Savitribai Phule Pune University, Pune

Maharashtra, India

सावित्रीबाई फुले पुणे विद्यापीठ

Faculty of Science and Technology

National Education Policy (NEP) -2020 Compliant Curriculum

Second Year Engineering (2024 Pattern) in

Robotics and Automation Engineering

(With effect from Academic Year 2025-26)

Preface by Board of Studies

Dear Students and Faculty Members,

We, the members of the Board of Studies in Production and Industrial Engineering, are pleased to present the revised syllabus for Second Year Robotics and Automation Engineering, effective from the Academic Year 2025–26. This curriculum will be progressively implemented for Third Year and Final Year in the academic years 2026–27 and 2027–28, respectively.

Robotics and Automation Engineering is an evolving interdisciplinary domain that brings together the principles of mechanical engineering, electronics, computer science, and control systems. It serves as the backbone for the design, development, and implementation of intelligent robotic systems and automated solutions across industries. This curriculum aims to provide students with a strong foundation in core concepts, emerging technologies, and practical applications, while preparing them for the dynamic landscape of Industry 4.0 and beyond.

The syllabus has been carefully aligned with the vision of the National Education Policy (NEP) 2020, and adheres to the guidelines of Savitribai Phule Pune University, AICTE, UGC, and leading accreditation bodies. It emphasizes innovation, multidisciplinary learning, and industry relevance to ensure students are well-equipped for the future.

This outcome-based curriculum has been developed through collaborative input from academic experts, industry professionals, and alumni. It not only addresses current industry needs but also nurtures the skills required for higher studies, research, and entrepreneurial ventures in the field of robotics and automation.

We are confident that this revised curriculum will empower students to emerge as technically sound, ethically responsible, and future-ready professionals, contributing meaningfully to society and the technological ecosystem.

Dr. K N Nandurkar
Co-ordinator
Board of Studies (Production and Industrial Engineering)

Members of Board of Studies: Production and Industrial Engineering	
Dr S S Ohol	Dr N G Shekapure
Dr S H Wankhade	Dr S M Kherde
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Department of Robotics and Automation Engineering

Program Specific Outcomes (PSO)

PSO1: Interdisciplinary Engineering Skills: The ability to apply knowledge from mechanical systems, electronics, control systems, and computer programming to design, analyze, and implement intelligent robotic and automated systems.

PSO2: Problem Solving and Innovation: The ability to model, simulate, and optimize automation processes and robotic mechanisms using modern engineering tools and methodologies to solve real-world industrial and societal challenges.

PSO3: Professional Growth and Entrepreneurship: The ability to pursue successful careers in robotics, industrial automation, and related fields, with an entrepreneurial mindset and a commitment to lifelong learning, innovation, and societal development.

Programme Educational Objectives (PEO)

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve.

PEO	PEO Focus	PEO Statements
PEO1	Core Competence	Attainment of fundamental principles of mechanical, electrical, and computer engineering to enable graduates to design, build, and operate robotic and automated systems.
PEO2	Problem Solving and Ethics	Ability to analyze engineering problems and provide sustainable automation solutions while adhering to ethical practices and engineering standards.
PEO3	Professionalism and Lifelong Learning	Cultivate professionalism, a spirit of innovation, and a lifelong learning attitude to adapt to emerging technologies and make meaningful contributions to industry and society.

Knowledge and Attitude Profile (WK)

A Knowledge and Attitude Profile (KAP), often represented as WK (Knowledge and Attitude Profile) in some contexts, is a framework or assessment tool used to evaluate an individual's knowledge and attitudes related to a specific area, topic, or domain.

WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9	Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Reference: Self-Assessment Report (SAR) Format Undergraduate Engineering Programs Graduate Attributes and Professional Competencies Version 4.0 (GAPC V4.0) - (August 2024) Page 55.

Programme Outcomes (PO)

Program Outcomes are statements that describe what students are expected to know and be able to do upon graduating from the program. These relate to the skills, knowledge, attitude and behaviour that students acquire through the program. On successful completion of B.E. in Artificial Intelligence and Data Science, graduating students/graduates will be able to:

PO1	Engineering Knowledge	Applying knowledge of mathematics, natural science, engineering fundamentals, and the chosen engineering specialization to solve complex problems.
PO2	Problem Analysis	Identifying, formulating, reviewing research literature, and analyzing complex engineering problems to reach substantiated conclusions.
PO3	Design/Development of Solutions	Designing creative solutions for complex engineering problems, developing system components or processes to meet specified needs while considering public health and safety, and environmental concerns.
PO4	Conduct Investigations of Complex Problems	Conducting investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to reach valid conclusions.
PO5	Modern Tool Usage	Selecting and applying appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of their limitations.
PO6	The Engineer and Society	Applying reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO7	Environment and Sustainability	Understanding the impact of professional engineering solutions in societal and environmental contexts, and demonstrating knowledge of and need for sustainable development.
PO8	Ethics	Applying ethical principles and commit to professional ethics and responsibilities and norms of engineering practice
PO9	Individual and Team Work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communication	Communicating effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Project Management and Finance	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Reference: Self-Assessment Report (SAR) Format Undergraduate Engineering Programs Graduate Attributes and Professional Competencies Version 4.0 (GAPC V4.0) - (August 2024) Page 56.

Abbreviations

AEC	Ability Enhancement Course
BSC	Basic Science Course
CCC	Co-Curricular Courses
CCE	Comprehensive Continuous Evaluation
CEP	Common Engineering Project
CO	Course Outcome
ELC	Experiential Learning Courses
ESC	Engineering Science Course
FP	Field Project
IKS	Indian Knowledge System
INT	Internship
MDM	Multidisciplinary Minor
NEP	National Education Policy
OEL	Open Elective
OJT	On Job Training
PCC	Program Core Course
PEC	Programme Elective Course
PO	Program Outcomes
PR	Practical
PRJ	Project
PSO	Program Specific Outcome
RM	Research Methodology
TH	Theory
TU	Tutorials
VEC	Value Education Course
VSE	Vocational and Skill Enhancement Course

General Rules and Guidelines

- Course Outcomes (CO): Course Outcomes are narrower statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.
- Assessment: Assessment is one or more processes, carried out by the institution, that identify, collect, and prepare data to evaluate the achievement of Program Educational Objectives and Program Outcomes.
- Evaluation: Evaluation is one or more processes, done by the Evaluation Team, for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which Program Educational Objectives or Program Outcomes are being achieved, and results in decisions and actions to improve the program

Guidelines for Examination Scheme

Theory Examination: The theory examination shall be conducted in two different parts Comprehensive Continuous Evaluation (CCE) and End-Semester Examination (ESE).

Comprehensive Continuous Evaluation (CCE):

1. CCE of 30 marks based on all the Units of course syllabus to be scheduled and conducted at institute level.
2. Case studies included under each unit are intended to support applied learning and are part of Comprehensive Continuous Evaluation
3. These case studies will be assessed through internal assessment components such as presentations, assignments, or group discussions. They shall not be included in the End-Semester Theory Examination.
4. To design a Comprehensive Continuous Evaluation scheme for a theory subject of 30 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr No	Parameters	Marks	Coverage of Units
1	Unit Test	12	Units 1 & Unit 2 (6 Marks/Unit)
2	Assignments / Case Study	12	Units 3 & Unit 4 (6 Marks/Unit)
3	Seminar Presentation / Open Book Test/ Quiz	6	Unit 5

5. CCE of 15 marks based on all the Units of course syllabus to be scheduled and conducted at institute level. To design a Comprehensive Continuous Evaluation (CCE) scheme for a theory subject of 15 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr No	Parameters	Marks	Coverage of Units
1	Unit Test	10	Units 1 & Unit 2 (5 Marks/Unit)
2	Seminar Presentation / Open Book Test/ Quiz	5	Unit 3 and Unit 4

Format and Implementation of Comprehensive Continuous Evaluation (CCE)

- **Unit Test**
  - **Format:** Questions designed as per Bloom's Taxonomy guidelines to assess various cognitive levels (Remember, Understand, Apply, Analyze, Evaluate, Create).
  - **Implementation:** Schedule the test after completing Units 1 and 2. Ensure the question paper is balanced and covers key concepts and applications.
- **Sample Question Distribution**
  - **Remembering (2 Marks):** Define key terms related to [Topic from Units 1 and 2].
  - **Understanding (2 Marks):** Explain the principle of [Concept] in [Context].
  - **Applying (2 Marks):** Demonstrate how [Concept] can be used in [Scenario].
  - **Analyzing (3 Marks):** Compare & contrast [Two related concepts] from Units 1 and 2.
  - **Evaluating (3 Marks):** Evaluate the effectiveness of [Theory/Model] in [Situation].
- **Assignments / Case Study**: Students should submit one assignment or one Case Study Report based on Unit 3 and one assignment or one Case Study Report based on Unit 4.
  - **Format:** Problem-solving tasks, theoretical questions, practical exercises, or case studies that require in-depth analysis and application of concepts.
  - **Implementation:** Distribute the assignments or case study after covering Units 3 and 4. Provide clear guidelines and a rubric for evaluation.
- **Seminar Presentation:**
  - **Format:** Oral presentation on a topic from Unit 5, followed by a Q&A session.
  - **Deliverables:** Presentation slides, a summary report in 2 to 3 pages, and performance during the presentation.
  - **Implementation:** Schedule the seminar presentations towards the end of the course. Provide students with ample time to prepare and offer guidance on presentation skills.
- **Open Book Test:**
  - **Format:** Analytical and application-based questions to assess depth of understanding.
  - **Implementation:** Schedule the open book test towards the end of the course, ensuring it covers critical aspects of Unit 5.
- **Quiz:**
  - **Format:** Quizzes can help your students practice existing knowledge while stimulating interest in learning about new topic in that course. You can set your quizzes to be completed individually or in small groups.
  - **Implementation:** Online tools and software can be used create quiz. Each quiz is made up of a variety of question types including multiple choice, missing words, true or false etc

- **Example Timeline for conducting CCE:**
  - **Weeks 1-4:** Cover Units 1 and 2
  - **Week 5:** Conduct Unit Test (12 marks)
  - **Weeks 6-8:** Cover Units 3 and 4
  - **Week 9:** Distribute and collect Assignments / Case Study (12 marks)
  - **Weeks 10-12:** Cover Unit 5
  - **Week 13:** Conduct Seminar Presentations or Open Book Test or Quiz (6 marks)
- **Evaluation and Feedback:**
  - **Unit Test:** Evaluate promptly and provide constructive feedback on strengths and areas for improvement.
  - **Assignments / Case Study:** Assess the quality of submissions based on the provided rubric. Offer feedback to help students understand their performance.
  - **Seminar Presentation:** Evaluate based on content, delivery, and engagement during the Q&A session. Provide feedback on presentation skills and comprehension of the topic.
  - **Open Book Test:** Evaluate based on the depth of analysis and application of concepts. Provide feedback on critical thinking and problem-solving skills.

End-Semester Examination (ESE)

End-Semester Examination (ESE) of 70 marks written theory examination based on all the unit of course syllabus scheduled by university. Question papers will be sent by the University through QPD (Question Paper Delivery). University will schedule and conduct ESE at the end of the semester.

- **Format and Implementation:**
  - **Question Paper Design :** Below structure is to be followed to design an End-Semester Examination (ESE) for a theory subject of 70 marks on all 5 units of the syllabus with questions set as per Bloom's Taxonomy guidelines and 14 marks allocated per unit.
  - **Balanced Coverage:** Ensure balanced coverage of all units with questions that assess different cognitive levels of Bloom's Taxonomy: Remember, Understand, Apply, Analyze, Evaluate, and Create. The questions should be structured to cover:
    - **Remembering:** Basic recall of facts and concepts.
    - **Understanding:** Explanation of ideas or concepts.
    - **Applying:** Use of information in new situations.
    - **Analyzing:** Drawing connections among ideas.
    - **Evaluating:** Justifying a decision or course of action.
    - **Creating:** Producing new or original work (if applicable).
  - **Detailed Scheme:** Unit-Wise Allocation (14 Marks per Unit): Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students' understanding and application of the course material, adhering to Bloom's Taxonomy guidelines for cognitive skills evaluation.

NEP 2020 Compliant Curriculum Structure

Second Year Engineering (2024 Pattern)

Robotics and Automation Engineering

Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE*	End-Sem	Term work	Practical	Oral	Total	Theory	Tutorial	Practical	Total
	Semester III														
PCC-201-ROA	PCC	Robot Operating System	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-202-ROA	PCC	Industrial Electronics and Electrical Machines	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-203-ROA	PCC	Hydraulics and Pneumatics	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-201A-ROA	PCC	Robot Operating System Lab	-	-	4	-	-	25	50	-	**75**	-	-	2	**2**
PCC-202A-ROA	PCC	Industrial Electronics and Electrical Machines Lab	-	-	2	-	-	25	-	25	**50**	-	-	1	**1**
	OEL	*Open Elective - I	2	-	-	15	35	-	-	-	**50**	2	-	-	**2**
MDM-231-ROA	MDM	Statistics and Probability	2	-	-	30	70	-	-	-	**100**	2	-	-	**2**
EEM-241-ROA	EEM	Engineering Economics	-	1	2	-	-	25	-	-	**25**	1	-	1	**2**
VEC-251-ROA	VEC	Universal Human Values	2	-	-	15	35	-	-	-	**50**	2	-	-	**2**
CEP-261-ROA	CEP	Mini-project/ Case study/ Seminar	-	-	4	-	-	25	-	25	**50**	-	-	2	**2**
Total			**15**	**01**	**12**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**01**	**06**	**22**

***Note:**

Students can opt for Open Electives offered by different faculty like Arts, Science, Commerce, Management, Humanities or Inter-Disciplinary studies.

• Example – Open Elective I - Financial Accounting, Digital Finance, Digital Marketing can be opted from Commerce and Management faculty.

• Elective II - Project Management, Business Analytical, Financial Management can be opted from Inter-Disciplinary studies, Commerce and Management faculty respectively.

NEP 2020 Compliant Curriculum Structure

Second Year Engineering (2024 Pattern)

Robotics and Automation Engineering

Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE*	End-Sem	Term work	Practical	Oral	Total	Theory	Tutorial	Practical	Total
	Semester IV														
PCC-204- ROA	PCC	Design of Machines and Mechanism	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-205- ROA	PPC	Materials and Manufacturing Technology	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-206-ROA	PPC	Computer Graphics for Robotics	2	-	-	30	70	-	-	-	**100**	2	-	-	**2**
PCC-207-ROA	PCC	Programming for Robotics Lab	-	-	2	-	-	25	25	-	**50**	-	-	1	**1**
PCC-206A-ROA	PCC	Computer Graphics for Robotics Lab	-	-	2	-	-	-	-	25	**25**	-	-	1	**1**
	OEL	*Open Elective - II	2	-	-	15	35	-	-	-	**50**	2	-	-	**2**
MDM-232- ROA	MDM	Industrial Engineering and Management	2	-	-	30	70	-	-	-	**100**	2	-	-	**2**
VSE- 252- ROA	VSEC	Measurement Lab	-	-	2	-	-	-	25	-	**25**	-	-	1	**1**
VSE- 253- ROA	VSEC	Creative Problem Solving and Critical Thinking	-	-	2	-	-	25	-	-	**25**	-	-	1	**1**
ACE-261-ROA	ACE	Modern Indian Languages (Marathi/Hindi)	-	1	2	-	-	50	-	-	**50**	-	1	1	
EEM-242- ROA	EEM	Behavioural Science	-	1	2	-	-	25	-	-	**25**	-	1	1	**1**
VEC-252-ROA	VEC	Environmental Studies	2	-	-	15	35	-	-	-	**50**	2	-	-	**2**
Total			**14**	**02**	**12**	**150**	**350**	**125**	**50**	**50**	**700**	**14**	**02**	**06**	**22**

Savitribai Phule Pune University, Pune

Maharashtra, India

SE – Robotics and Automation Engineering

2024 Pattern

Semester – III

With effect from Academic Year 2025-26

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Course Code: PCC-201-ROA
Course Name: Robot Operating System

Teaching Scheme	Credit	Examination Scheme
Theory : 3 Hours/Week	03	CCE : 30 Marks End-Semester : 70 Marks

Prerequisite Courses, if any:

- Basics of the programming languages.

Course Objectives:

The course aims to

1. Introduce fundamental concepts of Robot operating System.
2. Familiarize students with basics of Robot programming.
3. Provide knowledge of basic commands of VAL & VALII
4. Provide fundamental understanding of Basic commands of Rapid & AML.
5. Expose students to Robot studio Online Software for various application.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Explain the architecture and core components of Robot Operating System (ROS).
2. Develop robot programs using online programming techniques for standard tasks.
3. Apply VAL Language commands to solve basic robotic programming tasks.
4. Demonstrate programming proficiency using RAPID and AML for motion and task control.
5. Describe the fundamentals and real-world applications of soft robotics and RPA.

Course Contents

Unit I	Robot Operating Systems	(07 Hours)

Introduction – History, The ROS Equation, Distributions & difference from other meta-operating systems. ROS framework: Operating system and its various releases.

Unit II	Robot Programming	(07 Hours)

Introduction to Robotic Programming, On-line and off-line programming, programming examples. Various Teaching Methods, Robot Program as a Path in Space, Motion Interpolation, various Textual Robot Languages, Typical Programming Examples such as Palletizing, Loading a Machine, etc.

Unit III	Robot Language: VAL Language	(07 Hours)

Classifications, Structures- VAL language commands motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY commands for communications using simple applications. VAL-II programming-basic commands, Simple applications.

Unit IV	Robot Language: RAPID Language & AML	(07 Hours)

Motion Instructions-Pick and place operation using Industrial robot automatic mode, and subroutine command based programming. Move master command language- Introduction, syntax, simple problems. AML Language - General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor commands-Data processing.

Unit V	Soft Robotics	(08 Hours)

Introduction to soft robotics; Robotic Process Automation (RPA); Computer Vision, AR & VR in Robotics. Multiple robot and machine Interference-Process chart-Simple problems.

Learning Resources

Text Books:

1. Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, A press, 2018
2. Patrick Gabriel, "ROS by Example: A do it yourself guide to Robot Operating System", Lulu, 2012.
3. lafter. R.D, Chmielewski. T.A. and Noggin's., Robot Engineering: An Integrated Approach, Prentice Hall of India Pvt. Ltd.,1994.
4. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., Robotics control, sensing, vision and intelligence, McGrawHill Book co, 1987

Reference Books:

1. Anis Koubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.
2. Kumar Bipin, "Robot Operating System Cookbook", Packt Publishing, 2018.
3. Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017.

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Course Code: PCC-202-ROA

Course Name: Industrial Electronics and Electrical Machines

Teaching Scheme	Credit	Examination Scheme
Theory : 3 Hours/Week	03	CCE : 30 Marks End-Semester : 70 Marks

Prerequisite Courses, if any:

- Basic Electrical Engineering, Basic Electronics.

Course Objectives:

The course aims to
1. Introduce fundamental concepts of Industrial Electronics for automation.
2. Familiarize students with embedded systems using Arduino for automation tasks.
3. Provide knowledge of DC motors, their characteristics.
4. Provide fundamental understanding of AC motors, starters and speed control methods.
5. Expose students to special purpose motors and actuators essential in robotics.

Course Outcomes:

After successful completion of the course, learner will be able to:
1. Explain the working of basic semiconductor devices and apply them in simple industrial automation circuits.
2. Develop embedded solutions using Arduino for sensor interfacing and automation applications.
3. Evaluate and select suitable DC motors for automation applications.
4. Analyze AC motor characteristics and apply appropriate control strategies.
5. Select and integrate suitable special purpose motors into robotic applications.

Course Contents

Unit I	Fundamentals of Industrial Electronics	(07 Hours)

Introduction, scope and applications of Industrial Electronics. Semiconductor Devices: Diodes, BJTs, SCR, MOSFET, IGBT (Characteristics & applications). Rectifiers (half-wave & full-wave; Numerical on efficiency & ripple factor), Relay logic and simple relay-based circuits.

Unit II	Embedded Systems for Automation	(07 Hours)

Introduction to embedded systems & Arduino platform. Arduino UNO programming (GPIO, Analog/Digital I/O). Serial Communication basics (UART, SPI, I²C). Sensor Interfacing: LM35, Ultrasonic, LDR. Simple Arduino automation examples.

Unit III	DC Machines	(07 Hours)
Construction, working principle of D.C. generator, DC motor: Construction, torque & speed relations (Numericals on torque-speed & back EMF). Types of DC Motors: Shunt, series, compound (characteristics & applications). Starters: 3-point, 4-point (working and diagrams). Speed control methods: PWM, voltage control (Numericals on PWM frequency & duty-cycle).		
Unit IV	**AC Machines**	**(07 Hours)**
Three-phase induction motor: construction, slip & torque-slip characteristics (Numericals on slip & torque calculations). Motor starters: DOL, Star-Delta, Auto-transformer (operation & circuits). Speed control: VFD & V/f method (conceptual). Single-phase induction motor - Construction, types and applications.		
Unit V	**Special Purpose Motors**	**(08 Hours)**
Stepper Motors: Types, step angle calculation (Numericals on step-angle & RPM), driver circuits. Servo Motors: Principle, feedback & closed-loop control. BLDC Motors: Working principle, role of Electronic Speed Controller (ESC), and typical industrial and consumer applications. Universal Motors: Basic construction, working principle, and common applications.		

Learning Resources

Text Books:

1. Muhammad Rashid "Power Electronics" Pearson
2. Ashfaq Husain "Electrical Machines" Dhanpat Rai & Sons
3. Thomas L. Floyd "Electronic Devices" (9th Edition) Pearson
4. I. J. Nagrath & D. P. Kothari "Electrical Machines" Tata McGraw-Hill Publishing Co. Ltd.
5. Warwick Smith "C Programming with Arduino" Elektor Publication

Reference Books:

1. D. Patrnabis "Sensors and Transducers" (2nd Edition) PHI
2. Smarajit Ghosh "Electrical Machines" Pearson Education, New Delhi
3. Massimo Banzi and Michael Shiloh "Started with Arduino" Maker Media, Inc
4. A. E. Fitzgerald, Charles Kingsley, Stephen D. Umans "Electrical Machines" (Fifth Edition) Tata McGraw-Hill Publication Ltd.

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Code: PPC-203-ROA
Course Name: Hydraulics and Pneumatics

Teaching Scheme	Credit	Examination Scheme
Theory : 3 Hours/Week	03	CCE : 30 Marks End-Semester : 70 Marks

Prerequisite Courses, if any:

- Engineering Mechanics, Engineering Chemistry

Course Objectives:

The course aims to

1. To introduce fundamental concepts, governing laws, and working mediums in hydraulic and pneumatic systems.
2. To explain construction and working of pumps, actuators, and motors used in fluid power systems.
3. To describe the function and operation of different types of valves used for control and regulation.
4. To develop an understanding of designing, analyzing, and simulating hydraulic circuits for various applications.
5. To familiarize students with practical applications, maintenance practices, and safety protocols in fluid power systems.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Explain the principles, structure, and benefits of hydraulic and pneumatic systems.
2. Compare and classify pumps, actuators, and motors used in hydraulic systems.
3. Select and explain various control valves based on system requirements.
4. Design and analyze basic fluid power circuits used in automation and robotics.
5. Evaluate and troubleshoot fluid power systems for safe and efficient operations.

Course Contents

Unit I	Introduction to Fluid Power and Pumps	(08 Hours)

Overview of hydraulic and pneumatic systems: structure, applications, advantages, limitations
Governing laws: Pascal’s law, Bernoulli’s principle, continuity equation (overview only)
Hydraulic fluids and their properties, fluid conditioning, filters, coolers
Pneumatics: working medium, FRL unit, characteristics of compressed air
Classification of pumps: gear, vane, piston (construction, working principles)
Pumping theory of positive displacement pumps

Unit II	Hydraulic Valves and Control Components	(07 Hours)

Classification of valves: symbols and standards
Directional control valves (DCVs): poppet, sliding spool, rotary types
Solenoid and pilot-operated DCVs, check valves, shuttle valves
Pressure control valves: relief, sequence, unloading, reducing
Flow control valves: needle, throttle, compensated and non-compensated types

Unit III	Actuators and Motors	(07 Hours)
Classification of actuators Hydraulic cylinders: single-acting and double-acting, construction, mounting Hydraulic motors: types (gear, vane, radial piston), characteristics, selection criteria Pneumatic actuators: single-acting, double-acting, diaphragm and rotary actuators (brief introduction)		
Unit IV	**Hydraulic Circuit Design and Simulation**	**(07 Hours)**
Basic circuits: control of single and double-acting cylinders Regenerative and pump unloading circuits Sequencing, counterbalance, and speed control circuits Accumulators: types, working, applications with circuits Intensifier: function and application Circuit design using simulation tools (e.g., Fluidsim, Automation Studio - overview)		
Unit V	**Applications, Troubleshooting and Safety**	**(07 Hours)**
Application areas: robotics, material handling, automation, machine tools Systematic troubleshooting in hydraulic and pneumatic systems Maintenance practices and preventive checks Safety considerations: pressure ratings, failure modes, hydraulic shock Case study: Fault analysis and rectification in a hydraulic press or pneumatic pick-and-place unit		

Learning Resources

Text Books:

1. S.R. Mujumdar, *Pneumatic Systems*, Tata McGraw Hill, 2002 Edition, ISBN: 9780074602317
2. Anthony Esposito, *Fluid Power with Applications*, Pearson Education, ISBN: 9788177585803
3. Peter Rohner, *Industrial Hydraulic Control*, Hydraulic Supermarket, 2005, ISBN: 9780958149310

Reference Books:

1. Fluid Power: Generation, Transmission and Control, Wiley, 2018, ISBN: 9788126539543
2. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education (Singapore) Pvt. Ltd., ISBN: 8178083396
3. Andrew Parr, Hydraulics and Pneumatics: A Technician's and Engineer's Guide, Elsevier (Recommended for simplified understanding and practical troubleshooting)
4. M. Galal Rabie, Fluid Power Engineering, McGraw Hill (Good for in-depth system modeling and mathematical treatment)

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Course Code: PCC-201A-ROA
Course Name: Robot Operating System Lab

Teaching Scheme	Credit	Examination Scheme
Practical : 4 Hours/Week	02	Term Work : 25 Marks Practical : 50 Marks

Prerequisite Courses, if any:

- Basics of the programming languages.

Course Objectives:

The course aims to

1. To reinforce conceptual understanding of Robot Operating System (ROS) architecture and its core elements like nodes, topics, services, and actions through hands-on practice.
2. To develop student proficiency in simulating and programming industrial robot tasks using real or virtual robot platforms (e.g., ABB, UR, Robot Studio, ROS-Gazebo).
3. To enable learners to design, simulate, and test automation scenarios such as pick-and-place, spray painting, and path tracking in industrial settings.
4. To familiarize students with robot programming using both teach pendant methods and ROS-based code for real-world robotic applications.
5. To cultivate teamwork, innovation, and documentation skills through mini-projects that integrate robot hardware/simulation, programming, and sensor-actuator logic.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Apply ROS architecture elements (topics, nodes, services, actions) to simulate basic robotic tasks using tools like Turtlesim and Gazebo.
2. Develop programs using teach pendant or simulation software to execute standard robotic operations such as pick-and-place and path tracking.
3. Analyze the performance of ROS-based robotic systems for object detection, sensor integration, and autonomous task execution.
4. Design and simulate robot applications using industry tools (e.g., Robot Studio, RoboDK) for operations like spray painting or sorting.
5. Evaluate the effectiveness of a mini-project solution by integrating sensors, actuators, and robot programming to solve real-world industrial or automation problems.

List of Lab Assignments/Activities (Any 8-10 out of the following)

1. **ROS Basics & Communication:**
    - Explore **Nodes, Topics, Services, Parameters** using Turtlesim.
    - Simulate publisher-subscriber nodes with real-time message exchange.

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2. **Teach Pendant Programming:**
    - Teach basic online programming for industrial robot arms (ABB/Yaskawa UR Sim).

3. **Pick and Place (Real Robot or Simulated):**
    - Implement using ROS MoveIt! or Robot Studio.
    - Add logic for object identification (color/shape) if possible.

4. **Spray Painting Simulation:**
   - Use Robot Studio Online or RoboDK to simulate painting paths.
5. **Path Tracking/Obstacle Avoidance Task:**
   - Program a differential-drive robot to track a predefined path or avoid obstacles.
6. **ROS Navigation Stack Setup:**
   - Simulate SLAM & path planning using Turtlebot3 and Gazebo.
7. **Color/Shape Identification with OpenCV (in ROS):**
   - Use a camera or simulated vision system for real-time object recognition.
8. **Collaborative Robot Programming (UR3e/UR5 Sim):**
   - Define safe zones and simulate collaboration with human operator.
9. **Voice/Gesture-Based Robot Commanding (Optional):**
   - Implement basic control using Python + voice libraries or gesture sensors.
10. **Mini Project (Mandatory):**
    - Design a complete automation solution (e.g., warehouse picking robot, smart delivery bot, robotic bartender) using available simulation/physical tools.
    - Present a demo + viva with documented code and report.

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Course Code: PCC-202A-ROA

Course Name: Industrial Electronics and Electrical Machines Lab

Teaching Scheme	Credit	Examination Scheme
Practical : 2 Hours/Week	01	Term Work : 25 Marks Oral : 25 Marks

Course Objectives:
The course aims to
1. To reinforce understanding of fundamental concepts in industrial electronics and electrical technology through practical experimentation.
2. To impart hands-on experience with microcontroller (Arduino) programming and sensor integration for industrial automation.
3. To enable students to experimentally analyze and evaluate the performance characteristics of DC and AC electrical machines.
4. To provide practical exposure to the control methods of special-purpose motors and actuators used in robotics and automation.
5. To develop essential skills for integrating sensors, actuators, and controllers to design automated systems.
6. To foster creativity, teamwork, and problem-solving abilities through a structured automation-based mini-project.

Course Outcomes:
After successful completion of the course, learner will be able to:
1. Conduct experiments to characterize and select suitable power electronic devices for given industrial applications.
2. Develop and test Arduino-based embedded systems for sensor interfacing and basic automation tasks.
3. Experimentally verify and analyze the performance and control strategies of DC motors for industrial automation scenarios.
4. Evaluate AC motor operations and effectively implement suitable starting and speed control methods.
5. Demonstrate hands-on skills in controlling stepper, servo, and BLDC motors for robotics and automation applications.
6. Integrate sensors, actuators, and Arduino controllers to successfully design, build, and present a simple working automated system through a mini-project.

Lab Assignments/Activities: (Any 6)

1. Interfacing of LED to blink after every 1 sec.
2. Sensor interfacing with Arduino (LM35, Ultrasonic).
3. DC motor speed control using PWM.
4. AC motor starters practical demonstration.
5. Stepper motor positioning control.
6. Servo motor positional accuracy experiments.
7. BLDC motor speed control demonstration.
8. Mini-project: Arduino-based automation system integrating sensors, actuators (Mandatory).

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Code: MDM-231-ROA

Course Name: Statistics and Probability

Teaching Scheme	Credit	Examination Scheme
Theory : 2 Hours/Week	02	CCE : 30 Marks End-Semester : 70 Marks

Prerequisite Courses, if any:

Engineering Mathematics I, Engineering Mathematics II.

Course Objectives:

The course aims to

1. Introduce foundational concepts of statistics and data interpretation.
2. Familiarize students with correlation, regression, and predictive analysis.
3. Develop an understanding of probability theory and discrete/continuous distributions.
4. Provide a basic understanding of sampling and statistical decision-making techniques.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Apply descriptive statistics for data summarization and interpretation.
2. Analyze relationships using correlation and regression models.
3. Solve engineering problems using discrete and continuous probability distributions.
4. Evaluate hypotheses using basic inferential statistical tests.

Course Contents

Unit I	Descriptive Statistics and Data Analysis	(06 Hours)

Types of data, data representation: frequency tables, histograms
Measures of central tendency: mean, median, mode
Measures of dispersion: range, variance, standard deviation, coefficient of variation
Conceptual overview: skewness and kurtosis, Simple numerical examples for each concept

Unit II	Correlation and Regression	(06 Hours)

Scatter plots and concept of correlation
Pearson's correlation coefficient (with numerical examples)
Simple linear regression: regression equations, least squares method
Coefficient of determination, significance, and limitations, Use cases in engineering applications

Unit III	Basics of Probability and Distributions	(06 Hours)
Classical, frequentist, and axiomatic definitions of probability Addition and multiplication rules, Conditional probability, Bayes' theorem Discrete random variables: PMF, CDF, expectation, variance Binomial and Poisson distributions: characteristics and numerical examples Continuous distributions: PDF, CDF, Normal distribution and standardization.		
Unit IV	**Sampling and Hypothesis Testing**	**(06 Hours)**
Sampling methods, sampling distributions, Central Limit Theorem (conceptual) Hypothesis testing basics: null and alternative hypotheses, Type I and II errors Z-test and t-test (one-sample and two-sample cases, concept + examples) Chi-square test (goodness-of-fit and independence – conceptual only)		
Learning Resources		
Text Books: 1. S.C. Gupta & V.K. Kapoor, *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons 2. Douglas C. Montgomery, *Applied Statistics and Probability for Engineers*, Wiley		
Reference Books: 1. Sheldon Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier 2. Jay Devore, Probability and Statistics for Engineering and the Sciences, Cengage Learning		

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Course Code: EEM-241-ROA
Course Name: Engineering Economics

Teaching Scheme	Credit	Examination Scheme
Practical : 2 Hours/Week Tutorial : 1 Hour/Week	01 01	Term Work : 25 Marks

Prerequisite Courses, if any:

- Basic Mathematics (no specialized prerequisites).

Course Objectives:

The course aims to

1. Introduce the basic economic principles relevant to engineers and technocrats.
2. Provide skills to evaluate engineering alternatives using economic criteria.
3. Develop practical competency in cost estimation, cash flow analysis, and break-even decisions.
4. Familiarize students with economic feasibility analysis and contemporary economic issues related to engineering.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Explain fundamental concepts of engineering economics and financial decision-making.
2. Apply cost estimation, break-even analysis, and interest calculation to evaluate engineering problems.
3. Compute and analyze depreciation and replacement scenarios using standard methods.
4. Conduct mini-projects involving feasibility analysis for engineering-based products or services.

Tutorial Sessions

- Introduction to Engineering Economics: Demand, Supply, Equilibrium
- Time Value of Money: Simple and Compound Interest
- Cost Estimation Techniques: Fixed, Variable, Marginal Costs
- Break-even Point and Applications
- Depreciation Methods: Straight Line, Declining Balance
- Replacement and Risk Analysis: Concept, Overview
- Cash Flow Diagrams and Present/Future Worth Analysis
- Contemporary Issues: Inflation, Industry 4.0 and Economic Decisions

Practical Sessions

1. Interest Calculations: Simple and Compound interest for engineering payments.
2. Cash Flow Diagram Preparation: PW/FW calculations for alternatives.
3. Annual Worth Method: Comparing alternatives using AW approach.
4. Break-even Analysis: Numerical exercises and graphical interpretation.
5. Depreciation Calculations: Straight-line and declining balance methods.
6. Payback Period and IRR: Calculation for two project alternatives.
7. Replacement Analysis: Practical case involving equipment substitution.

8. Economic Impact Case Study: E.g., impact of automation on cost-benefit.
9. Mini-Project (Mandatory): Conduct a feasibility study or economic evaluation of an engineering project or product (e.g., solar water heater, electric bike, automation of a production line, IoT-based irrigation).

   Deliverables:

   - Cost Analysis
   - Cash Flow Table
   - Economic Metrics (NPV, IRR, Payback)
   - 6-8 Page Report + Presentation

Text Books:

1. Leland Blank & Anthony Tarquin, Engineering Economy, McGraw-Hill Education
2. Donald G. Newnan & Jerome P. Lavelle, Engineering Economic Analysis, Oxford University Press

Reference Books:

1. Chan S. Park, Fundamentals of Engineering Economics, Pearson Education
2. Sullivan, Wicks, & Koelling, Engineering Economy, Prentice Hall

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Code: VEC-251-ROA

Course Name: Universal Human Values

Teaching Scheme	Credit	Examination Scheme
Theory : 2 Hours/Week	02	CCE : 15 Marks End-Semester : 35 Marks

Prerequisite Courses, if any:

Student Induction Program (SIP)

Course Objectives:

The course aims to

1. Introduce value education as a process of self-exploration to understand one's purpose and aspirations.
2. Facilitate the understanding of harmony in the human being, family, society, and nature.
3. Enable students to identify the relationship between right understanding and ethical human conduct.
4. Inspire a holistic vision for life and profession based on universal human values and coexistence

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Describe the process of self-exploration and explain its importance in achieving happiness and prosperity.
2. Analyze the coexistence of self and body, and assess their distinct needs for leading a balanced life.
3. Demonstrate an understanding of harmonious relationships within the family and society.
4. Evaluate harmony in nature and existence, and integrate universal values into professional and personal life.

Course Contents

Unit I	Introduction to Value Education	(06 Hours)

Meaning and need for value education
Self-exploration as the basis for right understanding
Human aspirations: happiness and prosperity
Right understanding, relationship, and physical facility
Current scenario: confusion and contradictions in life
Method to fulfill basic human aspirations

Unit II	Harmony in the Human Being	(06 Hours)

Human being as coexistence of self and body
Distinction between needs of the self and body
Role of the body as an instrument of the self
Harmony in the self and harmony of self with the body
Self-regulation and health: a value-based approach

Unit III	Harmony in the Family and Society	(06 Hours)
Family as the basic unit of human interaction Values in relationships: trust, respect, affection, care Right evaluation and mutual fulfillment Harmony in society: justice, fearlessness, and coexistence Vision for a universal human order		
Unit IV	**Harmony in Nature and Existence**	**(06 Hours)**
Interconnectedness and mutual fulfillment in nature Four orders in nature and their harmony Existence as coexistence of units in space Holistic perception of harmony in existence Professional ethics and transition to a value-based lifestyle		

Learning Resources

Text Books:

1. *A Foundation Course in Human Values and Professional Ethics*, R.R. Gaur, R. Asthana, G.P. Bagaria, 3rd Revised Edition, UHV Publications, 2023 ISBN: 978-81-957703-7-3
2. *Teachers' Manual for A Foundation Course*, R.R. Gaur, R. Asthana, G.P. Bagaria, UHV Publications, 2023

Reference Books:

1. P. L. Dhar & R. R. Gaur - *Science and Humanism*, Commonwealth Publishers
2. A. Nagaraj - *Jeevan Vidya: Ek Parichaya*, Jeevan Vidya Prakashan
3. A. N. Tripathy - *Human Values*, New Age International
4. E. G. Seebauer & R. L. Berry - *Fundamentals of Ethics for Scientists & Engineers*, Oxford
5. B. L. Bajpai - *Indian Ethos and Modern Management*, New Royal Book Co.
6. M. Govindarajan, S. Natarajan & V.S. Senthil Kumar - *Engineering Ethics and Human Values*, PHI
7. M. K. Gandhi - *The Story of My Experiments with Truth*

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)
Course Code: CEP-261-ROA
Course Name: Mini-project/ Case study/ Seminar

Teaching Scheme	Credit	Examination Scheme
Practical : 4 Hours/Week	02	Term Work : 25 Marks Oral : 25 Marks

Course Objectives:

The course aims to

1. Develop students' understanding of societal challenges through direct community engagement.
2. Foster application of engineering knowledge to solve practical community problems.
3. Enhance individual and teamwork capabilities, communication skills, and research orientation.
4. Encourage critical analysis and documentation skills for comprehensive learning.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Identify and understand societal issues within a community context clearly.
2. Apply appropriate robotics and automation technologies to real-life community needs.
3. Effectively document and communicate research findings or project outcomes through structured reporting and presentations.
4. Demonstrate professional ethics, social responsibility, and teamwork/individual skills during community interactions.
5. Critically analyze existing systems/technologies and propose informed improvements.
6. Reflect effectively on personal and professional learning outcomes from community engagement.

Detailed Guidelines for Tasks:

Mini-project (Group-based: maximum 4 students):

Guidelines:

1. **Group Formation and Mentor Allocation**
   - Form groups of **maximum 4 students**.
   - Assign one faculty mentor per group for regular guidance.
2. **Community Problem Identification**
   - Conduct initial visits/interviews/surveys to identify real community issues that can be addressed using basic robotics or automation (e.g., agriculture, waste management, energy conservation, water quality).
3. **Problem Definition and Project Proposal**
   - Clearly define the problem, objectives, scope, and feasibility of your project.
   - Prepare a one-page project proposal to be reviewed and approved by your mentor.
4. **Project Planning and Implementation**
   - Perform literature review and select relevant technology.
   - Design, develop, and test a simple working prototype or solution.

- Regular mentor-guided reviews to ensure practical viability.

5. Documentation and Reporting

- Compile a comprehensive final report (~20 pages):
  - ✓ Introduction, Problem Statement
  - ✓ Objectives and Methodology
  - ✓ Technology and Tools used
  - ✓ Prototype development and Testing results
  - ✓ Community Impact and Outcomes
  - ✓ Conclusions, Challenges faced, Future scope
- Prepare a group presentation clearly demonstrating outcomes.

Case Study (Individual or Group of Two)

Guidelines:

Assign one faculty mentor per Student for regular guidance

1. Topic Identification

- Choose a relevant case study from your community involving robotics or automation systems (e.g., smart farming, automated waste management, automated irrigation).

2. Case Analysis

- Collect detailed data via field visits, interviews, and observations.
- Analyze the system's implementation, benefits, challenges, and effectiveness.

3. Documentation and Critical Review

- Document findings with relevant data, photographs, and references.
- Critically review and propose informed recommendations or improvements.

4. Final Report and Presentation

- Structured report (~15 pages):
  - ✓ Introduction, Objectives, and Scope
  - ✓ Detailed analysis of the current system
  - ✓ Benefits, Challenges, Observations
  - ✓ Recommendations for improvement
  - ✓ Conclusion and Reflection
- Individual oral presentation summarizing key insights and recommendations.

Seminar (Individual-based)

Guidelines:

Assign one faculty mentor per Student for regular guidance

1. Seminar Topic Selection
   - Select a community-relevant topic linked with automation or robotics (e.g., role of robotics in healthcare, robotics in disaster management, automation for rural development).
2. Research and Preparation
   - Conduct comprehensive literature research and field interaction.
   - Gather detailed information, statistics, case examples relevant to your topic.
3. Seminar Content Development
   - Develop structured seminar content with clear introduction, main body, examples, practical implications, and conclusions.
4. Delivery and Report Submission
   - Present seminar individually (10-15 minutes) clearly communicating your findings.
   - Submit a concise structured report (~15-20 pages) summarizing seminar content and community insights.

Savitribai Phule Pune University, Pune

Maharashtra, India

SE – Robotics and Automation Engineering

2024 Pattern

Semester – IV

With effect from Academic Year 2025-26

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Code: PCC-204-ROA

Course Name: Design of Machines and Mechanism

Teaching Scheme	Credit	Examination Scheme
Theory : 3 Hours/Week	03	CCE : 30 Marks End-Semester : 70 Marks

Prerequisite Courses, if any:

- Engineering Graphics, Engineering Mathematics, Basic Mechanical Engineering.

Course Objectives:

The course aims to

1. Understand the basic principles, procedures, and standards in machine design, and apply them to the design of simple mechanical components.
2. Analyze the stresses in beams and shafts subjected to bending and torsional loads.
3. Apply mechanical engineering principles to the design and analysis of power screw mechanisms.
4. Understand and apply design methods for different types of Gears and Bearings.
5. Analyze the kinematics of mechanical linkages and mechanisms used in robotic systems.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Apply design procedures and standards to develop basic machine elements like joints, keys, and couplings.
2. Analyze and evaluate shafts and beams under bending and torsional loading using appropriate mechanical theories.
3. Design power screws and lifting mechanisms by considering torque, friction, and strength criteria.
4. Design helical springs for various loading and configuration requirements.
5. Analyze and synthesize the motion of robotic mechanisms and mechanical linkages.

Course Contents

Unit I	Introduction to Machine Design	(07 Hours)

Machine Design, Basic procedure of Machine Design, Requisites of design engineer, Use of standards in design, Factor of safety, Theories of Failures, Design of simple machine parts, Socket and Spigot cotter joint, knuckle joint, Keys: Classification of keys, Design of square, Couplings: Design considerations, Classification, Design of Rigid, Muff coupling, Flange coupling

Unit II	Design of Shaft	(08 Hours)

Transversely Loaded Components, Force and Bending Moment in Determinate Beams due to Concentrated Loads, Uniformly Distributed Loads. Bending stresses, Theory of simple bending, assumptions, and derivation of flexure formula. Torsion of circular shafts. Theory of torsion, assumptions, and derivation of torsion equation.

Shafts: Design considerations in Transmission shafts with spur gear and pulley, splined Shafts, Shaft design on strength basis, Shaft design on torsional rigidity basis, ASME code for shaft design.

Unit III	Design of Power Screws	(07 Hours)

Power Screws: Types of screw threads, multiple threaded screws, Torque analysis with square and trapezoidal threads, Self-locking screw, Collar friction torque, Stresses in power screws, design of screw and nut, design of Screw jack.

Unit IV	Design of Gears and Bearings	(08 Hours)

Introduction to Gear Design: Basic terminology: pitch circle, module, pressure angle, addendum, dedendum, Detailed Analysis of Spur Gears, Force analysis on gear teeth (tangential and radial forces), Lewis equation for gear tooth strength
Types of Gears: Helical, Bevel, Worm, Rack and Pinion, Internal gears
Introduction to Bearings: Classification: sliding/contact bearings and rolling element bearings, Bearing selection criteria: load, speed, temperature, alignment, Static and dynamic load carrying capacities, Lubrication and maintenance for enhanced life.

Unit V	Fundamentals of Mechanisms	(07 Hours)

Kinematic Link, Types of links, Kinematics pair, Types of constrained motion, Classification of Kinematics pairs, Kinematics chain, Degrees of freedom of mechanisms, Inversion of mechanism, Analysis of mechanisms such as cams and followers, belt drives, four bar mechanism, slider crank mechanism etc.

Learning Resources

Text Books:

1. Shigley J. E. and Mischke C. R., “Mechanical Engineering Design”, McGraw- Hill publication Co. Ltd., 1989, ISBN 0-07-049462-2.
2. Spotts M. F. and Shoup T. E., “Design of Machine Elements”, 8ed., Pearson Education Pvt Ltd., 2008, ISBN 81 -7758- 4219.
3. Bhandari V.B., “Design of Machine Elements”, Tata Mcgraw-hill publishing, 2007, ISBN 978-00-70-681798.
4. Rattan S.S., “Theory of Machines”, 3nd edition, Tata McGraw-hill publishing, 2005, ISBN 007-059120-2.
5. S. K. Saha, Introduction to Robotics, 3rd Edition, Tata McGraw Hill; Standard Edition (30 November 2024), ISBN-13 : 978-9355326461.

Reference Books:

1. Orthewein and William C. Orthewein, “Machine Component Design”.
2. PSG Design data”, M/S DPV printers, Coimbatore, 2000.
3. Shigley Joseph Edward and Vicker John Joseph. “Theory of Machines and Mechanisms”,
4. 3rd edition, 1995, Oxford University Press. ISBN 0-19-515598-x.
5. S. R. Deb, Robotics Technology and Flexible Automation, 2nd Edition, McGraw Hill
6. Education (India) Private Limited, ISBN: 9780070077911

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)

Course Code: PCC-205-ROA
Course Name: Materials and Manufacturing Technology

Teaching Scheme	Credit	Examination Scheme
Theory : 3 Hours/Week	03	CCE : 30 Marks End-Semester : 70 Marks

Prerequisite Courses, if any:

- Engineering Physics, Chemistry, Manufacturing Practices Workshop

Course Objectives:

The course aims to

1. Introduce conventional and advanced material processing methods relevant to robotics.
2. Familiarize students with the basic and emerging engineering materials used in robotics.
3. Provide an overview of mechanical property testing, including traditional and modern NDE techniques.
4. Cover foundational metal forming and joining processes alongside digital and smart manufacturing.
5. Discuss additive manufacturing, precision machining, and CNC automation with simplified concepts.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Identify and describe conventional and advanced materials used in robotic systems.
2. Conduct and interpret basic material testing procedures and understand automated inspection techniques.
3. Explain casting, metal cutting, and joining processes with real-world robotics examples.
4. Understand additive manufacturing and precision machining with simplified applications.
5. Apply foundational forming and joining techniques relevant to robotic component design.

Course Contents

Unit I	Engineering Materials in Robotics	(07 Hours)

Material Classification: Ferrous, non-ferrous, polymers, ceramics, composites Smart materials: shape memory alloys, piezoelectrics (basic overview) Lightweight materials: Aluminum alloys, plastics, carbon fiber basics.
Material properties relevant to robotic arms and chassis (strength, stiffness, weight)

Unit II	Mechanical Properties and Testing	(07 Hours)

Destructive tests: Tensile, compression, impact, fatigue (with simple lab examples) Hardness tests: Brinell, Rockwell, Vickers (concept only)
Non-Destructive Tests: Visual, Dye Penetrant, Ultrasonic, Radiography (intro level)
Use of robotic arms in modern testing environments.

Unit III	Alloying and Phase Diagrams	(07 Hours)

Basic terms: solid solution, solubility, polymorphism
Iron-Carbon diagram: concept and importance
Alloy steels for robotic applications
Heat treatment basics: hardening, annealing, tempering

Unit IV	Casting and Powder Metallurgy	(07 Hours)
Sand casting, Investment Casting, Vacuum Casting / Vacuum-Assisted Casting, Centrifugal and Pressure Die Casting Enhancements, Squeeze Casting basics. Powder metallurgy: Advanced Powder Manufacturing Techniques, Powder Shaping and Forming Automation, Sintering Technologies, Additive Manufacturing & 3D Printing in PM		
Unit V	Forming and Joining for Robotics	(08 Hours)
Rolling, forging, extrusion (basic classification and diagrams) Sheet metal operations: blanking, bending, deep drawing Joining methods: Arc welding, gas welding, soldering, brazing, friction stir (FSW) and laser beam welding (intro level), Ultrasonic Welding, Intelligent Robotic Welding Systems.		

Learning Resources

Text and Reference Books:

1. V. D. Kodgire - Material Science and Metallurgy for Engineers
2. P. N. Rao - Manufacturing Technology Vol. I & II
3. Kalpakjian & Schmid - Manufacturing Processes for Engineering Materials.

Reference Books:

1. R. K. Jain - Production Technology
2. Mikell P. Groover - Automation, Production Systems, and CIM
3. Serope Kalpakjian - Manufacturing Engineering and Technology
4. Hajara Choudhary - Elements of Workshop Technology

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)
Course Code: PCC-206-ROA

Course Name: Computer Graphics for Robotics

Teaching Scheme	Credit	Examination Scheme
Theory : 2 Hours/Week	02	CCE : 30 Marks End-Semester : 70 Marks

Prerequisite Courses, if any:
- Engineering Mathematics I, Engineering Mathematics II, Engineering Graphics and C Programming.

Course Objectives:
The course aims to
1. Introduce the fundamental concepts of computer graphics relevant to robotics applications.
2. Explain geometric transformations and their utility in robotic systems and simulation.
3. Familiarize students with interpolation techniques used in motion planning and animation.
4. Explore curve generation, patch modeling, and their application in robot path and surface modeling.

Course Outcomes:
After successful completion of the course, learner will be able to:
1. Apply coordinate systems and graphics principles to represent objects and scenes.
2. Implement 2D and 3D transformations used in robotic simulations and motion control.
3. Analyze interpolation techniques and use them for realistic modeling of movement.
4. Construct curves and surface patches for robotic path planning and shape modeling.

Course Contents

Unit I	Introduction to Computer Graphics & Coordinate Systems	(06 Hours)

Cartesian coordinate systems (2D and 3D), vectors and operations
Fundamentals of computer graphics for robotics visualization
Line drawing algorithms (Bresenham's, DDA - brief overview)
Simple graphical object creation using C programming

Unit II	Transformations in Graphics and Robotics	(06 Hours)

2D and 3D geometric transformations: translation, rotation, scaling
Homogeneous coordinates and matrix representation
Perspective and orthographic projections
Applications in robotic arm motion and kinematics

Unit III	Interpolation and Its Applications	(06 Hours)

Linear and non-linear interpolation
Interpolation of curves (Lagrange, spline interpolation overview)
Interpolating quaternions for smooth robotic rotation
Applications in animation and robot trajectory generation

Unit IV	Curves and Patches for Robotic Modeling	(06 Hours)

Bezier curves and B-splines: generation and properties
Surface modeling using patches (brief intro to Coons and Bézier surface patches)
Use of curves and patches in robot path and surface planning
Implementation using C or open-source graphics tools (overview).

Learning Resources

Text Books:

1. Roger D., Adams A. J., Mathematical Elements for Computer Graphics, McGraw Hill, ISBN: 978-0070486775
2. Jon Vince, Mathematics for Computer Graphics, Springer, ISBN: 978-1-84628-034-4

Reference Books:

1. Chopra Rajiv, Computer Graphics, S. Chand and Co. Pvt. Ltd., ISBN: 81-219-3581-4
2. Davis Martin J., Computer Graphics, Nova Science Publishers, ISBN: 9781617618116

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)
Code: PCC- 207- ROA

Course Name: Programming for Robotics Lab

Teaching Scheme	Credit	Examination Scheme
Practical : 2 Hours/Week	01	Term Work : 25 Marks Practical : 25 Marks

Prerequisite Courses, if any:

- Industrial Electronics and Electrical Machines.

Course Objectives:

The course aims to

1. To introduce students to foundational programming for robotics applications.
2. To develop basic coding skills using open-source platforms such as Python, Arduino IDE, and ROS.
3. To apply programming in tasks like sensor interfacing, motor control, and data processing.
4. To familiarize students with simulation tools for robotics.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Write basic programs to interface sensors and actuators using Arduino and Python.
2. Simulate and control robotic movements using Python-based tools.
3. Implement simple data acquisition and decision-making algorithms.
4. Understand and apply open-source tools like ROS and Gazebo for robotics simulation.
5. Demonstrate teamwork and practical problem-solving in automation programming tasks.

Lab Assignments/Activities: (Any 8)

1. Programming with Arduino IDE: LED blinking, motor control, buzzer.
2. Sensor Data Acquisition: Write a Python/Arduino script to read values from IR or Ultrasonic sensor.
3. Motor Control using PWM: Speed and direction control of DC/servo motor.
4. Line Following Robot Simulation using Tinkercad or Proteus.
5. Python Program to Control a Simulated Robot in Webots or VPL.
6. ROS Basics: Writing a simple publisher-subscriber Python node in ROS Noetic (Ubuntu).
7. Obstacle Detection using Raspberry Pi + Python + Camera/Ultrasonic module.
8. Data Logging and Plotting: Collect sensor data and plot in real-time using Python (matplotlib).
9. Mini Project: Design a small automation task (e.g., object sorting, room mapping using simulation).

Note: Software used must be open-source or free versions such as Arduino IDE, Python, ROS, Tinkercad, Webots, VPL, etc.

Tools/Platforms (Open-source Recommended)

Arduino IDE, Python (with GPIO, OpenCV, Matplotlib), ROS Noetic (Ubuntu 20.04), Tinkercad / Proteus (for virtual electronics), Webots / VPL (for robot simulation)

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)
Code: PCC- 206A- ROA

Course Name: Computer Graphics for Robotics Lab

Teaching Scheme	Credit	Examination Scheme
Practical : 2 Hours/Week	01	Oral : 25 Marks

Prerequisite Courses, if any:

- C/C++, Python Programing

Course Objectives:

The course aims to

1. To implement basic graphics algorithms using programming logic and visualize them in 2D/3D space.
2. To apply geometric transformations for robotic motion simulation.
3. To generate curves and interpolate paths used in robot movement planning.
4. To use graphics programming and visualization tools for creating robotic path and shape models.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Develop C/Python programs for basic line and shape rendering using graphics algorithms.
2. Simulate 2D/3D transformations and visualize robotic motion.
3. Implement interpolation and curve generation techniques for trajectory design.
4. Model robot paths and surfaces using Bezier, B-Splines, and patches in open-source software.

Lab Assignments/Activities

1. Implement Bresenham's and DDA line drawing algorithm (C / Python + matplotlib)
2. Create 2D objects (rectangle, triangle, polygon) and apply transformations (translation, rotation, scaling) (Python with matplotlib or C with graphics.h)
3. Simulate 3D object transformation using homogeneous coordinates (Python (numpy + matplotlib 3D))
4. Implement and visualize perspective and orthographic projection (Python (matplotlib 3D))
5. Perform linear and spline interpolation between robotic positions (Python (scipy.interpolate))
6. Implement Bezier and B-Spline curves for path planning (Python or WebGL / p5.js)
7. Model a robotic surface patch using Bezier surface techniques (Blender / OpenSCAD / FreeCAD)
8. Mini Project (Mandatory): Simulate a robotic arm motion with transformations and path interpolation (Webots / Blender / Python)

Learning Resources

Text Books:

1. Roger D. & Adams A. J., *Mathematical Elements for Computer Graphics*, McGraw Hill

   ISBN: 978-0070486775
2. Jon Vince, *Mathematics for Computer Graphics*, Springer

References:

1. Rajiv Chopra, Computer Graphics, S. Chand and Co. Pvt. Ltd.
2. Martin J. Davis, Computer Graphics, Nova Science Publishers
3. F. S. Hill & Stephen M. Kelley, Computer Graphics using OpenGL, Pearson Education
4. Blender Foundation, Blender Manual (Online, regularly updated)
5. Webots User Guide, Cyberbotics Ltd.

Savitribai Phule Pune University
Second Year of Robotics and Automation Engineering (2024 Pattern)
Course Code: MDM-232- ROA
Course Name: Industrial Engineering and Management

Teaching Scheme	Credit	Examination Scheme
Theory : 2 Hours/Week	02	CCE : 30 Marks End-Semester : 70 Marks

Prerequisite Courses, if any:

- Basic Engineering knowledge, Principles of Management.

Course Objectives:

The course aims to

1. Introduce the fundamentals and significance of industrial engineering and productivity enhancement.
2. Explain basic quality management concepts, tools, and production planning methods.
3. Enable learners to analyze work processes using method study, motion economy, and time measurement techniques.
4. Familiarize students with ergonomics, safety, and emerging technologies such as Lean Manufacturing and Industry 4.0.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Describe the scope of industrial engineering and compute basic productivity metrics.
2. Apply quality control tools, forecasting methods, and inventory models in production planning.
3. Analyze and optimize work methods using time and motion study tools.
4. Evaluate ergonomic design, workplace safety, and modern trends like Lean and Industry 4.0.

Course Contents

Unit I	Introduction to Industrial Engineering and Productivity	(06 Hours)

Definition, scope, and historical evolution of Industrial Engineering
Objectives and applications in manufacturing and service sectors
Productivity concepts and metrics: partial and total productivity
Factors influencing productivity; productivity improvement approaches

Unit II	Quality Control and Production Planning	(06 Hours)

Concepts of quality, quality control, and assurance
Statistical Quality Control: basic control charts ($\bar{X}$, R, and P charts – conceptual)
Overview of ISO standards (ISO 9001) and Total Quality Management (TQM)
Production planning and control basics; forecasting methods (overview)
Inventory management: EOQ model, ABC classification (numerical examples)

Unit III	Method Study and Work Measurement	(06 Hours)

Method study: procedure and charting techniques (operation process, flow process charts)
Principles of motion economy; micro-motion study and therbligs (conceptual)
Work measurement techniques: time study, work sampling
Standard time calculation and its role in cost and capacity planning

Unit IV	Ergonomics, Safety, and Emerging Trends	(06 Hours)

Introduction to ergonomics and anthropometry; design of workstations
Safety: industrial hazards, prevention, and safety regulations
Lean manufacturing: 5S, Kaizen, JIT (overview with examples)
Industry 4.0: digital manufacturing, IoT, AI, and smart factories
Case studies of implementation in modern industries

Learning Resources

Text Books:

1. O.P. Khanna, "Industrial Engineering and Management," Dhanpat Rai Publications.
2. M. Mahajan, "Industrial Engineering & Production Management," Dhanpat Rai & Co.

Reference Books:

1. O.P. Khanna, "Industrial Engineering and Management," Dhanpat Rai Publications.
2. M. Mahajan, "Industrial Engineering & Production Management," Dhanpat Rai & Co.
3. Mikell P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing," Pearson.
4. R.K. Jain, "Production Technology," Khanna Publishers

Second Year of Robotics and Automation Engineering (2024 Pattern)
Code: PCC- 206A- ROA
Code: VSE- 252- ROA
Course Name: Measurement Lab

Teaching Scheme	Credit	Examination Scheme
Practical : 2 Hours/Week	01	Practical : 25 Marks

Prerequisite Courses, if any:

- Basic Engineering knowledge, Principles of Management.

Course Objectives:

The course aims to

1. To measure electrical parameters (DC voltage, current, resistance) using a digital multimeter and DSO/CRO..
2. Explain the application of thermistors for temperature measurement in automation systems.
3. Use proximity sensors to measure motor speed in automation systems.
4. Evaluate distance measurement using ultrasonic sensors for robotic applications.
5. Design and implement shaft torque measurement techniques using suitable sensors.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Identify electrical parameters and accurately measure them using a digital multimeter and DSO/CRO.
2. Explain the working principle and applications of thermistors for temperature measurement.
3. Use proximity sensors effectively to measure motor speed in automation tasks.
4. Analyze the performance of ultrasonic sensors for distance measurement in robotics.
5. Design and select appropriate sensing techniques to measure shaft torque in robotic systems.

Lab Assignments/Activities

1. Measurement of DC Voltage, Current and Resistance Using Digital Multi meter.
2. Measurement of Voltage and Frequency Using Digital Storage Oscilloscope (DSO)/CRO
3. Temperature Measurement using Thermistor.
4. Speed Measurement of a Motor using a Proximity sensor.
5. Measurement of Distance using Ultrasonic Sensor.
6. Light Intensity Measurement Using Photodiodes / LDRs.
7. To measure pressure in a hydraulic or pneumatic system using a pressure transducer.
8. Measurement of shaft Torque and identifying suitable technique for sensing.

(https://ic-coep.vlabs.ac.in/exp/shaft-torque/)

Savitribai Phule Pune University
Second Year of Engineering (2024 Pattern) Course
Code: VSE-253- ROA
Course Name: Creative Problem Solving and Critical Thinking

Teaching Scheme	Credit	Examination Scheme
Practical : 2 Hours/Week	01	Term Work : 25 Marks

Prerequisite Courses, if any:

- Design Thinking and Idea.

Course Objectives:

The course aims to

1. To develop creative and analytical problem-solving abilities in students.
2. To introduce structured methods of critical thinking and reasoning.
3. To enhance lateral thinking, brainstorming, and decision-making skills.
4. To apply creative frameworks to real-world engineering and social problems.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Apply creative thinking techniques to generate innovative ideas.
2. Analyze problems critically using structured thinking models.
3. Evaluate alternative solutions using decision-making frameworks.
4. Collaborate in teams to solve real-world challenges.
5. Communicate ideas effectively using visual thinking and presentation skills.

Assignments / Activities

Foundations of Creative Thinking

Introduction to creativity, fixed vs growth mindset, convergent vs divergent thinking

Practical: "30 Circles Activity", "SCAMPER Tool", Mind Mapping for idea generation

Critical Thinking Basics

Logic vs emotion, assumptions and biases, types of reasoning (inductive/deductive)

Practical: Case study analysis, identifying fallacies, "Fact vs Opinion" exercise

Problem-Solving Frameworks

Define the problem, Root Cause Analysis (5 Whys, Fishbone Diagram)

Practical: Apply tools to local problems (college/event-based), team discussions

Decision-Making and Evaluation

Decision trees, cost-benefit analysis, Pugh matrix

Practical: Scenario-based decision-making games, mock committee decisions

Innovation and Lateral Thinking

Edward de Bono's Six Thinking Hats, TRIZ basics

Practical: Role-play thinking hats, reverse thinking challenge

Communicating Ideas

Visual thinking, storytelling for innovation

Practical: Elevator pitch for a new solution, poster design for a creative idea

Savitribai Phule Pune University
Second Year of Engineering (2024 Pattern) Course
Code: EEM-242- ROA
Course Name: Behavioural Science

Teaching Scheme			Credit	Examination Scheme
Tutorial Practical	: :	1 Hour/Week 2 Hours/Week	01 01	Term Work : 25 Marks

Prerequisite Courses, if any:

- No Prerequisite required.

Course Objectives:

The course aims to

1. To introduce students to the psychological foundations of human behavior.
2. To develop emotional intelligence, interpersonal skills, and self-awareness.
3. To enhance group behavior, collaboration, and leadership in teams.
4. To nurture critical thinking, ethical reasoning, and lifelong behavioral competencies.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Understand and reflect on their personality, perception, and behavioral style.
2. Apply emotional intelligence and stress management in personal and academic life.
3. Demonstrate effective communication, teamwork, and leadership behaviors.
4. Use behavioral models for ethical reasoning and critical thinking.
5. Practice life skills like adaptability, grit, and motivation for personal growth.

Assignments / Activities

1. Foundations of Human Behavior

Tutorial Topics:

- Definition and importance of behavioral science
- Personality types, attitudes, and perception
- Johari Window for self-awareness

Practical Activities:

- Personality assessment quiz
- "Know Yourself" – Johari Window Reflection
- Group discussion: Role of behavior in tech teams

2. Emotional Intelligence & Self-Awareness

Tutorial Topics:

- Goleman's model of Emotional Intelligence
- Self-esteem, self-efficacy, motivation
- Stress causes and management

Practical Activities:

- EI Self-assessment
- Stress management techniques: Mindfulness, Time Logs
- Visualization and journaling for self-reflection

3. Interpersonal & Group Dynamics

Tutorial Topics:

- Verbal and non-verbal communication
- Team roles (Belbin), group behavior, conflict handling

Practical Activities:

- Listening circles and empathy exercises
- Team role-play: Handling difficult situations
- "Build a Bridge" collaborative game

4. Decision-Making

Tutorial Topics:

- Rational vs emotional decisions
- Common biases and heuristics
- Root Cause Analysis, 5 Whys, Mind Mapping

Practical Activities:

- Case study analysis (behavioral errors in decision-making)
- Team brainstorming and decision simulation

5. Ethics, Integrity & Professional Behavior

Tutorial Topics:

- Meaning of ethics and professional conduct
- Whistleblowing, accountability, and dilemmas in engineering

Practical Activities:

- Case study discussions on engineering ethics
- Role-play on ethical dilemmas
- Reflective writing on integrity and values

6. Life Skills & Self-Development

Tutorial Topics:

- Growth mindset (Carol Dweck), resilience, grit
- Self-leadership and behavioral adaptability

Practical Activities:

- Grit scale test
- Peer coaching and feedback session
- Vision board for personal growth

Savitribai Phule Pune University
Second Year of Engineering (2024 Pattern) Course
Course Code: VEC-252-ROA

Course Name: Environmental Studies

Teaching Scheme	Credit	Examination Scheme
Theory : 2 Hours/Week	02	CCE : 15 Marks End-Semester : 35 Marks

Prerequisite Courses, if any:

- No specialized prerequisites

Course Objectives:

The course aims to

1. To introduce the multidisciplinary nature and scope of environmental studies.
2. To understand ecosystem structures, biodiversity, and ecological balance through hands-on observation and documentation.
3. To examine the use and impact of natural resources on environmental sustainability.
4. To explore biodiversity conservation practices and develop eco-sensitive thinking through fieldbased inquiry.

Course Outcomes:

After successful completion of the course, learner will be able to:

1. Illustrate the interdependence of ecosystems through activity-based exploration
2. Analyze the role of natural resources in sustainable development using real-world data.
3. Investigate biodiversity threats and conservation strategies through surveys and projects
4. Create awareness tools or reports promoting sustainability based on their findings.

Course Contents

Unit I	Introduction to Environment and Ecosystem	(06 Hours)

Meaning and Scope of Environment: Definition of environment, Types of environment (natural, built), Components of environment (biotic and abiotic), Man-environment relationship, Importance of environment and sustainability, Need for public environmental awareness.
Ecosystem Basics: Definition and major components of ecosystems, Structure and function of ecosystem
Case studies: Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystem
Stability of ecosystems and their role in environmental sustainability

Unit II	Environmental Pollution and Control Measures	(06 Hours)

Definition and Types of Pollution
Air Pollution: sources, effects, and Air Pollution Control Act
Water Pollution: sources, effects, and Water Pollution Control Act
Noise Pollution: sources and effects
Solid Waste Pollution: sources and impacts
Concept of integrated pollution control

Unit III	E-Waste Management	(06 Hours)

Introduction to E-Waste: Definition, composition, and sources of e-waste, Global context of e-waste generation, Major pollutants and their hazardous properties, Effects of e-waste on human health and the environment

E-Waste Management Principles: Basic principles and hierarchy of e-waste management, Technologies for resource recovery from e-waste, Mechanical processing and material recovery techniques, Occupational and environmental health perspectives, E-waste recycling scenario in India

Unit IV	E-Waste Control, Laws, and Regulatory Framework	(06 Hours)

Regulatory and Legal Measures: Need for health and environmental protection laws in India, E-Waste Management Rules, 2016 and amendments, Extended Producer Responsibility (EPR), Import/export permissions and compliance, Administrative and engineering controls

Sustainable E-Waste Management: Role of government, industry, and citizens, Monitoring and enforcement mechanisms, Strategies for reduction of waste at source, Strengthening of regulatory mechanisms through technical expertise

Learning Resources

Text Books:

1. Odum, Eugene P. “Fundamentals of Ecology”
2. R. Rajagopalan, “Environmental Studies – From Crisis to Cure”, Oxford
3. Johri R., E-waste: implications, regulations, and management in India and current global best practices, TERI Press, New Delhi

Reference Books:

1. Erach Bharucha, “Textbook of Environmental Studies”, UGC
2. Anubha Kaushik and C.P. Kaushik, “Environmental Studies”, New Age International