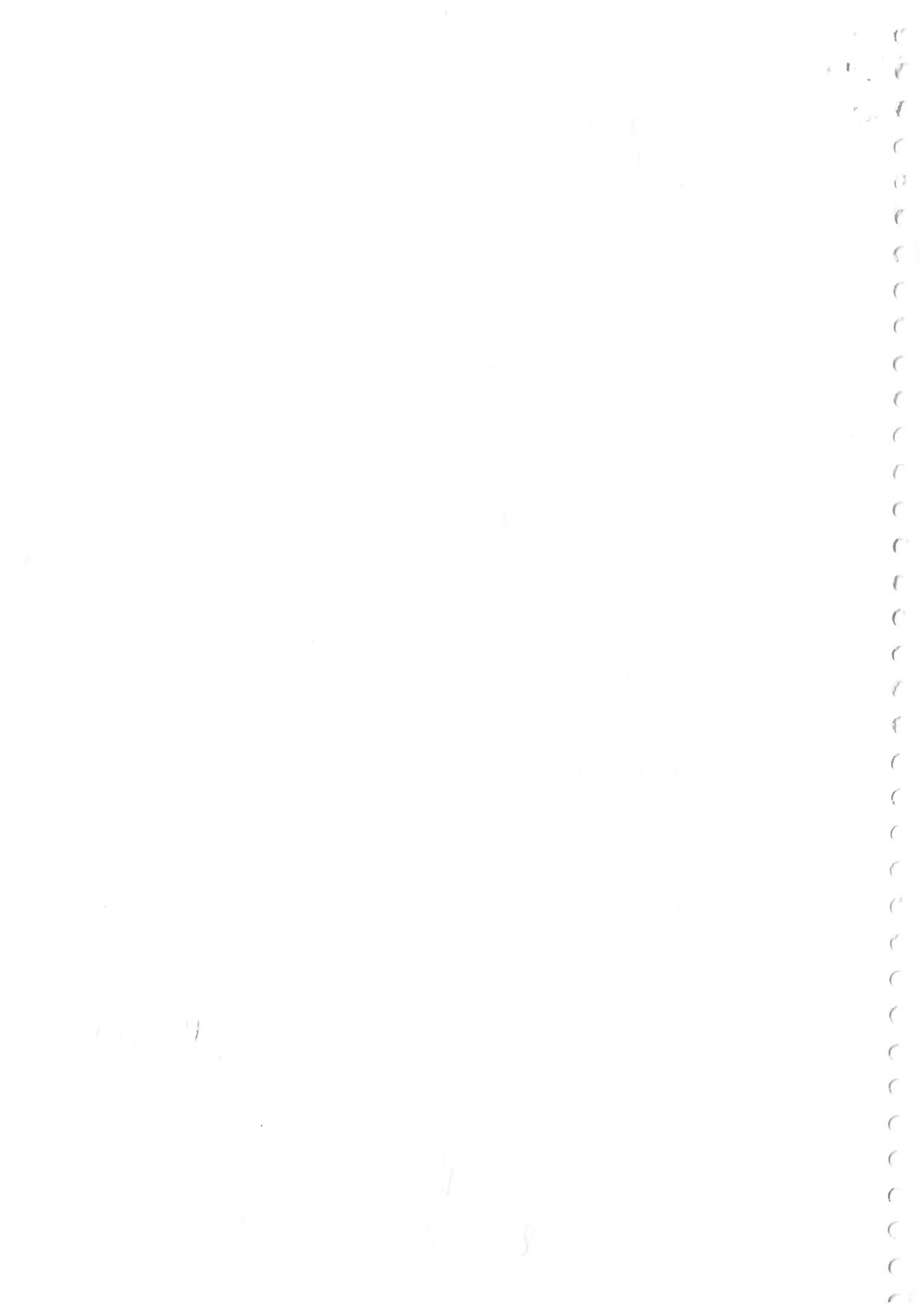
B. TECH. (ROBOTICS & AUTOMATION)

4TH SEMESTER

(FOR STUDENTS ADMITTED IN ACADEMIC YEAR 2024-25)

Yash 4/3/2025

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SCHEME OF EXAMINATION
B. Tech. Robotics & Automation 4th Semester

CODE	COURSE	L	T	P	Credits
MAIC 204	Applied Linear Algebra	3	0	0	3
RAPC208	Control System	3	0	0	3
RAPC209	Analog Electronics	3	0	0	3
RAPC210	Actuators, Drives and Sensors	3	0	0	3
RAPC211	Introduction to Robotics	3	0	0	3
RAPC212	Manufacturing Processes	3	0	0	3
RAPC213	Control System (P)	0	0	2	1
RAPC214	Analog Electronics (P)	0	0	2	1
RAPC215	Actuators, Drives and Sensors (P)	0	0	2	1
SWNC101	NCC/Sports/Yoga	0	0	2	1*
SWNC102	NSS/Clubs/Technical Societies	0	0	2	1*
Total Credits					21
A student will undergo internship/project/industrial training of 4-6 weeks during summer vacations					

* Continuous Evaluation Model as per guidelines and the credit to be awarded at the end of 6th Semester based on Cumulative performance up to 6th Semester

4/3/25

Course Code	Applied Linear Algebra	L - T - P -
MAIC 204	(For ECE & IIOT)	3 - 0 - 0 - 3

Pre-Requisites: MAIC 102 Course Objective:

1. To introduce the application of linear algebra and matrices in the different branches of mathematics.
2. To introduce theoretical aspects of linear algebra required for recent evolving branches like machine learning and data analysis.
3. Extensively introduce students with generalized inverse, QR de-composition and SVD.
4. Introduces Perron–Frobenius theorem, Quadratic form. Sylvester inertia theorem, Linear functional, Bilinear mapping.

Unit 1:

9L

Vector spaces, Bases and dimensions, Sums and direct sums, Quo-tient spaces.

Unit 2:

9L

Linear transformations, Kernel and Image of a linear transformation, Rank-nullity theorem, Representation of linear transformations by matrices, Change of bases for linear transformations, Bases-change Matrices, Orthonormal bases, Gram-Schmidt process.

Unit 3:

9L

Invariant subspaces, Cayley-Hamilton theorem, Minimal polynomial, Adjoint operators (matrix), Normal, unitary, and self-adjoint operators (matrix), Schur's Lemma, Spectral theorem for normal operators (matrix) (Unitary diagonalization, and triangulation of a matrix), Direct-sum decomposition, Cyclic subspaces, and Annihilators, Rational and Jordan canonical forms, LU and Cholesky decomposition, Householder's Reflection, QR and Polar Decomposition.

Unit 4:

9L

Tridiagonal Matrix, Strum's Sequence, Projection Matrix, Singular value decomposition, Generalized inverse of the matrix, Perron–Frobenius theorem, Quadratic form. Sylvester inertia theorem, Linear functional, Bilinear mapping and inner product spaces.

Text Books:

1. K. Hoffman and R. A. Kunze, Linear Algebra, Prentice Hall of India.
2. H. Dym, Linear algebra in Action (Graduate studies in Mathematics, American Mathematical Society.

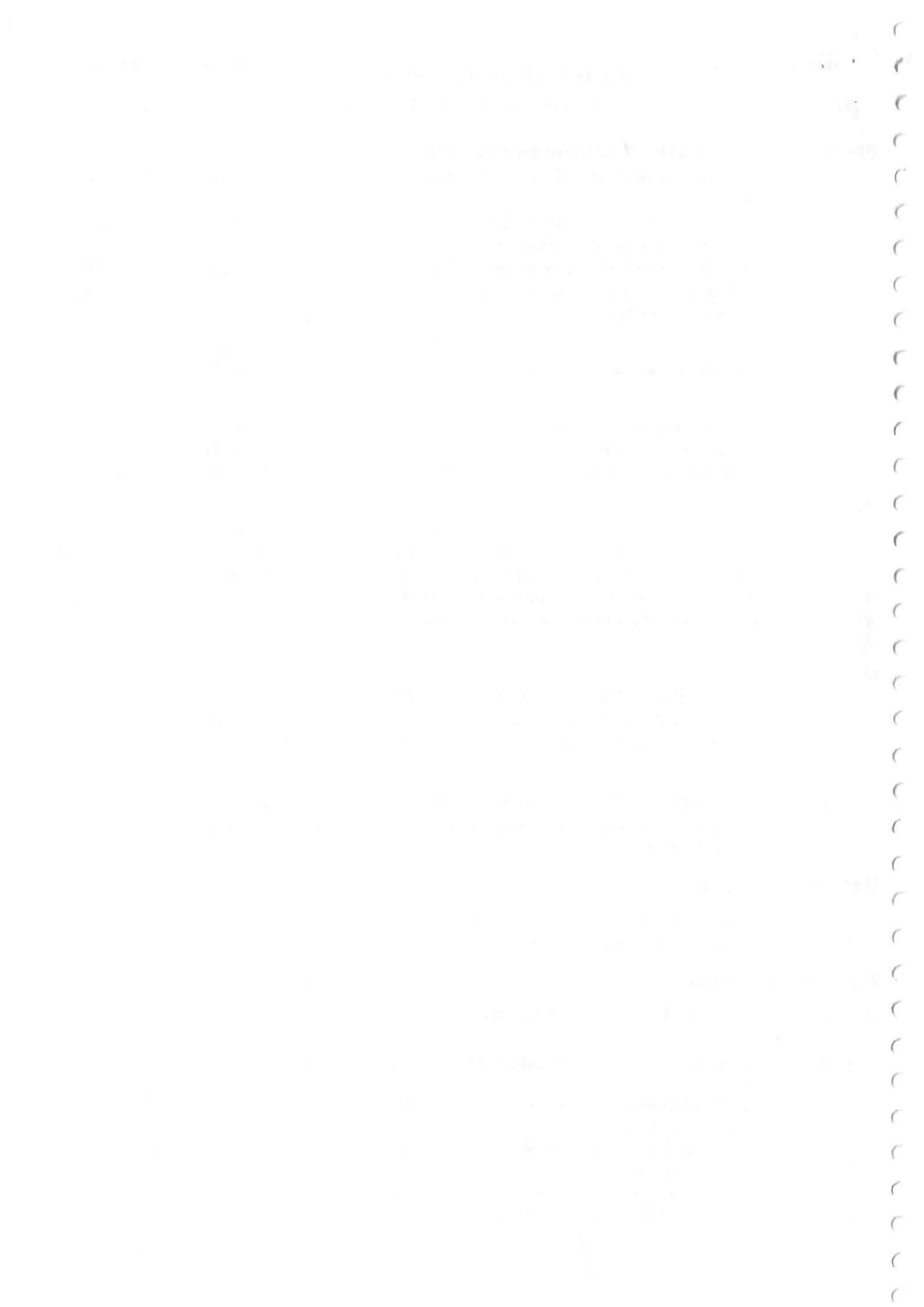
Reference Books:

1. R A Horn, C R Johnson, Matrix Analysis, Cambridge.
2. J H Kwak, S Hong, Linear Algebra, Birkhauser.

Course Outcomes:

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

CO1	Understand the basic concepts of linear algebra related to stability, accuracy, etc.
CO2	Find QR factorization of a matrix using Householder transformation and study its applications.
CO3	Write various algorithms to solve system of linear equations to understand computational issues.
CO4	Describe the numerical procedure of eigenvalue problem.
CO5	Apply the SVD of a matrix in solving real life problems.



Course Code	RAPC208
Course Title	CONTROL SYSTEMS
Number of Credits	3
Prerequisites (Course code)	
Course Type	PC

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief description:

This course aims to provide fundamental concepts of control system problems and their solution possibilities, mathematical modeling of the various physical systems, analysis of the systems in time and frequency domain, stability analysis, controller and compensator design specifications.

UNIT - I

Basics of control system: control systems elements, concept of open-loop and closed-loop systems with applications.

Mathematical modeling: electrical systems, mechanical systems, electro-mechanical systems, pneumatic and thermal systems, electrical analogues of dynamical systems.

Model simplification using block diagram reduction and signal flow methods, sensitivity analysis.

Control system components: concept of AC & DC servomotor, synchro, stepper motor and tachometer, etc. **(10hrs)**

UNIT-II

Time domain analysis: transient response analysis, first order systems, initial condition response, time response specifications of second order system for typical test signals.

Response of higher order systems: steady state error and error constants, dynamic error constants. Routh-Hurwitz Stability Criterion, System analysis and compensator design using Root-locus techniques. **(10hrs)**

UNIT-III

Frequency Domain Analysis: Sinusoidal transfer functions, Frequency response specifications, Polar plot, Nyquist plot, and Bode plot for stability analysis, Concept of gain margin & phase margin, relative stability, Nichols chart, M-N circle.

(10hrs)

UNIT-IV

Conventional Controller: Basic idea of feedback control systems, Concept of PID controller, Effect of P, PI, PD and PID controllers on system.

Case Studies and Numerical Simulations in MATLAB/SCILAB/LABVIEW, etc.

(10hrs)

Course outcomes:

On successful completion of the course, students will be able to

CO1: Fundamental knowledge of control system, mathematical modeling of various physical systems

CO2: Determine the response of systems for various inputs, and transient and steady-state analysis of open-loop and closed-loop systems

CO3: Analyze the stability of the linear systems in time-domain and frequency-domain

CO4: Design and implementation of PID controller and various compensators

Text Books:

1. Richard C. Dorf, Robert H. Bishop, "Modern Control Systems", Pearson, 13th Edition, 2016.
2. Kuo B.C., Automatic Control Systems, Prentice-Hall of India Pvt. Ltd., New Delhi, 6th Edition, 1991.
3. Ogata K., Modern Control Engineering, Prentice-Hall of India Pvt Ltd., New Delhi, 3rd edition, 2000.
4. M. Gopal, "Control System Principles and Design", McGraw Hill, 4th Edition, 2012.
5. William J. Palm III, Control Systems Engineering, John Wiley & Sons Inc., 198
6. Joseph J. Distefano III, Allen R. Stubberud, Ivan J. Williams, "Control Systems", 3rd Edition, McGraw Hill, Special Indian Edition, 2010. (Schaums Outlines Series)
7. J. Nagrath & M. Gopal, "Control System Engineering", 6th Ed. New Age International Publishers, 4th Edition 2018.
8. Norman S. Nise, "Control Systems Engineering", 5th Ed., Wiley, 2009.

Course Code	RAPC209
Course Title	ANALOG ELECTRONICS
Number of Credits	3
Prerequisites (Course code)	
Course Type	PC

L	T	P	Credit s	Total contact hours
3	0	0	3	40

Course objective:

The aim of this course is to familiarize the student with the analysis and design of basic transistor amplifier circuits, oscillators and wave shaping circuits.

UNIT - I

Amplifier models and AC Analysis: Voltage amplifier, current amplifier, trans-conductance amplifier and trans-resistance amplifier. Biasing schemes for BJT and FET amplifiers, bias stability, various configurations (such as CE/CS, CB/CG, CC/CD) and their features, small signal analysis, low frequency transistor models, estimation of voltage gain, input resistance, output resistance etc., design procedure for particular specifications, low frequency analysis of multistage amplifiers.

(10hrs)

UNIT-II

Multistage Amplifiers & Power Amplifiers: High frequency transistor models, frequency response of single stage and multistage amplifiers, cascode amplifier. Various classes of operation (Class A, B, AB, C etc.), Comparison of their power efficiency, types of distortion and linearity issues. Voltage regulators: Discrete transistor voltage regulation - Series and Shunt Voltage regulators

(10hrs)

UNIT-III

Op-Amp and its applications: Differential amplifier basic structure and principle of operation, calculation of differential gain, common mode gain, CMRR and ICMR. OP-AMP design for a given specification. OPAMP applications: review of inverting and non-inverting amplifiers, integrator and differentiator, summing amplifier, precision rectifier, Schmitt trigger and its applications. Feedback concepts, types, Practical feedback circuits, the transfer gain, General characteristics of negative-feedback amplifiers, Input resistance, Output resistance, Feedback topologies: Voltage series, current series, voltage shunt, current shunt, effect of feedback on gain, bandwidth etc.

(10hrs)

UNIT-IV

Oscillators & Wave shaping circuits: Oscillators basic concept, Barkhausen criterion, RC oscillators (phase shift, Wien bridge etc.), LC oscillators (Hartley, Collpit, Clapp etc.), non-sinusoidal oscillators, Frequency Stability. Multi-vibrators (Astable, Mono-stable, Bi-Stable), High pass and low pass filters using R-C Circuits and R-L, R-L-C Circuits & their response to step input, Pulse input, Square input and Ramp Input, Attenuators. Active filters: Low pass, high pass, bandpass and bandstop, design guidelines. Digital-to-analog converters (DAC), Analog-to-digital converters (ADC). Case study: practical circuits of typical electronic systems.

(10hrs)

Course outcomes: After studying this course, students will be able to:

- CO1: Acquire knowledge of Single stage, cascaded and feedback amplifier configurations, Frequency response characteristics of BJT and FET.
- CO2: Analyse the performance of Op-AMP, Power Amplifiers and Oscillator circuits.
- CO3: Analyse various filters and multi-vibrators circuits.
- CO4: Apply the knowledge gained in the design of transistorized circuits, amplifiers and Oscillators.

Text Books:

1. Milliman, J. and Halkias, C.C., "Intergrated Electronics," McGraw Hill Education, 2nd Edition, ISBN: 9780070151420.
2. Milliman, J. and Taub, H., "Pulse, Digital and switching waveforms," McGraw Hill Education, 3rd Edition, ISBN: 9780071072724.
3. Robert L. Boylestad and Louis Nashelsky, "Electronics devices and Circuit theory," Pearson, 11th Edition, ISBN: 9789332542600

Course Code	RAPC210
Course Title	ACTUATORS DRIVES AND SENSORS
Number of Credits	3
Prerequisites (Course code)	INTRODUCTION TO AUTOMATION
Course Type	PC

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief description about the course:

This course covers the fundamental concepts and principles of actuators, sensors, and drives used in robotics and automation systems. Students will learn about various types of actuators, sensors, and drives, their characteristics, and applications. The course will also cover the interfacing and control of these devices.

UNIT - I

Introduction to Actuators, Drives and Sensors

Overview of actuators, sensors, and drives, types of actuators; electrical, hydraulic, pneumatic, and mechanical actuation systems, types of sensors; position, velocity, acceleration, force, and torque, smart actuation systems, AI powered drives, IOT-enabled systems, role of actuation, drives, and sensors in automation.

(6 hrs)

UNIT-II

Pneumatic and Hydraulic Actuators

Introduction to Pneumatic and Hydraulic Actuation Systems, Key components, Comparison between pneumatic and hydraulic systems, Control valves, Components and working of pneumatic actuators, Rotary pneumatic actuators, Components and working of hydraulic actuators and Application of pneumatic and hydraulic actuators.

Mechanical Actuation Systems

Introduction to Mechanical Actuation Systems, Role and importance of mechanical actuation in engineering systems, Types of mechanical actuation mechanisms, Kinematics chains, Cams, gear trains, belt and chain drives, bearings, mechanical aspects of motor selection, Applications of mechanical actuation systems.

(12hrs)

UNIT-III

Sensors

Definition and Role of Sensors and Transducers, Characteristics of sensors, Types of Sensors and Transducers; Displacement, Position, and Proximity Sensors, Velocity and Acceleration Sensors, Accelerometers Force and Pressure Sensors, Strain Gauges, Piezoelectric Transducers, Temperature Sensors, and Specialized Sensors.

Signal Conditioning and Signal Conversion

Overview of Signal Conditioning, Signal Conditioning Techniques, Signal Amplification, Filtering, Noise Reduction Techniques, Isolation, Signal Conversion, Analog-to-Digital Conversion, Digital-to-Analog Conversion, and Data Acquisition Systems.

(12hrs)

UNIT-IV

Drives and Control

Overview of Drive systems: Continuous vs. Discrete drives, Types of drives; Servo drives, Stepper drives, Variable Frequency Drives, DC and AC Drives, Control Techniques in Drives; Open-Loop and Closed-Loop Systems, Role of Drives in Precision Control, Power electronic devices, DC-DC converters, DC-AC converters, and Motor control algorithms.

Industrial Automation

Applications in Industrial Automation; Robotic Arms, AGVs, and Conveyor Systems, Case Studies of Sensor-Driven Actuation in Robotics, Human-Robot Interaction; Actuation and Sensing for Collaboration and Safety, Emerging Trends: Smart Actuation Systems, AI Powered Drives, and IoT-Enabled Sensing.

(10 hrs)

Course Outcomes

1. Understand the functioning of various types of sensors, transducers and their applications.
2. Understand the concept of pneumatic, hydraulic and mechanical actuation systems.
3. Analyze and select appropriate actuators, sensors, and drives for robotic and automation systems.
4. Design and interface actuators, sensors, and drives with microcontrollers and computers.

Text Books:

1. D. Patranabis, "Sensors and Transducers", 2nd edition, PHI Learning Private Limited.
2. W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 4th edition, Pearson Education Limited.
3. Clarence W. de Silva, "Sensors and Actuators: Engineering System Instrumentation", 2nd edition, CRC Press

Course Code	RAPC211
Course Title	INTRODUCTION TO ROBOTICS
Number of Credits	3
Prerequisites (Course code)	
Course Type	PC

L	T	P	Credit s	Total contact hours
3	0	0	3	40

Brief Description about the course

This course will introduce the students to the fundamentals of robot design and hence, the learning objectives of this course are:

- To understand the basic concepts related to robot anatomy, classification and industrial applications of manipulators.
- To understand direct, inverse and differential kinematics of robot manipulator.
- To understand static and dynamic modeling of robot arm.
- To understand motion planning of robots.

To introduce the fundamentals of robot control involving actuator dynamics.

UNIT - I

Introduction to Robotics

Evolution of Robots and Robotics, Types of Automation, Robot anatomy, Classification of robots based on drive technologies, workspace geometry and motion, control systems; Robot specifications; Industrial applications of robots

Coordinate Frames, Mapping and Transforms

Coordinate Frames, Description of objects in space, Transformation of Vectors, Inverting a Homogeneous Transform, Fundamental Rotation matrices

(10 hrs)

UNIT-II

Direct Kinematic Model

Mechanical structure and notations, Kinematic modeling of the manipulator, Denavit-Hartenberg Notation, Manipulator Transformation Matrix.

The Inverse Kinematics

Manipulator workspace, solvability of Inverse kinematics model, solution techniques, closed form solution.

(10 hrs)

UNIT-III

Manipulator Differential Motion and Statics

Linear and angular velocity of a rigid body, relationship between transformation matrix and angular velocity, manipulator Jacobian, Jacobian Inverse, Jacobian Singularities, Static Analysis.

Dynamic Modeling

Lagrangian Mechanics, Two Degree of Freedom manipulator-Dynamic Model, Lagrange-Euler formulation Newton-Euler formulation, Inverse Dynamics.

(10 hrs)

UNIT-IV

Motion Planning

Joint space planning, Cartesian space planning, Path primitives, Cartesian trajectories, Point-to-Point vs. Continuous path planning

Control of Manipulators

linear control schemes, Actuator dynamics; Set point tracking: Performance of PID, controller.

Case Studies

For Microrobot Alpha-II and 5-axis Articulated Robot Rhino XR3, assign link frames and list kinematic parameters using D-H algorithm; formulate arm matrices and develop a computer code to simulate the end-effector motion for a given range of joint displacements; solve for joint displacements for a set of end-effector position and orientation; study the effect of link dimensions on end-effector trajectory; formulate the Jacobian and determine actuator torques for a given end-effector force vector.

(10 hrs)

Course Outcomes:

CO1: Understand the concept of Industrial Robotics and its applications

CO2: Understand the coordinate transformations between fixed and mobile frames and solve design problems involving direct, inverse and differential Kinematics

CO3: Formulate and solve static and dynamic models of Robot Arms.

CO4: Understand robot control actuator dynamics as well as evaluate the performance of PID controller for set point tracking.

Text Books:

1. Fundamental of Robotics by Robert J. Shilling Prentice Hall of India.
2. Introduction to Robotics by S. K. Saha, McGraw Hill Education (India) Pvt. Ltd.
3. Introduction to Robotics by Saeed B. Niku Pearson Education Asia.
4. Robot Modeling and kinematics by RachidManseur, Luxmi Publications.

Course Code	RAPC212
Course Title	MANUFACTURING PROCESSES
Number of Credits	3
Prerequisites (Course code)	Engineering Practice
Course Type	PC

L	T	P	Credit s	Total contact hours
3	0	0	3	40

Brief description about the course

This course will introduce students to the fundamental principles, techniques, and applications of various manufacturing processes used in modern industries. It provides a comprehensive understanding of how raw materials are transformed into finished products through different processes, highlighting the science, engineering, and economics behind manufacturing.

UNIT - I

Fundamentals of Material Science

Classification of materials, different type of material including metals, ceramics, polymers, and composites, Imperfections in solids, and diffusion mechanisms, Mechanical properties of materials, Material selection for engineering applications, Failure mechanisms, and Introduction to advanced materials.

(8hrs)

UNIT-II

Machining Processes

Overview of machining processes, Different machining operations; turning, drilling, milling, boring, and grinding, machining centres, and high-speed machining.

Metal Forming Processes

Overview of metal forming, material behaviour in metal forming, Introduction to cold/hot forming processes; rolling, forging, extrusion and drawing process, and Sheet metal forming process.

(8hrs)

UNIT-III

Joining and Assembly Processes

Overview of welding technology, weld joints, various joining processes; solid state welding, arc welding, resistance welding, gas welding, ultrasonic welding, electron beam welding, laser beam welding, and explosive welding, weld defects and inspection, mechanical assembly; threaded fasteners, rivets, and assembly methods based on interference fits.

Metal Casting

Introduction to metal casting, Patterns, cores and molds, Sand casting, Permanent mold casting; die casting, and centrifugal casting, Expandable mold casting; shell

molding, vacuum molding, and investment casting.

(8 hrs)

UNIT-IV

Powder Metallurgy

Introduction to Powder Metallurgy process, preparation of powders, types & function of binders, green compaction, sintering process, and application of powder metallurgy products.

Additive Manufacturing

Fundamental principles, advantages, and limitations of AM, Comparison to subtractive and formative manufacturing processes. Key AM techniques such as Material Extrusion, Powder Bed Fusion, Vat Photo-polymerization, Binder Jetting, and Laminated Object Manufacturing

(8hrs)

UNIT-V

Unconventional Machining

Introduction to unconventional machining processes, and classification, Ultra-Sonic Machining, Laser Beam Machining, Electric Discharge Machining, Electric discharge wire cutting, Electron Beam Machining, and Electrochemical Machining.

Unconventional Forming

Explosive forming, Electro hydraulic forming, Electromagnetic forming, Laser Bending, Powder rolling, Spray rolling, Hydro forming, Hydrostatic and Powder extrusion, rotary and isothermal forming.

(8 hrs)

Course Outcomes:

1. Learn the fundamentals of metal cutting, joining, metal forming, and powder metallurgy and metal casting.
2. Understand the working principles and applications of unconventional manufacturing processes.
3. Demonstrate knowledge of machining processes, including traditional and modern material removal techniques.
4. Gain insights into Additive Manufacturing (AM) technologies and their impact on modern manufacturing.

Text Books:

1. Mikell P. Groover, "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", seventh edition, Wile.
2. V.K.Jain, "Advanced Machining Processes", second edition, Allied Publisher.
3. Amitabha Ghosh and Asok Kumar Mallik "Manufacturing Science" second edition, East-West Press.

Course Code	RAPC213
Course Title	CONTROL SYSTEMS (Practical)
Number of Credits	1
Prerequisites (Course code)	
Course Type	PC

L	T	P	Credits	Total contact hours
		3	1	36

Brief description about the course

A "Control System Lab" course provides students with hands-on experience in designing, implementing, and analyzing systems by utilizing various hardware and software tools, allowing them to apply theoretical concepts learned in class to real-world scenarios, including building and testing control loops and controllers to regulate the behavior of a system, while gaining practical understanding of system stability, performance, and design techniques.

List of Experiments

1. Obtain the Step response of the 'First and Second order systems. Determine the time-domain specifications from their transfer functions.
2. Determine the characteristics of following Error Detectors for the control applications:
(i) LVDT, (ii) Potentiometer.
3. Obtain the response of 'P, PI, PD, PID and Relay' control actions on various processes:
(i) One time constant with and without delay,
(ii) Two time constant with and without delay
4. Study of a Thermal System and its temperature control:
(i) Find the transfer function of the Thermal System by obtaining open-loop time response.
(ii) Determine the closed-loop response by applying PID and Relay control actions;
(iii) Compare the obtained results.
5. Study the performance of:
(i) DC Motor position control.
6. (i) Obtain the speed-torque characteristics of AC servomotor.
(ii) Determine the speed control characteristics of DC motor with control parameter.
7. Design the Lag/Lead compensator of a given system. Obtain the frequency response and analyze.
8. For the given system (TF/SS), perform the simulation exercises in MATLAB environment and obtain the:
(i) Time-domain specifications,
(ii) Frequency-domain specifications,
(iii) Stability.

9. Study the performance of an Industrial Process for (i) Level control, and (ii) Flow control.

Course outcomes:

On successful completion of the course, students will be able to

- CO1: Determine the performance and time domain specifications of first order systems.
- CO2: Analyse various time domain and frequency domain techniques to assess the system performance.
- CO3: Study the system performance by selecting a suitable controller and/or a compensator for a specific application.
- CO4: Get the knowledge about the effect of poles and zeros location on transient and steady state behaviour of second order systems and can implement them to practical systems.
- CO5: Study of systems with the help of MATLAB software and study of some industrial processes.

Course Code	RAPC214
Course Title	ANALOG ELECTRONICS(PRACTICAL)
Number of Credits	1
Prerequisites (Course code)	
Course Type	PC

L	T	P	Credits	Total contact hours
		2	1	24

Brief description about the course:

The purpose of this course is to familiarize the students about the practical implementation of single and multistage amplifiers, oscillators and Op-Amp-based linear and non-linear circuits. The basic objective is to familiarize students with the working principle of single stage and multistage amplifiers and their frequency response, & to demonstrate students with the designing of basic current mirrors, differential amplifier and Op-amp using MOSFETs.

List of Experiments:

1. Study the characteristics of Transistor CB, CE characteristics (Input and Output).
2. Design a single stage RC Coupled Amplifier and plot its gain frequency response.
3. Design a double stage RC Coupled Amplifier and Plot its gain frequency response.
4. Design a RC phase shift oscillator using IC- 741.
5. Design a Wein Bridge oscillator using IC- 741.
6. Design a Voltage to Current Converter and Current to Voltage Converter using IC- 741.
7. To study various Wave Shaping circuits (clipper, clamper) using IC-741.
8. To design and test the performance of integrator and differentiator circuit using Op – Amp (IC-741).
9. To design first order Active Low Pass and High Pass filters using Op-Amp IC-741 for a given cut off frequency.
10. To design 4-bit R-2R ladder DAC using Op-Amp.

Course Outcomes:

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

- CO1: To Design & analyze a single stage, double stage for RC Coupled Amplifier and plot its gain frequency response.
- CO2: To Design & analyze oscillators using IC- 741.
- CO3: To Design & analyze various Wave Shaping circuits (clipper, clamper) using IC-741.
- CO4: To design and test the performance of integrator and differentiator circuit using Op– Amp (IC-741).
- CO5: To design first order Active Low Pass and High Pass filters using OP-Amp IC-741 for a given cut off frequency.

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Course Code	RAPC215
Course Title	ACTUATORS DRIVES AND SENSORS (Practical)
Number of Credits	1
Prerequisites (Course code)	
Course Type	PC

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description about the course

This course provides a comprehensive understanding of automation technologies, covering sensors, actuators, drive systems, and control techniques. Students will learn to implement real-time data acquisition, feedback control, and precision automation using microcontrollers and programmable logic controllers (PLCs). The course emphasizes hands-on experimentation, enabling students to work with proximity and distance sensors, stepper and servo drives, motor control algorithms, and real-time automation challenges.

List of Experiments

1. Performance analysis of proximity and distance sensors for object detection and range measurement.
2. Control of motors via various drive systems (servo, stepper, DC drives).
3. Real-time data acquisition and feedback control via microcontrollers (e.g., Arduino/ Raspberry Pi).
4. Develop a basic program and control logic to turn an LED on and off at regular intervals using Arduino/Raspberry Pi.
5. Achieve real time bed levelling using stepper motors and proximity sensors in a 3D printer.
6. Study the relationship between extrusion motor speed, temperature, and layer consistency in fused deposition modeling (FDM).
7. Study of single-acting and double-acting piston-cylinder mechanisms for a pneumatic system.
8. Study the working principle of an LVDT, and characterize the LVDT by determining; linear range, sensitivity, non-linearity and hysteresis.
9. Perform object detection and generate a 3D map of a scene using the depth data from the *Time of Flight (TOF)* sensor.
10. Implement a gesture recognition system using a TOF sensor to control a robotic arm.

Course Outcomes: Upon successful completion of the course, students will:

CO1: Analyze and compare the performance of various proximity and distance sensors for object detection and range measurement.

- CO2: Implement and control different drive systems, including servo, stepper, and DC motors.
- CO3: Develop real-time data acquisition and feedback control using microcontrollers such as Arduino and Raspberry Pi.
- CO4: Investigate the effect of extrusion speed, temperature, and layer consistency in FDM-based additive manufacturing.
- CO5: Understand and analyze pneumatic actuation systems, including single-acting and double-acting piston-cylinder mechanisms.
- CO6: Characterize the working principles of an LVDT sensor, determining key parameters such as sensitivity, linearity, and hysteresis.