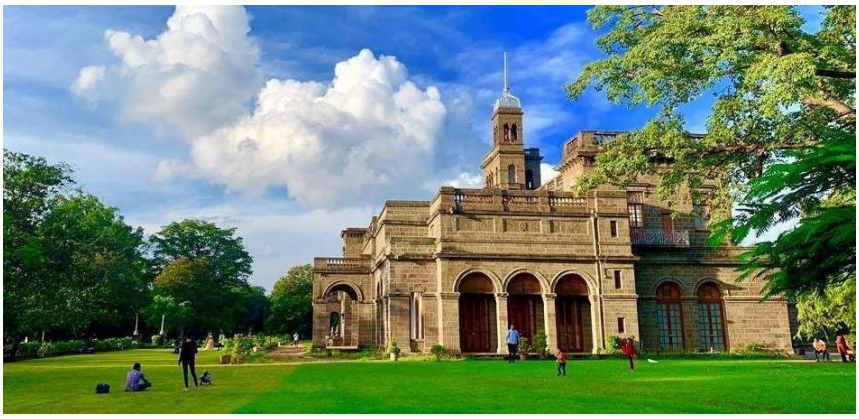
सावित्रीबाई फुले पुणे विद्यापीठ

Savitribai Phule Pune University, Pune, Maharashtra, India

Faculty of Science and Technology



National Education Policy (NEP)-2020 Compliant Curriculum

Second Year Engineering (2024 Pattern)

Production Engineering / Production Sandwich 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
Dr K R Borole	Dr N K Kamble
Dr R S Katikar	Dr V M Deshpande
Dr S S Sarnabot	Mr Nilesh Bagul
Dr S S Patil	

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.

Curriculum for Second Year of Engineering – Robotics and Automation Engineering (2024 Pattern)

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)

Production Engineering / Production Sandwich 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-PEE	PCC	Mathematics III	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-202-PEE	PCC	Manufacturing processes	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-203-PEE	PCC	Heat and Fluid Engineering	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-202A-PEE	PCC	Manufacturing processes Lab	-	-	4	-	-	25	50	-	**75**	-	-	2	**2**
PCC-203A-PEE	PCC	Heat and Fluid Engineering Lab	-	-	2	-	-	25	-	25	**50**	-	-	1	**1**
	OEL	*Open Elective – I	2	-	-	15	35	-	-	-	**50**	2	-	-	**2**
MDM-231-PEE	MDM	Material Science	2	-	-	30	70	-	-	-	**100**	2	-	-	**2**
EEM-241-PEE	EEM	Engineering Economics	-	1	2	-	-	25	-	-	**25**	1	-	1	**2**
VEC-251-PEE	VEC	Universal Human Values	2	-	-	15	35	-	-	-	**50**	2	-	-	**2**
CEP-261-PEE	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)

Production Engineering / Production Sandwich 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- PEE	PCC	Industrial Electronics and Electrical Machines	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-205- PEE	PPC	Theory of Machines	3	-	-	30	70	-	-	-	**100**	3	-	-	**3**
PCC-206-PEE	PPC	Design of Machine Elements	2	-	-	30	70	-	-	-	**100**	2	-	-	**2**
PCC-204A-PEE	PCC	Industrial Electronics and Electrical Machines Lab	-	-	2	-	-	25	25	-	**50**	-	-	1	**1**
PCC-206A-PEE	PCC	Design of Machine Elements Lab	-	-	2	-	-	-	-	25	**25**	-	-	1	**1**
	OEL	*Open Elective - II	2	-	-	15	35	-	-	-	**50**	2	-	-	**2**
MDM-232- PEE	MDM	Hydraulics and Pneumatics	2	-	-	30	70	-	-	-	**100**	2	-	-	**2**
VSE- 252- PEE	VSEC	Measurement Lab	-	-	2	-	-	-	25	-	**25**	-	-	1	**1**
VSE- 253- PEE	VSEC	Creative Problem Solving and Critical Thinking	-	-	2	-	-	25	-	-	**25**	-	-	1	**1**
ACE-261-PEE	ACE	Modern Indian Languages (Marathi/Hindi)	-	1	2	-	-	50	-	-	**50**	-	1	1	
EEM-242- PEE	EEM	Behavioural Science	-	1	2	-	-	25	-	-	**25**	-	1	1	**1**
VEC-252-PEE	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
Second Year of Engineering (2024 Pattern)

Course Code: PCC-201-PEE

Course Name: Mathematics III

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

Prerequisite Courses, if any:

- Differential and Integral calculus, Differential equations of first order and first degree, Fourier series, Collection, classification and representation of data, Permutations & combinations and Vector algebra

Course Objectives:

To make the students familiarize with concepts and techniques in Ordinary & Partial differential equations, Laplace transform & Fourier transform, Statistical methods, Probability theory and Vector calculus. The aim is to equip them with the techniques to understand advanced level mathematics and its applications that would enhance analytical thinking power, useful in their disciplines.

Course Outcomes:

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

1. Solve higher order linear differential equations and its applications to model and analyze mass spring systems.
2. Apply Integral transform techniques such as Laplace transform and Fourier transform to solve differential equations involved in vibration theory, heat transfer and related mechanical engineering applications.
3. Apply Statistical methods like correlation, regression in analyzing and interpreting experimental data applicable to Reliability engineering and probability theory in testing and quality control.
4. Perform Vector differentiation and integration, analyze the vector fields and apply to fluid flow problems.
5. Solve Partial differential equations such as wave equation, one and two dimensional heat flow equations

Course Contents

Unit I	Linear Differential Equations (LDE) and Applications	(07 Hours)

LDE of nth order with constant coefficients, Complementary Function, Particular Integral, General method, Short methods, Method of variation of parameters, Cauchy's and Legendre's DE, Simultaneous and Symmetric simultaneous DE. Modelling of mass-spring systems, free and forced damped and undamped systems.

Unit II	Transforms	(07 Hours)

Laplace Transform **(LT):** LT of standard functions, properties and theorems, Inverse LT, Application of LT to solve LDE.
Fourier Transform **(FT):** Fourier integral theorem, Fourier transform, Fourier Sine & Cosine transform, Inverse Fourier Transforms.

Unit III	Statistics	(07 Hours)
Measures of central tendency, Measures of dispersion, Coefficient of variation, Moments, Skewness and Kurtosis, Curve fitting: fitting of straight line, parabola and related curves, Correlation and Regression, Reliability of Regression Estimates.		
Unit IV	**Probability and Probability Distributions**	**(06 Hours)**
Probability, Theorems on Probability, Bayes Theorem, Random variables, Mathematical Expectation, Probability distributions: Binomial, Poisson, Normal, Test of Hypothesis: Chi-Square test, t-distribution		
Unit V	**Vector Calculus**	**(06 Hours)**
Vector differentiation, Gradient, Divergence and Curl, Directional derivative, Solenoidal and Irrotational fields, Vector identities. Line, Surface and Volume integrals, Green's Lemma, Gauss's Divergence theorem and Stoke's theorem.		

Learning Resources

Text Books:

1. Higher Engineering Mathematics by B.V. Ramana (Tata McGraw-Hill).
2. Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi)

Reference Books:

1. Advanced Engineering Mathematics, 10e, by Erwin Kreyszig (Wiley India).
2. Advanced Engineering Mathematics, 2e, by M. D. Greenberg (Pearson Education).
3. Advanced Engineering Mathematics, 7e, by Peter V. O'Neil (Cengage Learning).
4. Differential Equations, 3e by S. L. Ross (Wiley India).
5. Introduction to Probability and Statistics for Engineers and Scientists, 5e, by Sheldon M. Ross (Elsevier Academic Press)
6. Partial Differential Equations for Scientists and Engineers by S. J. Farlow (Dover Publications, 1993)

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

Course Code: PCC-202-PEE

Course Name: Manufacturing processes

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

Prerequisite Courses, if any:

Basic Mechanical Engineering, Physics

Course Objectives:

To make students understand the concepts and basic mechanics of metal casting, metal cutting, working of standard machine tools such as lathe, milling, drilling and allied machines, grinding and allied machines and super-fininshing processes along with additive manufacturing.

Course Outcomes:

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

1. Understand working principles and operations of sand casting process
2. Understand working principles and operations of metal cutting processes
3. Demonstrate operations/tooling and kinematics of conventional machines.
4. Select appropriate joining process for a given application
5. Identify applications of additive manufacturing processes

Course Contents

Unit I	Casting processes	(07 Hours)

Introduction, Solidification: progressive and directional solidification; rate of solidification; Chvorinov's Rule, Riser design, gating system: types, characteristics, and design, pattern design, moulding and core making processes, melting and fluidity, casting design consideration, Inspection and Quality Control

Unit II	Metal Joining	(07 Hours)

Survey of welding and allied processes. Gas welding and cutting, process and equipment. Arc welding: Power sources and consumables. TIG and MIG processes and their parameters. Resistance welding-spot, seam projection etc. Other welding processes such as atomic hydrogen, submerged arc, electroslag, friction welding. Soldering & Brazing. Adhesive bonding. Weld decay in HAZ.

Unit III	Machine Tools-I: Lathe and Milling	(07 Hours)
Lathe: Lathe, Specifications, Parts of lathe machine, accessories, Kinematics of lathe, Turret and Capstan lathe, various lathe operations Milling: Classification of milling machines, Various Milling operations, Indexing,		
Unit IV	**Machine Tools-II: Drilling and Grinding**	**(06 Hours)**
Drilling: Types of drilling machines, specifications, parts of drilling machine, Difference between drilling, boring & reaming, Boring operations & boring machines. Grinding: Types of grinding machines, specifications, cylindrical, surface, centerless grinding, Grinding operations, Grinding wheels and their selection.		
Unit V	**Super finishing processes**	**(06 Hours)**
Honing, Lapping, Buffing, Polishing, Tumbling, Electroplating, Galvanizing, Metal spraying, Hot dipping and Burnishing. Study of input process parameters of above processes.		

Learning Resources

Text Books:

1. S.K. Hajra Choudhury, A.K. Hajra Choudhury, Nirjhar Roy, "Elements of Workshop Technology" Vol I , II, Media Promoters, ISBN-10: 8185099154
2. S.K. Hajra Choudhury, A.K. Hajra Choudhury, Nirjhar Roy, "Elements of Workshop Technology" Vol I , Media Promoters, ISBN-10: 8185099154
3. Khanna O.P., "Welding Technology", Dhanpat Rai& sons, 1996.
4. Khanna O.P., " Foundry Technology", Dhanpat Rai& sons, 1999. Welding process and Technology", 2ed. Khanna Publishers, 1997.
5. Rao P. N., "Manufacturing Technology & Foundry, Forming & Welding", Vol I, II, Tata McGraw Hill Publishing Co., 2004, ISBN: 0 07 451863 1.
6. Jain R.K., "Production Technology", Khanna Publishers, 2008, ISBN 81-7409-099-1.
7. Sharma P.C., "A Text Book of Production Technology- Manufacturing Processes", S. Chand & Co., 2008, ISBN: 81-219-111-4-1.
8. Raghuwanshi B. S., "A course in Workshop Technology", Vol. I, II, Dhanpat Rai & Co. ISBN: 81-7409-099-1

Reference Books:

1. Chapman W .A. J., "Workshop Technology" Vol. I, II & III, Edward Arnold Publishers,1998, ISBN: 0 7131 3287
2. HMT, "Production Technology", Tata McGraw Hill Publishing Co., 1980. ISBN: 0-07- 096443-2
3. Degarmo, Black and Kosherth, "Materials & Processes in manufacturing", 8th Edition, Prentice Hall of India Ltd, Delhi, 2002. ISBN: 8126525223.
4. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011

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

Course Code: PCC-203-PEE

Course Name: Heat and Fluid Engineering

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

Prerequisite Courses, if any:

Engineering Mathematics I, Engineering Mathematics II.

Course Objectives:

The main objective of this unit is to introduce students to the fundamental thermodynamic and fluid mechanics physical laws, and develop in students the ability to apply these fundamental principles in thermal and fluid energy systems. It emphasizes understanding basic principles and applying them to practical situations using lab demonstrations. The aim is to give students the necessary skills to carry out basic design and performance analysis in the area of fluid statics, fluid motion, heat, and power system in steam and similar power plants, engines, and refrigeration systems. The thermal part will cover three thermodynamic laws and the application of thermodynamics laws in thermal analysis of engines, refrigerators/heat pumps, and power cycles. The fluid part deals with hydrostatic pressure and forces, flow along streamlines with and without friction, flow momentum and forces, similarity and modeling.

Course Outcomes:

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

1. Understand the basic principles and laws of fluid mechanics to recognize and analyze the type of fluid and fluid flow along with its application.
2. Develop the understanding of basic pressure measurement and its application in throughout fluid mechanics.
3. Analyse boiler and energy balance concept. Also understand the properties and behavior of steam and different types of fuels.
4. Understand basic working principle and application of Vapor compression cycle, turbines and compressor and analyze its performance characteristics.
5. Perform individually or in a group to formulate and solve the engineering problem and to conclude the result of the outcome.

Course Contents

Unit I	Introduction & Fluid properties	(06 Hours)

Definition of fluid, Newton's law of Viscosity, classification of fluid: Newtonian & Non -Newtonian fluids, Ideal & Real fluids, Fluid properties: viscosity, compressibility, cohesion, adhesion, surface tension, capillarity, vapour pressure, cavitation. (Numerical) Static's of Fluid, Pascal's law, Pressure on plane/curved surface, pressure measurements, Manometers, centre of pressure, metacentric height.

Unit II	Fluid Flow	(06 Hours)

Types of flow, examples, forces acting on fluid flow, Stream lines, Path lines, Streak lines. Velocity potential, Euler's equation of motion along a stream line, Bernoulli's equation, applications of Bernoulli's equation, orifice meter, venturimeter, Pitot tube(Numerical)

Unit III	Losses through pipes	(06 Hours)
Flow through pipes ,Laminar and turbulent flow through circular pipes, major loss-Darcy-Weisbach equation, minor losses, , water hammer, Buckingham's pie theorem, dimensionless numbers Fluid Machinery, Construction, working and applications of hydraulic turbines, centrifugal pumps and reciprocating pumps.		
Unit IV	**Fuels and lubricants**	**(06 Hours)**
Mass function, combustion equation, proximate and ultimate analysis of fuel, stoichiometric analysis of combustion products, volumetric and gravimetric analysis, types & properties of lubricants, flash point, fire point, viscosity, Vapour pressure Steam generators: Steam generation, steam properties, Babcock and Wilcox boiler, Cochran boilers (construction and working), boiler accessories, boiler performance, boiler efficiency, equivalent of evaporation and energy balance.(Numerical)		
Unit V	**Refrigeration**	**(06 Hours)**
Air refrigeration, vapour compression refrigeration system, various refrigerants used in refrigeration systems, their effect on environment		

Learning Resources

Text and Reference Books:

1. Bansal R.K., "Fluid Mechanics and Hydraulic Machines", 9th Edition, Laxmi Publication, 1990, ISBN 81-7008-311-7.
2. Jain A.K., "Fluid Mechanics including Hydraulic Machines", Khanna Publishers, 1990, ISBN 81-7409-194-7.
3. Munson, Young, Okiishi and Huebsch, "Fundamentals of Fluid Mechanics, Sixth Edition, Wiley – India Edition, 2010.
4. Kumar A., "Thermal Engineering", Narosa Publishing House, ISBN 97-88-1731-95281
5. Kothandaraman C. P., Khajuria P. P., Arora S. and Domkundawar S, "A course in Thermodynamics and heat engines (Thermal engineering with solar energy)", 3 ed.,Dhanpat Rai & sons, 1989.
6. Modi P. N. and Seth S. M, "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi, 1987.
7. Deshpande V. M., "Hydraulics Machinery Textbook of Fluid Machinery", Everest Publication, 1998.
8. Khurmi R. S. and Gupta J. K., "Textbook of Refrigeration and Air Conditioning", S. Chand Co.

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

Course Code: PCC-202A-PEE

Course Name: Manufacturing processes Lab

Teaching Scheme	Credit	Examination Scheme
Practical : 4 Hours/Week	**02**	**Practical : 50 Marks** **TW: 25 Marks**

Students have to perform mini-projects in workshop related to following topics

1. Job 1. Making simple solid pattern involving wood turning operation and preparing mould. (one job)
2. Job 2. Demonstration on MMA, TIG, MIG, Resistance welding (spot welding) and fabricate a job involve various welding processes like manual metal arc welding (MMA),TIG, MIG.(one job)
3. Job 3. Job involving various operations on lathe (step, taper turning, drilling, chamfering knurling etc.) and at list one operation on drilling machine, milling machine and cylindrical grinding. (one job)
4. Job 4: Prepare prototype using 3D Printing/additive manufacturing

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

Course Code: PCC-203A-PEE

Course Name: Heat and Fluid Engineering Lab

Teaching Scheme	Credit	Examination Scheme
Practical : 4 Hours/Week	**02**	**Practical : 50 Marks** **TW: 25 Marks**

List of Practical

1. Determining properties of fluids like viscosity, density, and surface tension using instruments such as viscometers and densitometers.
2. Analyzing laminar and turbulent flow in pipes, including experiments to measure pressure drops, flow rate, and velocity profiles (using manometers or pitot tubes).
3. Measuring the flow rate of a fluid through a Venturi meter to calculate velocity and discharge, and comparing with theoretical predictions.
4. Studying the performance characteristics of pumps and turbines, such as head-flow relationships, efficiency, and cavitation phenomena.
5. Determining the thermal conductivity of various materials (metals, insulations, etc.) using the steady-state or transient method.
6. Studying natural convection heat transfer using vertical and horizontal flat plates or cylindrical surfaces, typically involving temperature distribution along the surfaces.
7. Investigating the effectiveness of different types of heat exchangers (counter-flow, parallel-flow, shell and tube) and calculating parameters such as heat transfer rate and thermal resistance.

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

Course Code: MDM-231-PEE

Course Name: Materials Science

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

Prerequisite Courses, if any:

- Engineering Chemistry

Course Objectives:

This course aims to explore the knowledge in fundamentals of materials science. Studying with good knowledge about the semiconductors, solid solutions, Phase diagrams, mechanical properties, optical and magnetic properties of materials are very essential for materials scientists and engineers.

Course Outcomes:

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

1. Draw and explain equilibrium diagrams for various alloy systems
2. Define the mechanical properties of materials and conduct destructive and nondestructive tests to evaluate the properties of materials
3. Explain various aspects of applications of powder metallurgy
4. Impart knowledge of various heat treatment processes of metals.
5. Acquaint about types, characteristics and applications of different ferrous, non-ferrous metals and their alloys.

Course Contents

Unit I	Fundamentals of materials science	(06 Hours)

Mechanism of plastic deformation, Hume Rothery's rules of solid solubility, Gibb's phase rule, Solidification, Dendritic growth, Cooling curves, Lever rule, Iron-Iron carbide equilibrium diagram, Critical temperatures, Allotropy, volume changes of pure iron, Non-equilibrium cooling of steel, Widmanstatten structures

Unit II	Material Testing	(06 Hours)

Destructive Tests: Evaluation of properties. Numerical based on Tension Test. Engineering stress - Strain curves of different materials. Compression Test, Cupping Test on Sheet metal, Hardness Tests: Brinell, Poldi, Vickers, Rockwell, Shore scleroscope, Durometer, Moh's test, Microhardness test, Impact tests. Non-destructive tests: Visual Inspection, Magna flux test Dye penetrant test, Sonic and Ultrasonic test, Radiography, Eddy current test

Unit III	Ferrous metals and alloys	(06 Hours)
Classification and applications of steels, specifications of some commonly used steels, Heat treatment processes, Surface Hardening processes, Alloy Steels and Cast Irons		
Unit IV	**Non-Ferrous Alloys**	**(06 Hours)**
Copper alloys: Brasses, Bronzes, Tin alloys, Aluminium alloys Beryllium, Silicon Copper nickel alloys, Nickel - Silver, Solders, Bearing materials and their applications, Precipitation hardening alloys		

Learning Resources

Text and Reference Books:

1. Kodgire V. D., “Material Science and Metallurgy for Engineers”, Everest Publishing House, Pune, 2008, ISBN 81-86314-00-8.
2. Smith W.F., “Principles of Material Science and Engineering”, McGraw Hill Book Co., 2002.ISBN: 0070591695
3. Davis H. E., Troxell G.E. and Wiskocil C. T., “Testing of Engineering Materials”, McGraw Hill Book Co.ISBN:0070662479
4. Van Vlack L.H., “Elements of Material Science”, Addison- Wesley Publishing Co., 1998.ISBN: 8131706001
5. 5. Murthy, “Structure and properties engineering materials”, Tata McGraw Hill 2003.ISBN: 007048287X
6. Donald R. Askland, Phule P. P., “Science and engineering of materials”, Thomson Learning, 2003.ISBN: 0534553966

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

Course Code: EEM-241-PEE

Course Name: Engineering Economics

Teaching Scheme	Credit	Examination Scheme
Tutorial : 1 Hour/Week **Practical : 2 Hour/Week**	**02**	**Term work : 25 Marks**

Prerequisite Courses, if any:

- Basic Mathematics (no specialized prerequisites).

Course Objectives:

The course aims to

1. Introduce fundamental economic concepts relevant to engineering.
2. Equip students with methods to economically evaluate engineering projects.
3. Provide fundamental knowledge on cost estimation and break-even analysis.
4. Explain various depreciation methods and their importance in economics.
5. Introduce basics of replacement analysis and risk considerations.
6. Provide insights into contemporary economic issues affecting engineering decisions.

Course Outcomes:

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

1. Apply fundamental economic concepts to engineering scenarios.
2. Perform economic evaluation of projects using cash-flow techniques.
3. Conduct basic cost estimations and break-even analyses for decision-making.
4. Calculate depreciation and understand its impact on project economics.
5. Analyze basic replacement decisions and understand associated risks.
6. Discuss contemporary economic issues and their implications in engineering.

Course Contents

Unit I	Fundamental Economic Principles	(02 Hours)

Importance of Engineering Economics, Basic economic concepts: Demand, Supply, Market Equilibrium, Time value of money: Interest types (Simple and Compound).

Unit II	Economic Evaluation of Engineering Projects	(03 Hours)

Cash Flow diagrams, Economic evaluation methods: Present Worth (PW), Future Worth (FW), Annual Worth (AW), Internal Rate of Return (IRR)
Payback Period (basic numerical examples).

Unit III	Cost Estimation and Break-even Analysis	(02 Hours)

Types of costs: Fixed, Variable, Marginal, Average
Basic cost estimation methods (overview)
Break-even analysis and practical applications (numerical examples).

Unit IV	Depreciation Methods	(02 Hours)
Depreciation: Purpose and significance Depreciation calculation: Straight Line method, Declining Balance method (simple numerical problems)		
Unit V	**Replacement Analysis and Risk Considerations**	**(02 Hours)**
Basics of replacement analysis (concept and criteria) Risk and uncertainty in economic analysis (conceptual overview and basic examples)		

Learning Resources

Text and Reference Books:

6. Leland Blank & Anthony Tarquin, "Engineering Economy," McGraw-Hill Education.
7. Donald G. Newnan & Jerome P. Lavelle, "Engineering Economic Analysis," Oxford University Press.
8. Chan S. Park, "Fundamentals of Engineering Economics," Pearson Education.

Savitribai Phule Pune University
Second Year of Engineering (2024 Pattern)
Course Code: VEC-252- PEE
Course Name: Universal Human Values

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

Prerequisite Courses, if any:

- No Prerequisite required.

Course Objectives:

The course aims to

1. To provide students a space for guided self-reflection on their life goals and behavior.
2. To help students understand the interconnectedness of self, relationships, society, and nature.
3. To enable students to analyze and align their lifestyle with universal human values.
4. To foster ethical, sustainable, and empathetic thinking for personal and professional development.

Course Outcomes:

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

1. Differentiate between material and non-material needs and assess their lifestyle accordingly.
2. Build and sustain meaningful relationships based on trust, respect, and empathy.
3. Recognize their individual role in contributing to a responsible and sustainable society.
4. Practice ethical reasoning in life and profession.
5. Define a personal action plan aligned with values like compassion, self-leadership, and contribution.

Course Contents

Week 1	**Orientation & Self-Exploration**	**(04 Hours)**
Icebreakers, values clarification, reflective journaling: “What really matters to me?”		
Week 2	**Understanding the Self and Human Aspirations**	**(04 Hours)**
Desire mapping (material vs. non-material), guided journaling: What makes me feel fulfilled?		
Week 3	**Harmony in Relationships**	**(04 Hours)**
Trust walk, appreciation circle, letter-writing (to a parent/peer expressing respect or gratitude)		
Week 4	**Living with Others – Society and Cooperation**	**(04 Hours)**
Circle dialogue: My role in society, collaborative challenge activity		
Week 5	**Harmony with Nature**	**(04 Hours)**
Campus/Nature walk, sustainability reflection, creating a “zero-waste” lifestyle plan		
Week 6	**Understanding and Practicing Empathy**	**(04 Hours)**
Role-play on perspectives, story-based empathy exercise, discussion: Walking in another’s shoes		
Week 7	**Ethics and Right Conduct in Daily Life**	**(04 Hours)**
Case studies, group ethical dilemma games, discussion on doing the right thing when it’s hard		

Week 8	Professional Ethics for Engineers	(04 Hours)

Video analysis: Ethics in tech, worksheet: What would I do?, team discussion on responsible Innovation		
Week 9	**Vision, Goals, and Inner Alignment**	**(04 Hours)**
Goal setting workshop, “Ideal Day” visualization, personal growth plan worksheet		
Week 10	**Presentation & Closure**	**(04 Hours)**
Group presentations: Value-based project or learning journal, reflection circle, course feedback		

Assignments / Portfolio Tasks

1. Who Am I? – Reflective Essay or Journal
2. Body vs Self Needs – Lifestyle Audit
3. Gratitude or Apology Letter – Strengthening relationships
4. Nature & Me – Reflection poster or report
5. Case Study on Ethical Decision – Role-play or analysis
6. Vision Board / Personal Life Map – Presentation or poster

Methods of Delivery

- Experiential activities and reflective writing
- Group discussions, value games, real-life role plays
- Visual journaling, short documentaries, storytelling
- Peer feedback and collaborative planning

References:

1. A Foundation Course in Human Values and Professional Ethics – R.R. Gaur et al.
2. NEP 2020 Vision Documents
3. Videos from AICTE-UHV, The Better India, TED Talks on empathy, ethics, sustainability

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

Course Code: CEP-261-PEE

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-based)

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)

Assign one faculty mentor per Student for regular guidance

Guidelines:

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
Second Year of Engineering (2024 Pattern)

Course Code: PCC-204-PEE

Course Name: Industrial Electronics and Electrical Machines

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

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.
6. Integrate electronics, controllers, sensors and actuators into real-world automation systems.

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.
6. Design and demonstrate simple automated systems using integrated control systems.

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 functions of several variables, Limit, Continuity and Partial Derivatives. Euler's Theorem on Homogeneous functions, Partial derivative of Composite Function, Total Derivative and Change of Independent variables.

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**	**(06 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 types and applications.		
Unit V	**Special Purpose Motors**	**(06 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. Ajay Deshmukh, "Microcontrollers: Theory & Applications," Tata McGraw Hill.
4. Electronics Devices by Thomas.` L. Floyd, 9th Edition, Pearson.

Reference Books:

1. Sensors and Transducers by D. Patrnabis, 2nd Edition, PHI
2. Smarajit Ghosh, “Electrical Machines”, Pearson Education, New Delhi.
3. Kenneth J. Ayala, ‘The 8051 Microcontroller’, Cengage Learning
4. Started with Arduino by Massimo Banzi and Michael Shiloh Published by Maker Media, Inc
5. A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, “Electrical Machines”, TataMcGraw Hill Publication Ltd. Fifth Edition.

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

Course Code: PCC-205-PEE

Course Name: Theory of Machines

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

Prerequisite Courses, if any:

- Basic mechanical Engineering, Engineering Mechanics.

Course Objectives:

The course aims to

1. To make the student conversant with commonly used mechanism for industrial application.
2. To acquaint students with basic concepts of belt drives and its applications.
3. To learn the students about types and applications of brakes and dynamometers
4. To develop competency in velocity analysis of mechanism by relative velocity and ICR methods.
5. To develop competency in acceleration analysis of mechanism by relative acceleration and Klein's construction.

Course Outcomes:

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

1. CO 1. Understand the basic knowledge of mechanism, their inversions and applications.
2. CO 2. Select best suitable belt drive system for mechanical systems.
3. CO 3. Understand the application of brakes, dynamometer in mechanical systems.
4. CO 4. Analyze velocity in mechanisms by graphical method
5. CO 5. Analyze acceleration in mechanisms by analytical and graphical method

Course Contents

Unit I	Fundamentals of Mechanism	(07 Hours)

Basics: Kinematic Link, Types of links, Difference between machines, mechanism and structure, Kinematics pair, Types of Constrained Motion, Classification of Kinematics Pairs, Inversions of kinematic chain, Degrees of freedom of mechanisms, Kutzbach and Grubler Criterion, Grasoff's law, Equivalent linkage concept,.

Mechanisms: Straight line mechanisms- Exact straight line and approximate straight line type, Intermittent Motion Mechanism, Steering gear mechanisms- Davis and Ackerman type.

Unit II	Static and Dynamic Force Analysis	(07 Hours)

Theory and analysis of Compound Pendulum, Concept of equivalent length of simple pendulum, Bifilar suspension, Trifilar suspension.

Dynamics of reciprocating engines: Two mass statically and dynamically equivalent system, correction couple, static and dynamic force analysis of reciprocating engine mechanism (analytical method only), Crank shaft torque.

Unit III	Belt Drives	(07 Hours)
Types of belt drives, Materials for Belt. Velocity Ratio, Slip, Creep of belt. Length of open and cross belt drive. Tension ratio, maximum tension in a belt, Centrifugal tension, Initial tension in belt, Maximum power transmitted, Power transmission and Ratio of driving tension for V- Belt drive (Numerical treatment expected)		
Unit IV	**Brakes and Dynamometers**	**(06 Hours)**
Brakes: Types of brakes, Force analysis of brakes, block brakes, self energize and self locking brakes, band brakes, band and block brakes, Internal expanding shoe brakes, braking torque. (Numerical treatment expected) Dynamometer: Different types of absorption and transmission dynamometers.		
Unit V	**Kinematic Analysis of mechanisms**	**(06 Hours)**
Concept of position, displacement and velocity of a point and link of a given mechanism, Kinematic analysis of mechanism by- Relative velocity method, Relative acceleration method , Instantaneous center of rotation method, Klein's construction,		

Learning Resources

Text and Reference Books:

1. S. S. Rattan, "Theory of Machines", Third Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. Bevan T, "Theory of Machines", Third Edition, Longman Publication
3. G. Ambekar, "Mechanism and Machine Theory", PHI
4. Sadhu Singh, "Theory of Machines", Pearson
5. Ghosh Malik, "Theory of Mechanism and Machines", East-West Pvt. Ltd.
6. Hannah and Stephans, "Mechanics of Machines", Edward Arnolde Publication
7. R. L. Norton, "Kinematics and Dynamics of Machinery", First Edition, McGraw Hill Education (India) P Ltd. New Delhi
8. Dr. V. P. Singh, "Theory of Machine", Dhanpatrai and Sons
9. C. S. Sharma & Kamlesh Purohit, "Theory of Machine and Mechanism", PHI
10. J. J. Uicker, G. R. Pennock, J. E. Shigley, "Theory of Machines and Mechanisms", Fifth Edition,International Student Edition, Oxford
11. R S Khurmi & J K Gupta "Theory of Machines" S. Chand Publication, New Delhi.

Links to online SWAYAM/NPTELCourses-

1) https://nptel.ac.in/courses/112105268

2) https://nptel.ac.in/courses/112104121

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

Course Code: PCC-206-PEE

Course Name: Design of Machine Elements

Teaching Scheme	Credit	Examination Scheme
Theory : 2 Hours/Week	03	CCE : 30 Marks End-Semester : 70 Marks

Prerequisite Courses, if any:

- :Basic mechanical Engineering, Engineering Mechanics,

Course Objectives:

The course aims to

1. To understand various design considerations, design procedure and select materials
2. for a specific application
3. To learn the design of various machine components such as shafts, couplings, keys.
4. To calculate the stresses in power screw due to various types of loads and study its failure.
5. To analyze the welded and threaded joints in mechanical systems subjected axial and eccentric loading.
6. To learn the design of various types of springs used in mechanical system.

Course Outcomes:

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

1. DESIGN AND ANALYZE the cotter and knuckle Joints, levers and components.
2. DESIGN shafts, keys and couplings under static loading conditions.
3. ANALYZE different stresses in power screws and APPLY those in the procedure to design screw jack.
4. EVALUATE & INTERPRET the stress developed on the different type of welded and threaded joints.
5. APPLY the design and development procedure for different types of springs.

Course Contents

Unit I	Design process and design of Simple Machine elements	(07 Hours)

Design Process : Machine Design, Design Process, Design considerations, Standards and codes, Use of preferred series, Factor of safety, Service factor.
Design of Simple Machine Parts : Design of Cotter joint, Knuckle joint, Levers - hand / foot lever, lever for safety valve, bell crank lever, curved beams of circular cross section and components subjected to eccentric loading.

Unit II	Design of Shafts and Gears	(07 Hours)

Shafts : Design considerations in Transmission shafts with spur gear and pulley , splined shafts, Shaft design on strength basis, Shaft design on torsional rigidity basis, A.S.M.E. code for shaft design,
Keys: Classification of keys, Design considerations in parallel and tapered sunk keys,

Design of square, flat and Kennedy keys, Splines.
Couplings: Design considerations, Classification, Design of Rigid, Muff coupling, Flange coupling and Flexible bushed pin coupling.
Gear design: Classification of gears, Selection of type of gears, Types of Gears

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 Springs	(06 Hours)

Mechanical Springs: Types, Applications and materials of springs, Stress and deflection equations for helical springs, Types of ends, Design of helical compression and tension springs, Springs in series and parallel, Helical torsion spring, surge in spring.

Unit V	Threaded and welded joints	(06 Hours)

Threaded Joints: Basic types of screw fasteners, Bolts of uniform strength, I.S.O. Metric screw threads, Bolts under tension, Eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt, Eccentric load on circular base. Design of Turn Buckle.
Welded Joints : Welding symbols, Stresses in butt and fillet welds, Strength of butt, parallel and transverse fillet welds, Axially loaded unsymmetrical welded joints, Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments.

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 Engineering (2024 Pattern)

Course Code: PCC-204A-PEE

Course Name: Industrial Electronics and Electrical Machines Lab

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

List of Practical:

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 Engineering (2024 Pattern)

Course Code: PCC-206A- PEE

Course Name: Design of Machine Elements Lab

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

List of Practical

1. Design of shaft and detail drawing using any CAD software
2. Design of helical spring and detail drawing using any CAD software
3. Design of spur gear and detail drawing using any CAD software
4. Design of power screw and detail drawing using any CAD software
5. Design of welded joint
6. Design of threaded joints
7. Complete design case study of gear box design and detail drawing using any CAD software

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

Course Code: MDM-232-PEE

Course Name: Hydraulics and Pneumatics

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

Prerequisite Courses, if any:

- Engineering Mechanics, Engineering Chemistry

Course Objectives:

The course aims to

1. To introduce the fundamental principles, structure, advantages, and limitations of hydraulic and pneumatic fluid power systems.
2. To study the construction, classification, and working principles of hydraulic pumps and actuators.
3. To understand the construction and function of control components such as valves in hydraulic systems.
4. To develop the ability to design, interpret, and analyze various hydraulic circuits used in industrial applications.

Course Outcomes:

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

1. Explain the structure, benefits, limitations, and governing laws of hydraulic and pneumatic systems.
2. Describe the construction, working principles, and selection criteria of hydraulic pumps and actuators.
3. Identify and explain various types of control valves and their symbolic representations in hydraulic systems.
4. Design and analyze hydraulic circuits including accumulator, intensifier, sequencing, and safety circuits.

Course Contents

Unit I	Fundamentals of Fluid Power and Pumps	(06 Hours)

Introduction to hydraulics and pneumatics: Structure, advantages, and limitations
Properties of fluids, types of fluids for hydraulic systems, governing laws
Pneumatics: Definition, advantages, limitations, applications
Choice of working medium and characteristics of compressed air
Structure of pneumatic control system, fluid conditioners and FRL unit
Classification of pumps: Pumping theory of positive displacement pumps
Construction and working of gear, vane, and piston pumps

Unit II	Control Components in Hydraulic Systems	(06 Hours)

Classification of control valves. Directional control valves: Symbolic representation and types (poppet, sliding spool, rotary), Solenoid and pilot-operated DCVs, shuttle valves, check valves, Pressure control valves: Types, direct and pilot-operated, Flow control valves: Compensated and non-compensated types

Unit III	Hydraulic Actuators and Motors	(06 Hours)

Classification of actuators
Linear hydraulic actuators (cylinders): Single-acting and double-acting cylinders
Construction and working of hydraulic cylinders
Hydraulic motors: Types, selection, and characteristics

Unit IV	Hydraulic Circuit Design and Analysis	(06 Hours)

Control of single and double-acting hydraulic cylinders
Regenerative circuits, pump unloading circuits
Counterbalance valve applications, cylinder sequencing circuits
Automatic cylinder reciprocating system, speed control of cylinders and motors, Safety circuits
Accumulators: Types, construction, applications with circuits, Intensifier circuits and applications

Learning Resources

Text and Reference Books:

1. Mujumdar S.R., Pneumatic Systems, Tata McGraw Hill, 2002 Edition. ISBN: 9780074602317
2. Fluid Power: Generation, Transmission and Control, Wiley, 2018, ISBN: 9788126539543
3. Peter Rohner, Industrial hydraulic control, Hydraulic Supermarket, 2005, ISBN 978-0958149310
4. Bolton W., Mechatronics Electronic Control Systems in Mechanical and Electrical Engineering, Pearson, Education (Singapore) Pvt Ltd., ISBN 81-7808-339-6.
5. Esposito Anthony, Fluid power with Applications, Pearson, ISBN: 978-81-7758-580-3

Savitribai Phule Pune University
Second Year of Engineering (2024 Pattern)
Course Code: VSE- 252- PEE
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: (Any 6)

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: AEC-271- PEE

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

Tutorial: 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

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

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

Problem-Solving Frameworks

Tutorial: 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

Tutorial: Decision trees, cost-benefit analysis, Pugh matrix

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

Innovation and Lateral Thinking

Tutorial: Edward de Bono’s Six Thinking Hats, TRIZ basics

Practical: Role-play thinking hats, reverse thinking challenge

Communicating Ideas

Tutorial: 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- PEE

Course Name: Behavioural Science

Teaching Scheme	Credit	Examination Scheme
Tutorial : 1 Hour/Week Practical : 2 Hours/Week	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

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

Emotional Intelligence & Self-Awareness

Tutorial Topics:

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

Practical Activities:

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

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

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

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

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-PEE
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		