Savitribai Phule Pune University, Pune

Maharashtra, India

Faculty of Science and Technology

National Education Policy (NEP)-2020 Compliant Curriculum

SE - Second Year Engineering (2024 Pattern) in

AUTOMATION & ROBOTICS ENGINEERING

(With effect from Academic Year 2025-26)

Contents

Nomenclature

AEC	Ability Enhancement Courses
AICTE	All India Council for Technical Education
AUR	Automation & Robotics Engineering
CO	Course Outcome
CEP	Community Engagement Project
CCE	Comprehensive Continuous Evaluation
HSSM	Humanities, Social Science, and Management
MDM	Multidisciplinary Minor
MEC	Mechanical Engineering
MOOC	Massive Open Online Course
NPTEL	National Programme on Technology Enhanced Learning
OEL	Open Elective
PCC	Program Core Course
PEO	Program Educational Objectives
PSO	Program Specific Objectives
SWAYAM	Study Webs of Active-learning for Young Aspiring Minds
UGC	University Grants Commission
VEC	Value Education Course
VSE	Vocational Skill Course
WK	Knowledge and Attitude Profile

Preface by Board of Studies

Dear Students and Teachers,

We, the members of the Board of Studies - Mechanical, Automobile and Automation & Robotics Engineering, are very happy to present the Second Year Automation & Robotics Engineering syllabus, effective from the Academic Year 2025-26 (2024 Pattern). We are confident that you will find this syllabus both interesting and challenging. The present curriculum will be implemented for Second Year Engineering from the academic year 2025-26, and it will be subsequently extended to the Third and Final Years in the academic years 2026-27 and 2027-28, respectively.

Automation & Robotics Engineering is one of the most sought-after branches among engineering students, which necessitates continuous revision and up gradation of the syllabus. Automation & Robotics Engineering is a dynamic discipline that integrates principles from core engineering fields and supports innovation across manufacturing, design, energy, materials, and automation. This curriculum is designed to provide students with a comprehensive understanding of the fundamentals, emerging technologies, and practical applications in Automation & Robotics Engineering, while also equipping them to meet the demands of a rapidly evolving industry.

The revised syllabus aligns with the vision of NEP-2020, and conforms to the frameworks set by Savitribai Phule Pune University, AICTE New Delhi, UGC, and various accreditation agencies. It takes into account recent technological developments, innovations, and industry needs to ensure students are well prepared for professional challenges.

Wherever applicable, additional learning resources such as NPTEL and SWAYAM links are provided at the end of each course. Students are encouraged to utilize these platforms for self-learning, engage in online courses, and undertake additional projects to enhance their knowledge and skill set. On successful completion, they are advised to submit their course certifications, which will further support and enrich their academic growth.

This curriculum is the result of collaborative efforts involving academic experts, industry professionals, and alumni to ensure relevance and excellence. It is designed not only to meet current industry expectations but also to prepare students for higher studies, research, and entrepreneurial ventures in the field of Automation & Robotics Engineering.

We hope this curriculum inspires students to become technically competent professionals, responsible citizens, and contributors to the technological and sustainable advancement of society.

Dr. Pradeep A. Patil
Chairman,
Board of Studies - Mechanical, Automobile and Automation & Robotics Engineering

Department of Automation & Robotics Engineering

Program Educational Outcomes (PEO)

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

- **PEO1:** The graduates will possess an ability to work in diversified fields along with team work and leadership qualities.
- **PEO2:** The graduates will have successful career with strong technical, research & professional skills.
- **PEO3:** The graduates will continue to learn and to adapt in a society of constantly evolving technological environment.

Program Specific Outcomes (PSO)

Program Specific Outcomes (PSOs) define the specific skills, knowledge, and abilities that students should acquire within a particular program of study at the time of graduation. PSOs are distinct from broader Program Outcomes (POs), which represent general graduate attributes.

- **PSO1:** Design and develop robotic systems from concept to realization for diverse applications by applying analytical thinking, logical reasoning, and problem-solving skills.
- **PSO2:** Develop the AI-powered cutting-edge technologies to create innovative and sustainable automation solutions for industrial and societal needs.
- **PSO3:** Exhibit domain expertise through impactful research in robotics, control systems, and autonomous technologies to solve real-world problems in sectors such as manufacturing, healthcare, and intelligent systems.

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 Automation & Robotics, graduating students/graduates will be able to:

PO No.	Title	Program Outcome Description
PO1	Engineering Knowledge	Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop the solution of complex engineering problems.
PO2	Problem Analysis	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
PO3	Design / Development of Solutions	Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for public health and safety, whole-life cost, net zero carbon, culture, society and environment. (WK5)
PO4	Conduct Investigations of Complex Problems	Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)
PO5	Engineering Tool Usage	Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling, recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
PO6	The Engineer and The World	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7)
PO7	Ethics	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	Individual and Collaborative Team Work	Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	Communication	Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	Project Management and Finance	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects in multidisciplinary environments.
PO11	Life-Long Learning	Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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) FormatUndergraduate Engineering Programs Graduate Attributes and Professional Competencies Version 4.0 (GAPC V4.0) - (August 2024) Page 55-56

General Rules and Guidelines

Term	Definition
Course Outcomes (COs)	Course Outcomes are narrower statements that describe what students are expected to know and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire throughout 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 (PEOs)** and **Program Outcomes (POs)**.
Evaluation	Evaluation is one or more processes, performed by the **Evaluation Team**, to interpret the data and evidence gathered through assessment practices. It determines how well PEOs or POs are being achieved, and informs decisions for improvement.

Assessment and Evaluation:

Assessment and Evaluation shall be conducted in two parts:
1. Comprehensive Continuous Evaluation (CCE)
2. End-Semester Examination (ESE)

Component	Description	Marks
Comprehensive Continuous Evaluation (CCE)	Conducted at institute level, covering all Units of the syllabus. The design and mark allocation follow the Continuous Assessment Sheet structure.	15 to 35
End-Semester Examination (ESE)	Conducted at university level, typically covering the entire syllabus through summative examination.	70
	Total Marks per Subject	**100**

A) Comprehensive Continuous Evaluation (CCE)

To design a Comprehensive Continuous Evaluation (CCE) scheme for a theory subject of 30 marks with the specified parameters, the allocation of marks and the structure can be as per continuous assessment sheet;

Savitribai Phule Pune University																				
Board of Studies (Mechanical and Automobile Engineering)																				
Comprehensive Continous Evaluation																				
Class: SE A													Subject: Fluid Mechanics							
Exam Seat No.	Roll No.	Name of Student	Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Cumulative Sum				30 Marks Distribution				Marks obtained out
			Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Internal Test	Attendance	Field Activity	Quiz	Internal Test	Attendance	
			A	B	C	D	E	F	G	H	I	J	SUM(A+C+E+G+I)	SUM(B+D+F+H+J)							
			10	10	10	10	10	10	10	10	10	10	50	50	50	100	15	5	5	5	30
S9970160753	2020	AMOGH M SHINDE	8	8	8	8	8	8	8	8	8	8	40	40	40	75	12	4	4	3.75	23.75

Figure 1 Template Comprehensive Continuous Evaluation (CCE), Click here for excel Template

Field Activities / Home Assignments

Field activities and home assignments are essential components of experiential learning. Under this head, course projects, industrial visits, and guest lectures are to be incorporated. For each unit, one such activity should be designed and executed to reinforce theoretical learning through practical exposure.

1. **Course Projects**

   Course Projects should be framed based on real-world problems relevant to the subject. Each course project must be communicated through one of the following modes. It is recommended to complete all the communication modes across different course projects:

- **Poster Presentation**
- **PowerPoint Presentation**
- **Model Making**
- **Field or Survey Report with Oral Presentation** (e.g., case study)
- **Submission of Digital Content (e.g. Video Summary)**

To evaluate these field activities, **assessment rubrics** should be designed. The rubrics should include criteria such as clarity, innovation, subject relevance, presentation skills, and technical content.

Note: Part of work of any co-curricular activities (relevant to subject contents) like national level project competitions, club activities, paper presentations, startup activities can be accepted as a course projects.

2. **Industrial Visit**

An industrial visit should be planned in alignment with the subject's scope and should particularly address advancements in the respective field. The purpose is to provide students exposure to actual engineering practices and systems.

Assessment of industrial visits should be carried out using any of the following tools:

- Quiz (based on the visit)
- Interactive video or oral discussion
- Submission of a detailed visit report

3. **Guest Lectures**

Guest lectures should be relevant to the course and highlight advanced topics or recent trends in the field. Subject experts from academia or industry may be invited.

Assessment methods for guest lectures may include:

- Quiz conducted post-lecture
- Attendance monitoring
- Evaluation of attentiveness and participation

Rubrics can be developed, if possible, to objectively assess student involvement in guest lectures.

4. **Quiz**

Unit-wise quizzes should be planned and can be conducted either **online** (via LMS, Google Forms) or **offline**. Each quiz should include a **pool of 20 questions**, from which **students are required to attempt any 10**. The quizzes should be diversified across the following question types:

- Simple Multiple Choice Questions (MCQs)
- Numerical MCQs
- Image-based Questions
- Match the Following
- Fill in the Blanks

- Drag and Drop (using images or words)

This variety ensures the assessment caters to different cognitive skills and learning styles.

5. Internal Tests

Two major internal tests should be conducted as follows:

1. **Midterm Examination**: This should cover **Unit I and Unit II**, and should include questions targeting **Bloom's Taxonomy Levels 2, 3, and 4** (UNDERSTAND, APPLY, and ANALYZE).
2. **End term Examination**: This should cover the **remaining units** and should also include questions mapped to **BL Levels 2, 3, and 4**.

B) End-Semester Examination (ESE)

- **Detailed Scheme for 70 Marks:**
  - **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.

- **Detailed Scheme for 35 Marks:**
  - **Unit-Wise Allocation (08 Marks for Unit 1, 09 Marks for Unit 2, Unit 3 and Unit 4):** 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.

Curriculum Structure - Semester III

NEP 2020 Compliant Curriculum Structure

Second Year Engineering (2024 Pattern) - Automation & Robotics Engineering

Level 5.0														
Course Code	Course Type	Course Name	Teaching Scheme (Hr/week)			Examination Scheme and Marks						Credit			
			Theory	Practical	Tutorial	CCE	End-Semester	Term Work	Practical	Oral	Total	Theory	Practical	Tutorial	Total
PCC201AUR	Major Course-1	Materials and Machine Elements	3			30	70				**100**	3	-	-	**3**
PCC202AUR	Major Course-2	Industrial Electronics & Controls	3			30	70				**100**	3	-	-	**3**
PCC203AUR	Major Course-3	Manufacturing Technology	3			30	70				**100**	3	-	-	**3**
PCC204AUR	Major Course-3A	Material Testing and Characterisation Laboratory		2					50		**50**	0	1	-	**1**
MDM221AUR	Multidisiplinary Course-1	Engineering Mathematics - III	3			30	70				**100**	3	-	-	**3**
MDM222AUR	Multidisiplinary Course-1A	Industrial Electronics & Controls Laboratory		2					50		**50**	0	1	-	**1**
	Open Elective-I	Open Elective-I	2			15	35				**50**	2	-	-	**2**
VSE231AUR	Vocational Skill Course	Workshop Practices		2					25		**25**	0	1	-	**1**
HSSM232AUR	Enterpreneurship/ Management course	Enterpreneurship Development and Innovation	1			25					**25**	1	-	-	**1**
VEC233AUR	Value Education Course	Universal Human Values	2			15	35				**50**	2	-	-	**2**
CEP241AUR	Comunity Engagement Project	Community Enagagement activity / Field Project		4				25		25	**50**	0	2	-	**2**
		Total =	**17**	**10**	**-**	**175**	**350**	**25**	**125**	**25**	**700**	**17**	**5**	**-**	**22**

CCE: Comprehensive Continuous Evaluation

Note: Students can opt for Open Electives offered by different faculties such as Arts, Science, Commerce, Management, Humanities, or Inter-disciplinary studies.

• Open Elective I:

Students may choose courses like Financial *Accounting, Digital Finance, or Digital Marketing* from Commerce and Management faculty.

Curriculum Structure - Semester IV

NEP 2020 Compliant Curriculum Structure

Second Year Engineering (2024 Pattern) - Automation & Robotics Engineering

Level 5.0															
Course Code	Course Type	Course Name	Teaching Scheme (Hr/week)			Examination Scheme and Marks						Credit			
			Theory	Practical	Tutorial	CCE	End-Semester	Term Work	Practical	Oral	Total	Theory	Practical	Tutorial	Total
PCC251AUR	Major Course-4	Principles of Robotics	3			30	70				**100**	3	-	-	**3**
PCC252AUR	Major Course-5	Kinematics of Machines	3			30	70				**100**	3	-	-	**3**
PCC253AUR	Major Course-6	Electric Drives for Automation Systems	3			30	70				**100**	3	-	-	**3**
PCC254AUR	Major Course-4A	Robots & Drive System Laboratory		2					25		**25**	0	1	-	**1**
PCC255AUR	Major Course-6A	Kinematics of Machines Laboratory		2					25		**25**	0	1	-	**1**
MDM271AUR	Multidisiplinary Course-2	Artificial Intelligence & Machine Learning	2			50					**50**	2	-	-	**2**
	Open Elective-II	Open Elective-II	2			15	35				**50**	2	-	-	**2**
VSE281AUR	Vocational & Skill Enhancement Course	Product Development Laboratory		2					50		**50**	0	1	-	**1**
VSE282AUR	Vocational & Skill Enhancement Course	Data Science & Artificial Intelligence Laboratory		2					50		**50**	0	1	-	**1**
AEC283AUR	Ability Enhancement Course	Modern Indian Language: 02		2	1	15	35				**50**	0	1	1	**2**
HSSM284AUR	Enterpreneurship/ Management course	Engineering Economics and Financial Management	1			50					**50**	1	-	-	**1**
VEC285AUR	Value Education Course	Environmental Science and Sustaibale Development	2			15	35				**50**	2	-	-	**2**
		Total =	**16**	**10**	**1**	**235**	**315**	**-**	**150**	**-**	**700**	**16**	**5**	**1**	**22**

CCE: Comprehensive Continuous Evaluation

Note: Students can opt for Open Electives offered by different faculties such as Arts, Science, Commerce, Management, Humanities, or Inter-disciplinary studies.

- **Open Elective II:**

Students may choose courses like Project Management, Business Analytics, or Financial Management can be opted from Onter-disciplinary Studies, Commerce and Management faculties, respectively.

Savitribai Phule Pune University, Pune

Maharashtra, India

SE - Automation & Robotics Engineering

2024 Pattern

Semester III Courses

With effect from Academic Year 2025-26

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
PCC201AUR: Materials and Machine Elements		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**3**	**CCE: 30 Marks**
Practical: NA		**End-Semester: 70 Marks**

Prerequisite Courses, if any:

- Engineering Mathematics – I, II
- Fundamentals of Programming Languages
- Programming & Problem Solving

Course Objectives:

1. To impart fundamental knowledge of material science and engineering
2. To explain the material selection process
3. To acquire basic knowledge of stress, strain due to various types of loading
4. To draw Shear Force and Bending Moment Diagram for transverse loading
5. To solve problems of Torsional shear stress for shaft

Course Outcomes:

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

CO1. COMPARE crystal structures and ASSESS different lattice parameters

CO2. SELECT appropriate materials for various applications

CO3. DRAW Shear force and bending moment diagram for various types of transverse loading and support.

CO4. COMPUTE the slope & deflection, bending stresses and shear stresses on a beam.

CO5. CALCULATE torsional shear stress in shaft.

Course Contents

Unit I	Crystal Structures and Deformation of Materials	(08 Hours)

Crystal Structures: Study of Crystal structures BCC, FCC, HCP and lattice parameters & properties, Miller indices, Crystal imperfections, and Diffusion Mechanisms

Material Properties: Mechanical (Impact, hardness, etc.), Electrical, optical and Magnetic Properties

Deformation of Materials: Elastic deformation, Plastic deformation: slip, twinning, work hardening, baushinger effect, recovery, re-crystallization and grain growth

Fracture: Types of fractures (brittle, ductile), Creep & Fatigue failures

Real World Assignment (Assignment 1 compulsory, any one of remaining two):

1. Steps for Specimen Preparation for microscopic examination & Demonstration of Optical Metallurgical microscope
2. Observation and Drawing of Microstructure of Steels, Cast Iron of various compositions
3. Observation and Drawing of Microstructure of Non Ferrous Metals of various compositions

Explore / Practical Applications:

1. **Material Analysis**: Investigate the crystal structure of a common material (e.g., metals like aluminum or steel) and analyze how its structure influences its mechanical properties, such as ductility or hardness.
2. **Deformation Mechanisms**: Study the deformation process in real crystal structures, focusing on dislocations and their role in material strength. You can explore strengthening mechanisms like grain size reduction or alloying.
3. **Engineering Applications**: Examine how crystal structures are utilized in engineering applications, such as

turbine blades or semiconductor devices. Discuss how deformation affects their performance.

4. **Experimental Study**: Conduct experiments to observe deformation in materials under stress. For example, use a tensile test to measure yield strength and correlate it with the material's crystal structure.
5. **Case Studies**: Research real-world failures in materials (e.g., bridge collapses or aircraft component failures) and analyze how crystal structure and deformation contributed to the failure.

Unit II	Ferrous & Non-Ferrous Materials	(08 Hours)

Ferrous Carbon Steel: Classification, types & their composition, properties and Industrial application

Alloy Steels: Classification of alloy steels & Effect of alloying elements, examples of alloy steels, (Stainless steel, Tool steel) sensitization of stainless steel

Cast Iron: Classification, types & their composition, properties and Industrial application of (White CI, Gray CI, SG CI, Malleable Cast and alloy Cast Iron) Microstructure and property relationship of various ferrous Materials

Classification of Non-Ferrous Metals: Study of Non-ferrous alloys with Designation, Composition, Microstructure Mechanical & other properties for Industrial Applications

Recent Material used in Additive Manufacturing: Properties, Composition and Application only

Real World Assignment:

1. The Industrial Visit must be preferably to
   (i) Material & Metallurgy related like Engineering Cluster, NDT Lab, and Nearby NABL lab or
   (ii) Any manufacturing unit with material orientation

   Student must submit a properly documented Industrial Visit Report.

Explore / Practical Applications:

1. Exploration of engineering Alloy (Name, composition, properties, microstructure, Heat treatment, Designation & specific applications) - One student one Alloy or material
2. Examine aspects of component form material and manufacturing process point of view (Name, Material, Drawing, Manufacturing Process, properties, microstructure, Heat treatment, & specific applications) - For example spur gear, Needle etc. One student one component

Unit III	Simple Stress & Strain	(08 Hours)

Introduction to types of loads (Static, Dynamic & Impact Loading) and various types of stresses with applications, Hooke's law, Poisson's ratio, Modulus of Elasticity, Modulus of Rigidity, Bulk Modulus.

Interrelation between elastic constants, Stress-strain diagram for ductile and brittle materials, factor of safety, Stresses and strains in determinate and indeterminate beam, homogeneous and composite bars under concentrated loads and self-weight

Real World Assignment:

1. Mechanical properties of materials, Stresses and Design of components with case study.
2. Tension test for Ductile material using extensometer on Universal Testing Machine
3. Compression test for Brittle material on Universal Testing Machine.
4. Shear test of ductile material on Universal Testing Machine.
5. Tension test of Plastic/Composite material on low load capacity Tensile Testing Machine.

Explore / Practical Applications:

1. Failure Mode Analysis and Stresses with case study.
2. **Structural Integrity**: Stress analysis ensures that components can withstand applied forces without failure. For example, bridges and buildings are designed to handle stress from loads like vehicles, wind, and earthquakes.
3. **Material Selection**: Engineers use stress-strain curves to choose materials with appropriate properties, such

as elasticity, ductility, or toughness, for specific applications

4. **Fatigue Analysis**: Components subjected to cyclic loading, like aircraft wings or car axles, are analyzed for fatigue to prevent failure over time.
5. **Optimization**: Stress and strain data help optimize designs for weight reduction while maintaining strength, as seen in aerospace and automotive industries.
6. **Failure Prevention**: By understanding how materials deform under stress, engineers can predict and prevent failures, ensuring safety and reliability

Unit IV	Shear Force & Bending Moment Diagrams	(08 Hours)

SFD & BMD: Introduction to SFD, BMD with application, SFD & BMD for statically determinate beam due to concentrated load, uniformly distributed load, uniformly varying load, couple and combined loading, Concept of zero shear force, Maximum bending moment, point of contra-flexure

Bending Stress on a Beam: Introduction to bending stress on a beam with application, Theory of Simple bending, assumptions in pure bending, derivation of flexural formula, Moment of inertia of common cross section (Solid Circular, Rectangular, I-section), Bending stress distribution along the same cross-section

Real World Assignment:

1. Experimental verification of flexural formula in bending for cantilever, Simple supported beam.
2. Study and interpretations of stress distribution pattern using Polariscope for Plastic/Acrylic.

Explore / Practical Applications:

1. **Structural Engineering**: SFD and BMD are used to analyze beams and frames in buildings, bridges, and other structures to ensure they can withstand applied loads without failure
2. **Machine Design**: In mechanical engineering, these diagrams help in designing machine components like shafts, levers, and gears to handle forces and moments effectively.
3. **Aerospace Engineering**: Aircraft wings and fuselage sections are analyzed using SFD and BMD to ensure they can endure aerodynamic forces during flight.
4. **Automotive Engineering**: Vehicle chassis and suspension systems are designed using these diagrams to optimize strength and weight.
5. **Pipeline Design**: SFD and BMD are used to evaluate stresses in pipelines due to internal pressure and external loads.

Unit V	Shear Stress & Torsion	(10 Hours)

Shear Stress on a Beam: Introduction to transverse shear stress on a beam with application, shear stress distribution diagram (Solid Circular, Rectangular, I cross-section)

Torsion of circular shafts: Introduction to torsion on a shaft with application, Basic torsion formulae and assumption in torsion theory, Torsion in stepped shafts

Real World Assignment:

1. Experimental verification of flexural formula in bending for cantilever, Simple supported beam.
2. Study and interpretations of stress distribution pattern using Polariscope for Plastic/Acrylic.

Explore / Practical Applications:

1. **Automotive Engineering**: Drive shafts in vehicles are designed to handle torsional stress as they transfer torque from the engine to the wheels. Shear stress analysis ensures the durability of components like axles and suspension systems
2. **Mechanical Springs**: Torsion springs, which store rotational energy, are used in devices ranging from vehicle suspensions to garage doors.
3. **Rotary Tools**: Tools like drills and wrenches experience torsional loads during operation, requiring careful design to prevent failure.

4. **Structural Engineering**: Shear stress calculations are critical in designing beams and columns to withstand forces without buckling or breaking.
5. **Pipeline Design**: Shear stress analysis helps ensure pipelines can handle internal pressure and external loads safely.
6. **Aerospace Engineering**: Aircraft components, such as wings and fuselage sections, are analyzed for torsional and shear stresses to ensure they can endure aerodynamic forces during flight.

Learning Resources

Text Books:

1. Dr. V. D. Kodgire & S. V. Kodgire, "Material Science & Metallurgy For Engineers", Everest Publication.
2. R. K. Bansal, "Strength of Materials", Laxmi Publication
3. S. Ramamurtham, "Strength of material", Dhanpat Rai Publication
4. S.S. Rattan, "Strength of Material", Tata McGraw Hill Publication Co. Ltd.
5. B.K. Sarkar, "Strength of Material", McGraw Hill New Delhi
6. Singer and Pytel, "Strength of materials", Harper and row Publication
7. R. C. Hibbeler, "Mechanics of Materials", Prentice Hall Publication

Reference Books:

1. Cleghorn, W. L., (2005), "Mechanisms of Machines", Oxford University Press
2. James M. Gere, "Mechanics of Materials", CL Engineering
3. Timoshenko and Young, "Strength of Materials", CBS Publication, Singapore
4. Prof. S.K. Bhattacharyya, IIT Kharagpur , "NPTEL Web course material" https://drive.google.com/file/d/1N2Eyv9ofPimIT2OSMZeMrSxe68Ulclei/view?usp=sharing

MOOC / NPTEL/YouTube Links: -

1. Prof. S.K. Bhattacharyya, IIT Kharagpur , "NPTEL Web course material" https://drive.google.com/file/d/1N2Eyv9ofPimIT2OSMZeMrSxe68Ulclei/view?usp=sharing

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
PCC202AUR: Industrial Electronics & Controls		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**3**	**CCE: 30 Marks**
Practical: NA		**End-Semester: 70 Marks**

Prerequisite Courses, if any:

- Engineering Physics
- Basic Electrical Engineering
- Basic Electronics Engineering
- Engineering Mathematics – I, II

Course Objectives:

1. To identify and use fundamental concepts of industrial electronics and power semiconductor devices.
2. To understand power electronics conversion techniques and apply in industrial power supply systems.
3. To compare between different control strategies used in industrial automation and motor control systems.
4. To understand working of industrial sensors and instrumentation techniques in real-world applications.
5. To learn industrial automation systems and communication protocols.
6. To understand need of Industry 4.0, IoT, and smart manufacturing concepts.

Course Outcomes:

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

CO1. INTERPRET fundamental concepts of industrial electronics and power semiconductor devices and their role in industrial applications.

CO2. ANALYZE power electronics conversion techniques and industrial power supply systems for efficiency and performance improvement.

CO3. COMPARE different control strategies used in industrial automation and motor control systems to determine their effectiveness.

CO4. APPLY industrial sensors and instrumentation techniques in real-world applications to enhance automation and process control.

CO5. KNOWLEDGE of industrial automation systems and communication protocols for seamless system integration.

CO6. UNDERSTAND and APPLY Industry 4.0, IoT, and smart manufacturing concepts in modern industrial environments for enhanced productivity and innovation

Course Contents		
Unit I	**Introduction to Industrial Electronics**	**(08 Hours)**

Overview of industrial electronics applications, Power semiconductor devices: (Diodes, SCRs, Triacs, BJTs, MOSFETs, IGBTs), Characteristics and switching properties: Limit Switches, Electromechanical Relays

Industrial power supply systems: Basics of rectifiers, inverters, choppers, and industrial power supplies

Power quality issues (Harmonics, Power Factor, Voltage Sags & Surges)

Power factor correction methods & Industrial power protection devices (Circuit Breakers, Fuses, Surge Protectors), EMI/EMC considerations in industrial electronics

Real World Assignment

1. Characteristics of Power Semiconductor Devices – Study and testing of SCR, TRIAC, DIAC, IGBT, and MOSFET.
2. Concept of working principle and response of Limit Switches and Electromechanical Relays in control circuits.
3. Analyze power quality issues such as harmonics, voltage sags, and surges, and to study industrial protection devices like circuit breakers, fuses, and surge protectors.
4. Study the power factor in an industrial circuit and apply correction methods using capacitors and inductors.

Exemplars / Practical Applications: By using different electrical/electronic/mechanical apparatus construct the industrial test circuits and measure, analyze I-V characteristics and different other parameters using appropriate test circuits.

Unit II	**Power Electronics & Conversion Techniques**	**(06 Hours)**

Rectifiers: Single-phase & three-phase rectifiers, Inverters: Single-phase & three-phase inverters,
DC-DC converters (Choppers, Buck, Boost, Buck-Boost, Cuk Converters),
AC to DC Converters (Controlled & Uncontrolled Rectifiers),
DC to AC Converters (Inverters: Single-phase & Three-phase),
AC to AC Converters (Cyclo-converters, Voltage Regulators)

Real World Assignment

1. AC Voltage Controller Using TRIAC & DIAC – Speed control of single-phase induction motor.
2. Design a simple relay control circuit and test switching operation DC-DC Converter (Chopper) Circuits – Implementation of step-up & step-down choppers for motor control.
3. Efficiency Testing of DC-DC Converters (Buck, Boost, and Buck-Boost) in Renewable Energy Systems
4. Application of Cyclo converters in Large-Scale AC Motor Speed Control
5. Industrial Voltage Regulation Using AC Voltage Controllers

Exemplars / Practical Applications: Design the test circuits using PSpice /Proteus/TinkerCad/MATLAB and study the characteristics.

Unit III	Industrial Control Systems & Automation	(08 Hours)
Basic control system concepts (Open-loop, Closed-loop, Feedback Control), Proportional (P), Integral (I), Derivative (D) control & PID controllers: Tuning and implementation Basic of Programmable Logic Controllers (PLC): Architecture, Ladder Diagrams, and Programming SCADA Systems: Fundamentals & Applications (Industrial electronics enables remote monitoring and control via Supervisory Control and Data Acquisition (SCADA) and Distributed Control Systems (DCS). Motor Control Devices: Variable Frequency Drives (VFDs), Soft Starters, Motor Starters (DOL, Star-Delta)		
Real World Assignment – 1. PLC Programming for Industrial Automation – Basic logic operations and motor control using PLC 2. PID Controller Implementation – Tuning and response study of first-order & second-order systems 3. Implement a PID Controller to regulate temperature using a heater and a temperature sensor 4. Speed Control of DC Motor Using PWM & Choppers – Closed-loop control with variable speed operation 5. Interface a SCADA system with a PLC for remote monitoring of industrial parameters (e.g., Temperature & Pressure) 6. Industrial Visit		
Exemplars / Practical Applications: Write code or generate simulation model in PLC/ MATLAB Simulator to analyze the characteristics of the control system Simulink models.		
Unit IV	**Industrial Sensors & Instrumentation**	**(08 Hours)**
Overview of industrial sensors (Temperature, Pressure, Flow, Level, Proximity, Optical) Motion and Position Sensors: Understand principles of motion and position sensing, Encoders, accelerometers, and gyroscopes applications of motion and position sensors in robotics Signal conditioning & Data acquisition, Transducers and their industrial applications, Wireless sensor networks in industrial applications Bridge Circuit: Wheatstone Bridge, AC & DC Bridge.		
Real World Assignment – 1. Understand temperature, pressure, flow, and proximity sensors and their signal conditioning: Procedure, Measure and Calibrate different sensors using data acquisition systems. 2. To study signal conditioning techniques and implement data acquisition for industrial sensor signals. 3. Different types of transducers and their applications in industrial measurement systems. 4. Understanding of wireless sensor networks in Industry 4.0 applications and Hands-on implementation of IoT-based industrial monitoring. 5. Design and analyze Wheatstone Bridge, AC Bridge, and DC Bridge circuits for precise measurement.		
Exemplars / Practical Applications: Design a signal conditioning circuit and bridge circuit for a given sensor & Convert the analog sensor signal into a digital form using ADC further interface the sensor with a DAQ system and visualize the data on a PC		
Unit V	**Industrial Automation & Communication**	**(08 Hours)**
Introduction to Industrial Automation, CNC Machines and Robotics Industrial Communication Protocols: (Modbus, Profibus, CAN, Ethernet, RS232, RS485) Industry 4.0 and Smart Manufacturing, IoT Devices & Gateways: Enable remote monitoring and predictive		

maintenance.

Overview of industrial electronics applications, Power semiconductor devices: (Diodes, SCRs, Triacs, BJTs, MOSFETs, IGBTs), Characteristics and switching properties: Limit Switches, Electromechanical Relays

Industrial power supply systems: Basics of rectifiers, inverters, choppers, and industrial power supplies

Power quality issues (Harmonics, Power Factor, Voltage Sags & Surges)

Power factor correction methods & Industrial power protection devices (Circuit Breakers, Fuses, Surge Protectors), EMI/EMC considerations in industrial electronics

Real World Assignment –

1. Understand the operation of a CNC machine and create a basic machining program using G-Code.
2. To establish communication between industrial devices using RS232 and Modbus protocols.
3. Hands-on experience with industrial communication protocols and understanding of data transmission and error handling in RS232 and Modbus.
4. Implement an IoT-enabled remote monitoring system for an industrial process.
5. To program and operate a robotic arm for an industrial pick-and-place task..

Exemplars / Practical Applications: Design the simulation model by using the software tools MATLAB Robotics Toolbox/ Arduino IDE/ MQTT Explorer/ QModMaster/ Fusion 360.

Learning Resources

Text Books:

1. Muhammad H. Rashid – Power Electronics: Circuits, Devices, and Applications (Pearson)
2. Bimbhra P.S. – Power Electronics (Khanna Publishers)
3. Hughes – Electrical and Electronic Technology (Pearson)
4. Dorf R.C. & Bishop R.H. – Modern Control Systems (Pearson)
5. Jon Stenerson – Industrial Automation and Process Control (Pearson)

Reference Books:

1. Mohan, Undeland, Robbins – Power Electronics: Converters, Applications, and Design (Wiley)
2. Bolton W. – Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering (Pearson)
3. Frank D. Petruzella – Programmable Logic Controllers (McGraw-Hill)
4. R.K. Rajput – Industrial Electronics and Control (S. Chand)
5. James A. Rehg & Glenn J. Sartori – Industrial Electronics (Pearson)

MOOC / NPTEL/YouTube Links: -

1. https://nptel.ac.in/courses/108105088
2. https://www.youtube.com/playlist?list=PLE8F9BF5CB1201D23
3. https://www.youtube.com/watch?v=3k9_YzcfGJo&list=PLgwJf8NK-

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
PCC203AUR: Manufacturing Technology		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**3**	**CCE: 30 Marks**
Practical: NA		**End-Semester: 70 Marks**

Prerequisite Courses, if any:

- Manufacturing Practice Workshop
- Programming & Problem Solving

Course Objectives:

1. Describe various sand and permanent mold casting methods, procedure and mold design aspects.
2. Classify, describe and compare the principles of various joining processes.
3. Study various metal cutting operations viz. turning, milling, grinding, etc.
4. Understand sheet metal forming operations and die design procedure.
5. Understand plastic processing techniques and 3D printing requirements.

Course Outcomes:

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

CO1. SELECT appropriate molding, core making and melting practice and ESTIMATE pouring time, solidification rate and DESIGN riser size and location for sand casting process

CO2. CLASSIFY suitable joining processes based on application and EVALUATE welding characteristics

CO3. SELECT suitable metal cutting operation based on requirements viz. surface finish, MRR, etc.

CO4. DEMONSTRATE press working operations and APPLY the basic principles to DESIGN dies and tools for forming and shearing operations

CO5. DIFFERENTIATE thermoplastics and thermosetting and applications in modern manufacturing in 3D printing

Course Contents

Unit I	Casting and Foundry Processes	(08 Hours)

Introduction to casting processes, Patterns: Pattern materials, types of pattern, allowances pattern design, molding sand, Properties of molding sands, Core making, melting practices and furnaces, Pouring and Gating system design

Numerical estimation to find mold filling time, Riser design and placement, Principles of cooling and solidification of casting, Directional and Progressive solidification, Estimation of solidification rate

Cleaning and Finishing of casting, Defects and remedies, Principle and equipment of Permanent mold casting, Investment casting, Centrifugal casting, Continuous casting

Real World Assignment:

1. Case Study on Industrial Casting Applications.
2. Understand the importance of pattern materials and types in the casting process.
3. Analyze the impact of gating system and riser design on casting quality.
4. Investigate real-world casting defects and propose solutions.

Exemplars / Practical Applications:

1. Design a basic gating system and riser for the selected component. Report (4-5 pages) including design calculations, gating system layout.

Unit II	Joining and Welding Processes	(08 Hours)
Classification of joining processes: Welding, brazing, soldering, Advantages and limitations of different joining process Welding terminology and types of joints, Gas Welding and Cutting Arc Welding Processes: Working principle, Equipment of Single carbon arc welding, FCAW, TIG, MIG, SAW, applications Resistance Welding: Spot, Seam and Projection weld process, Heat balance in resistance welding Welding Metallurgy and Heat Affected Zone, Weld inspection Defects in various joints and their remedies		
Real World Assignment: 1. Comparative Analysis of Welding, Brazing, and Soldering in Industrial Applications 2. Evaluate and select an appropriate welding process for a real-world structural application. 3. Investigate common welding defects and propose quality control measures. 4. Perform a welding operation and analyze the strength of the welded joint.		
Exemplars / Practical Applications: 1. Case study report (4-5 pages) with images, defect analysis, and quality control recommendations.		
Unit III	**Theory of Metal Cutting**	**(08 Hours)**
Basics of subtractive manufacturing, operations on Lathe, Milling & Grinding machines Basics of metal cutting mechanics, Chip formation and types of chips, Orthogonal and oblique cutting, Shear angle and Merchant's theory, Cutting Forces and Power Estimation, Properties of cutting tool materials, Tool signature, Tool wear and tool life, Taylor's tool life equation		
Real World Assignment – 1. Calculate the components of cutting force using the provided experimental data. 2. Determine tool life using the equation $VT^n = C$ and estimate machining costs based on tool life. 3. Conduct a real-time case study on tool life for an industrial component.		
Exemplars / Practical Applications: Perform and submit (4-5) pages report on turning or milling operation (in a lab or workshop) on different materials (e.g., aluminum, mild steel, stainless steel).		
Unit IV	**Metal Forming and Sheet Metal Working**	**(08 Hours)**
Metal Forming: Classification of forming processes, Stress-strain relations in plastic deformation, Hot working vs. cold working, Rolling: Types, defects, and applications **Forging:** Open-die, Closed-die, and Impression-die forging, Extrusion: Direct, Indirect, Wire and Tube drawing **Sheet Metal Working**: Types of sheet metal operations, Press working equipment and terminology, Types of dies, Clearance analysis, Estimation of cutting forces, Centre of pressure and blank size determination, Design of strip lay-out, Blanking die design, Introduction to Drawing, Bending dies		

Real World Assignment –

1. Identify at least one industrial applications for each process (e.g., hot rolling for railway tracks, cold rolling for automotive sheets).
2. Compare forging with other manufacturing processes (e.g., casting, machining) in terms of strength and durability.
3. Apply sheet metal operations such as shearing, bending, and deep drawing to create a real-world product.
4. Research the principles, advantages, and limitations of hot working and cold working

Exemplars / Practical Applications: Suggest an appropriate forming process for a given product (e.g., turbine blades, aluminum cans) and justify the choice.

Unit V	Polymer Processing	(08 Hours)

Thermoplastics and Thermosetting, Processing of polymers, Thermoforming

Extrusion Molding: Compression molding, transfer molding, Blow molding, Rotation moulding, Injection moulding - Process and equipment

Extrusion of Plastic: Type of extruder, extrusion of film, pipe, Cable, Introduction to Additive Manufacturing, 3D Printing techniques (FDM, SLA, SLS, DMLS)

Real World Assignment –

1. Design a functional part (e.g., gear, bracket, or prototype model) using CAD software.
2. Print the part using different 3D printing techniques.

Exemplars / Practical Applications: Comparison Report (2-3 Pages): 3D Printing vs. Conventional Machining

Learning Resources

Text Books:

1. Amitabha Ghosh & Ashok Kumar Mallik, ‘Manufacturing Science’, East-West Press.
2. R.K. Rajput, ‘A Textbook of Production Engineering’,Laxmi Publications.
3. Serope Kalpakjian & Steven R. Schmid, ‘Manufacturing Engineering and Technology’, Pearson Education
4. S.K. Hajra Choudhury, A.K. Hajra Choudhury & Nirjhar Roy, ‘Workshop Technology (Vol. 1 & 2)’, Media Promoters & Publishers Pvt. Ltd.

Reference Books:

1. J.S. Campbell, ‘Principles of Manufacturing Materials and Processes’, Tata McGraw-Hill.
2. Mikell P. Groover, ‘Introduction to Manufacturing Processes’, Wiley India
3. Ian Gibson, David Rosen, Brent Stucker, ‘Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing’, Springer

MOOC / NPTEL/YouTube Links: -

1. https://www.youtube.com/watch?v=z-mM8LwQcno/
2. https://www.youtube.com/watch?v=DA3r97Icgd0
3. https://www.youtube.com/watch?v=_AhfOzQDynE
4. https://www.youtube.com/watch?v=9JTRqfNAqhM&list=PLwdnzlV3ogoWI8QEu4hsT-n_r8UbWbquy&index=2
5. https://www.youtube.com/watch?v=ljveGnQw2G0&list=PL9ssGyHa3fnwPH1gSkV8pjX12Srkx8rgq

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
PCC204AUR: Material Testing and Characterization Laboratory		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**1**	**Oral: 50 Marks**

Prerequisite Courses, if any:

- Engineering Mechanics, Manufacturing processes workshop, Engineering Chemistry

Course Objectives:

1. To ACQUIRE basic knowledge of stress, strain due to various types of loading for different types of materials
2. To DRAW Shear Force and Bending Moment Diagram for transverse loading and to DETERMINE Bending, Shear stress, Slope and Deflection on Beam.
3. To IMPART fundamental knowledge of material science and engineering and to ESTABLISH significance of structure property relationship.
4. To INDICATE the importance of heat treatment on structure and mechanical properties of materials.
5. To EXPLAIN the material selection process
6. To UTILIZE the concepts of Solid Mechanics and Engineering Materials on application based combined mode of loading and failures

Course Outcomes:

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

CO1: DETERMINE various types of stresses and strain developed on determinate and indeterminate members.

CO2: CALCULATE Shear force and bending moment for various types of transverse loading and Support and COMPUTE the slope & deflection, bending stresses and shear stresses on a beam.

CO3: EXAMINE micro structures and different phases also LINK phase distribution with mechanical properties of materials.

CO4: DIFFERENTIATE and TEST mechanical properties using destructive and nondestructive methods

CO5: CATAGORIZE and RECOMMNOD appropriate materials for various applications.

CO6: UTILIZE the concepts of SFD & BMD, principal stresses, heat treatment and microstructure to SOLVE combined loading application-based problems virtually IoT based tools

List of Practical's

Experiment 01

1. Validation of experimental results of Tension and Compression tests using ductile and brittle (Comparison of other materials stress strain plots with tested samples. materials (Compare and conclude on failure behavior using experiment results graph)
2. Comparison of other materials stress strain plots with tested samples

Exemplars / Practical Applications

Aerospace Industry: Validation of aircraft structural components (e.g., wing spars, fuselage frames). Automotive Engineering: Crashworthiness and durability of vehicle frames and body panels

Experiment 02

1. Experimental verification of flexural formula in bending for cantilever and simply supported beam using strain gauges.
2. Case study on cantilever and simply supported structures and their failure.

Exemplars / Practical Applications

Quality Control in Beam Manufacturing (Steel, Aluminum, Concrete): Testing - standard beam sections (e.g., I-beams, T-beams) to verify mechanical properties before deployment. Design Validation in Mechanical Engineering Structures: Used in verifying the stress/strain profile in machine components like

support arms, robotic limbs, or levers.

Experiment 03

1. Conduction of torsional/ shear test on ductile material
2. Case study on part failure under torsion/shear

Exemplars / Practical Applications

Design and Validation of Shafts in Mechanical Systems: Drive shafts, crankshafts, camshafts, and axles in vehicles and machines Fastener and Threaded Component Testing: Bolts, screws, and threaded rods Automotive Powertrain and Steering Component Analysis: Torsion bars, drive shafts, steering knuckles

Experiment 04

1. Impact Test for Steel, Aluminum, Brass and Copper(Charpy/Izod)
2. Failure case studies under impact loading of any one material on which trials conducted

Exemplars / Practical Applications

Quality Control in Structural Steel Fabrication: Steel used in Bridges, high-rise buildings, offshore platforms Crashworthiness in Automotive Components: Aluminum, Steel, Brass used in Bumpers, crash zones, engine mounts, control arms

Experiment 05

1. Test of Creep, Fatigue and Fluorescence Microscope using simulator
2. Case studies of any one tested

Exemplars / Practical Applications

Creep Testing (Using Simulators): Turbine Blades in Jet Engines and Power Plants, Boiler Tubes and Steam Pipes Fatigue Testing (Using Simulators): Aircraft Wings and Fuselage Panels, Automotive Suspension and Chassis, Railway Tracks and Wheels Fluorescence Microscopy (Using Simulators): Material Science (Fluorescent Dye Penetrant)

Experiment 06

1. Material Hardness measurement using Brinell's / Vicker's / Rockwell / Poldi's Hardness testing set up. Test samples should be before and after case harden and core harden heat treatment
2. Visit to heat treatment plant/lab for hardening process.

Exemplars / Practical Applications

Quality Control in Gear Manufacturing: Test Sample: Steel gears before and after case hardening Inspection of Automotive Components (Camshafts, Crankshafts): Forged shafts after core hardening and induction hardening Heat Treatment Verification in Structural Steel Plates and Beams: Steel plate samples before and after quench and temper

Experiment 07

1. Analysis of given sample using any one of the Non-destructive tests: Dye Penetrant Test/ Magnetic Particle test/ Ultrasonic Test.
2. Samples can be collected from various failures occurring with automobiles, machine parts, household appliances, etc and analysis of parts failed.

Exemplars / Practical Applications

Dye Penetrant Test (DPT) – For Surface Crack Detection: Inspection of Welded Joints in Pressure Vessels Magnetic Particle Test (MPT) – For Surface & Near-Surface Flaw: Rail Axle and Wheel Shaft Inspection made up of Ferromagnetic materials like carbon steel ,Ultrasonic Test (UT) – For Internal Defect Detection: Inspection of Structural Steel in Bridges

Experiment 08

1. Interpretation and Drawing of Microstructures of Ferrous (Steel, cast iron) and Non-ferrous materials (Aluminum, nickel) of various compositions. Identified microstructures can be used for interpretation of material compositions
2. Visit to test lab for Reading and interpretation of standard material test report (certificate) of ferrous and non-ferrous materials (These test reports can be availed from Workshop, Industry)

Exemplars / Practical Applications

FERROUS MATERIALS: Low Carbon Steel (<0.25% C) - Ferrite + small amount of pearlite, Medium Carbon Steel (0.25–0.6% C) - Increased pearlite + ferrite, High Carbon Steel (>0.6% C) - Predominantly pearlite with some cementite, Gray Cast Iron - Graphite flakes in a pearlitic or ferritic matrix, White Cast Iron -Cementite and pearlite, no graphite

Experiment 09

1. Case study on material selection considering functional and environmental requirements
2. Identify various ASTM standards used or required in this case study and make comprehensive report of it

Exemplars / Practical Applications

Bicycle Frame Design for Urban Commuters : Functional Requirements: Lightweight, Corrosion resistant, Affordable Environmental Requirements: Recyclable material, Low manufacturing emissions Material Chosen: Aluminum, bamboo, or recycled steel: Sustainable transport, green mobility programs

Automotive Body Panel Design: Functional Requirements: High strength-to-weight ratio, good formability and crash resistance, Corrosion resistance Environmental Requirements: Low CO_2 footprint during production, Recyclability at end-of-life Material Chosen: Aluminum alloy or advanced high-strength steel (AHSS) : Used by companies like Ford and BMW in lightweight vehicle design

Wind Turbine Blade Material: Functional Requirements: High fatigue strength, Lightweight, Weather and UV resistance Environmental Requirements: Low embodied energy, Possibility for recyclable or bio-based composites Material Chosen: Glass fiber-reinforced polymer (GFRP) with epoxy or bio-resins: Used in offshore and onshore wind farms

Experiment 10

1. Conduction of any one test on VLab from the list: Tensile Test on Mild steel, Tensile Test on Cast Iron, Compression Test on Mild Steel, Compression Test on Cast Iron, Direct shear test on Mild steel Rod, Direct Shear test on Timber Specimen, Direct shear test on Mild steel Plate, Bending Test on Mild steel, Torsion Test on Mild Steel, flexural formula in bending for simply supported and cantilever beam, stress strain measurement through strain gauge, torsion formula for bar, flexural formula validation through other software.
2. Each student should have different load condition and case study of failure of such loading condition.

*** All destructive and non-destructive tests shall be performed as per applicable ASTM / BIS standards

Learning Resources

Text Books:

1. S. Ramamurtham, “Strength of material”, Dhanpat Rai Publication
2. S.S. Rattan, “Strength of Material”, Tata McGraw Hill Publication Co. Ltd.
3. R. K. Bansal, “Strength of Materials”, Laxmi Publication
4. Dr. V. D. Kodgire & S. V. Kodgire, “Material Science & Metallurgy For Engineers”, Everest Publication.
5. William D. Callister, “Materials Science and Engineering an Introduction”, Jr, John Wiley & Sons, Inc

Reference Books:

1. G. H. Ryder, “Strength of Materials”, Macmillan Publication
2. James M. Gere, “Mechanics of Materials”, CL Engineering
3. George Ellwood Dieter, “Mechanical Metallurgy”, McGraw-Hill 1988
4. A. K. Bhargava, C.P. Sharma, “Mechanical Behaviour & Testing of Materials”, P H I Learning Private Ltd
5. Raghvan V., “Material Science & Engineering”,Prentice Hall of India, New Delhi. 2003

MOOC / NPTEL/ YouTube Links: -

Prof. S.K. Bhattacharyya, IIT Kharagpur , “NPTEL Web course material”
https://drive.google.com/file/d/1N2Eyv9ofPimIT2OSMZeMrSxe68Ulclei/view?usp=sharing

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
MDM221AUR: Engineering Mathematics - III		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**3**	**CCE: 30 Marks**
Practical: NA		**End-Semester: 70 Marks**

Prerequisite Courses, if any:

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

Course Objectives:

1. To familiarize the students with concepts and techniques in Ordinary differential equations, Statistical methods, Probability theory, Numerical Methods 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:

CO1: **SOLVE** higher order linear differential equations and its applications to model and analyze mass spring systems.

CO2: **APPLY** Statistical methods like correlation, regression in analyzing and interpreting experimental data applicable to reliability engineering and probability theory in testing and quality control.

CO3: **SOLVE** Algebraic & Transcendental equations and System of linear equations using numerical techniques.

CO4: **OBTAIN** Interpolating polynomials, numerical differentiation and integration, numerical solutions of ordinary differential equations used in modern scientific computing applicable to Mechanical engineering.

CO5: **PERFORM** Vector differentiation & integration, **ANALYZE** the vector fields and **APPLY** to fluid flow problems.

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 DE. Modelling of Mass-spring systems, Free & Forced damped and undamped systems

Real World Assignment

1. Modelling of Mass-spring systems, Free & Forced damped and undamped systems.
2. Determination of natural frequency and resonant analysis of mechanical systems using LDE.

Exemplars / Practical Applications

Electrical Circuit Analysis, Structural Engineering

Unit II	**Statistics & Probability**	**(08 Hours)**

Introduction to Data Science, Measures of central tendency, Measures of dispersion, Coefficient of variation, Moments, Skewness and Kurtosis,

Correlation: Karl Pearson's correlation, Spearman's rank correlation, Regression analysis and Reliability of regression estimates.

Probability, Probability density function, and Central limit theorem, Probability distributions: Binomial, Poisson, Normal, and Test of hypothesis: Chi-square test and t- test

Real World Assignment

1. Analyze statistical features of experimental data/standard datasets in mechanical engineering

applications.
2. Problem solving and decision making related to quality control, reliability engineering, and predictive maintenance using probability theory.
3. Implement problem solving using software such as C/C++/Python/MATLAB.

Exemplars / Practical Applications
Quality Control in Manufacturing, assess product reliability and failure rates for maintenance scheduling

Unit III	**Numerical methods for solving algebraic and transcendental equations**	**(08 Hours)**

Numerical Solution of Algebraic and Transcendental equations: Bisection, Secant, Regula-Falsi, Newton– Raphson and Successive Approximation Methods, Convergence and Stability.
Numerical Solutions of System of linear equations: Gauss elimination with partial pivoting, LU Decomposition, Jacobi and Gauss-Seidel Methods.

Real World Assignment
1. Numerical solution of applied to Newton's laws of motion, Heat & Mass transfer equations and thermodynamic processes.
2. Numerical solution of coupled mass spring systems
3. Implement problem solving using software such as C/C++/Python/MATLAB

Exemplars / Practical Applications
Engineering Design Optimization, Electrical Power System Analysis, Computational Fluid Dynamics (CFD), Control System Engineering, Finance and Economics Modeling

Unit IV	**Numerical Interpolation and solution of ODE**	**(08 Hours)**

Interpolation: Finite Differences, Newton's and Lagrange's Interpolation formulae, Numerical Differentiation.
Numerical Integration: Trapezoidal and Simpson's rules, Bound of truncation error.
Solution of Ordinary differential equations (ODE): Euler's, Modified Euler's, Runge-Kutta 4th order methods and Predictor-Corrector methods.

Real World Assignment
1. Obtain interpolating polynomial passing through equally or unequally spaced data points applicable to fluid flow problems and material properties.
2. Use of numerical integration to calculate areas volumes forces fluid mechanics, heat transfer and machine design.
3. Numerical solution of ODE to predict temperature profile and transient behavior in heat conduction analysis.
4. Implement problem solving using software such as C/C++/Python/MATLAB**.**

Exemplars / Practical Applications
Data fitting and curve estimation, Engineering simulations and modeling, Signal processing and image reconstruction, Numerical weather prediction, Control systems and robotics modeling

Unit V	**Vector Calculus**	**(08 Hours)**

Vector differentiation, Gradient, Divergence and Curl, Directional derivative, Solenoidal & Irrotational fields, Vector identities. Line, Surface and Volume integrals, Green's Lemma, Gauss's Divergence theorem and Stoke's theorem.

Real World Assignment
1. Obtain fluid flow behavior such as velocity fields, rotational motion and scalar potential field.
2. Compute work done, circulation and determination of fluid flow rate.

Exemplars / Practical Applications
Electromagnetic field analysis, Fluid dynamics and aerodynamics, Structural stress and strain analysis, Heat transfer and thermodynamics, Robotics and control system design

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, 7e, by Peter V. O'Neil (Cengage Learning). 3. Differential Equations, 3e by S. L. Ross (Wiley India). 4. Introduction to Probability and Statistics for Engineers and Scientists, 5e, by Sheldon M. Ross (Elsevier Academic Press) 5. Steven C. Chapra, 'Applied Numerical Methods with MATLAB for Engineers and Scientist', (Tata Mc- Graw Hill Publishing Co. Ltd). 6. Jason Brownlee, 'Statistical Methods for Machine Learning', Machine learning Mastery.
MOOC / NPTEL/ YouTube Links: - 1. https://nptel.ac.in/courses/111107098/ 2. http://nptel.ac.in/courses/111105041/ 3. https://nptel.ac.in/courses/111107105/ 4. https://nptel.ac.in/courses/111105122/

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
MDM222AUR: Industrial Electronics & Controls Laboratory		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**1**	**Oral: 50 Marks**

Prerequisite Courses, if any:

- Basic Electronics & Electrical Engineering
- Digital Electronics
- Control Systems
- Engineering Mathematics – I & II

Course Objectives:

1. **INTERPRET** fundamental concepts of industrial electronics and power semiconductor devices.
2. **ANALYZE** power electronics conversion techniques and industrial power supply systems.
3. **COMPARE** different control strategies used in industrial automation and motor control systems.
4. **APPLY** industrial sensors and instrumentation techniques in real-world applications.
5. **LEARN** industrial automation systems and communication protocols.
6. **UNDERSTAND & APPLY** Industry 4.0, IoT, and smart manufacturing concepts.

Course Outcomes:

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

CO1: INTERPRET fundamental concepts of industrial electronics and power semiconductor devices and their role in industrial applications.

CO2: ANALYZE power electronics conversion techniques and industrial power supply systems for efficiency and performance improvement.

CO3: COMPARE different control strategies used in industrial automation and motor control systems to determine their effectiveness.

CO4: APPLY industrial sensors and instrumentation techniques in real-world applications to enhance automation and process control.

CO5: KNOWLEDGE of industrial automation systems and communication protocols for seamless system integration.

CO6: UNDERSTAND and APPLY Industry 4.0, IoT, and smart manufacturing concepts in modern industrial environments for enhanced productivity and innovation.

Course Contents

Perform any 7 experiments from the below mentioned list with mandatory industrial visit:

Experiment 1	**02 hrs.**

Study of Power Semiconductor Devices and Their Applications in Industrial Electronics & Measure and analyze I-V characteristics using appropriate test circuits.

Real World Assignment

Application-Oriented Analysis of Power Semiconductor Devices like SCR, TRIAC, MOSFET, and IGBT under different voltage and load conditions.

Exemplars / Practical Applications

Industrial Motor Control, Power Supplies and Inverters, Electric Vehicles (EVs), Light Dimming and Fan Speed Regulators, Renewable Energy Systems

Experiment 2	**02 hrs.**
Design and Analysis of Industrial Power Supply Systems: Rectifiers, Inverters, and Choppers (Design can be implemented by using circuit design software, Simulink model or hardware	
Real World Assignment Simulate and analyze the behavior of rectifiers (AC to DC), inverters (DC to AC), and choppers (DC to variable DC) under various load conditions using tools like MATLAB/Simulink, Multisim, or hardware kits	
Exemplars / Practical Applications Industrial Automation & Machinery, Renewable Energy Systems, Electric Vehicles (EVs), Power Backup and UPS Systems, High-Voltage DC (HVDC) Transmission	
Experiment 3	**02 hrs.**
Design and Control any of DC-DC/ DC-AC/AC-DC/AC-AC Converters for Industrial Applications	
Real-World Assignment: Design and simulate one type of power electronic converter (DC-DC, DC-AC, AC-DC, or AC-AC) using simulation tools like MATLAB/Simulink, PSIM, or hardware-based platforms.	
Exemplars / Practical Applications: DC-DC Converters (e.g., Buck, Boost, Buck-Boost), DC-AC Converters (Inverters), AC-DC Converters (Controlled Rectifiers), AC-AC Converters (Cyclo-converters, Matrix Converters)	
Experiment 4	**02 hrs.**
Design and Implementation of a Temperature and Pressure Monitoring System Using Industrial Sensors (With DAS mechanism)	
Real-World Assignment: Design and implement a system using industrial-grade temperature (e.g., RTD, thermocouple) and pressure (e.g., piezoelectric, strain gauge) sensors.	
Exemplars / Practical Applications: Process Industries (Oil, Gas, and Chemical Plants), HVAC Systems (Heating, Ventilation, Air Conditioning), Power Plants, Food and Pharmaceutical Industries, Smart Manufacturing (Industry 4.0)	
Experiment 5	**02 hrs.**
PLC Programming for Industrial Automation – Basic logic operations and motor control using PLC	
Real-World Assignment: Design ladder logic programs to implement basic logic operations (AND, OR, NOT, NAND) and control industrial actuators like motors, relays, and solenoids.	
Exemplars / Practical Applications: Conveyor Belt Automation, Pump Control in Water Treatment Plants, Industrial Motor Control Panels, Bottle Filling and Packaging Lines, HVAC and Building Automation	
Experiment 6	**02 hrs.**
PID Controller Implementation – Tuning and response study of first-order & second-order systems.	
Real-World Assignment: Design and implement PID controllers for first-order and second-order dynamic systems using MATLAB/Simulink, LabVIEW, or microcontroller-based hardware.	
Exemplars / Practical Applications: Temperature Control Systems (e.g., Furnaces, Incubators),Industrial Motor Speed Control, Process Control in Chemical Plants, Autonomous Vehicles & Drones, Liquid Level Control in Tanks	
Experiment 7	**02 hrs.**
Implementation of PID Control for a Closed-Loop Motor Speed Control System	
Real-World Assignment: Develop a closed-loop system using a DC motor (or BLDC/servo motor) with speed feedback via encoder or tachogenerator.	

Exemplars / Practical Applications: Conveyor Belt Speed Regulation, CNC Machine Spindle Speed Control, Robotic Arm Joint Control, Electric Vehicle (EV) Traction Motor Control, HVAC Fan Speed Control	
Experiment 8	**02 hrs.**
Robotic Arm Motion Control Using PID Controller	
Real-World Assignment: Model the robotic arm joints as servo or DC motors with position and velocity feedback.	
Exemplars / Practical Applications: Industrial Automation and Assembly Lines, Medical Robotics, Space Robotics, Research and Education, Agricultural Robotics	
Experiment 9	**02 hrs.**
Implementation of IoT-Enabled Predictive Maintenance for CNC Machines	
Real-World Assignment: Design a system integrating CNC machine sensors (vibration, temperature, spindle load, etc.) with IoT devices for real-time data acquisition.	
Exemplars / Practical Applications: Smart Manufacturing Plants, Aerospace Component Fabrication, Automotive Manufacturing, Industrial Equipment Rental Services, Research & Development Facilities	

Learning Resources

Text Books:

1. Muhammad H. Rashid – Power Electronics: Circuits, Devices, and Applications (Pearson)
2. Bimbhra P.S. – Power Electronics (Khanna Publishers)
3. Hughes – Electrical and Electronic Technology (Pearson)
4. Dorf R.C. & Bishop R.H. – Modern Control Systems (Pearson)
5. Jon Stenerson – Industrial Automation and Process Control (Pearson)

Reference Books:

1. Mohan, Undeland, Robbins – Power Electronics: Converters, Applications, and Design (Wiley)
2. Bolton W. – Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering (Pearson)
3. Frank D. Petruzella – Programmable Logic Controllers (McGraw-Hill)
4. R.K. Rajput – Industrial Electronics and Control (S. Chand)
5. James A. Rehg & Glenn J. Sartori – Industrial Electronics (Pearson)

MOOC / NPTEL/YouTube Links: -

1. https://nptel.ac.in/courses/108105088
2. https://www.youtube.com/playlist?list=PLE8F9BF5CB1201D23
3. https://www.youtube.com/watch?v=3k9_YzcfGJo&list=PLgwJf8NK-2e5Hnu82T1CYLZ8kbZs4Jx8x&index=2
4. https://www.youtube.com/watch?v=lVJYtJCgHjk
5. https://archive.nptel.ac.in/courses/112/103/112103293/
6. https://nptel.ac.in/courses/106105195

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
VSE231AUR: Workshop Practices		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**1**	**Practical: 25 Marks**

Prerequisite Courses, if any:

- Manufacturing Processes
- Manufacturing Practice Workshop
- Engineering Physics, Chemistry
- Engineering Graphics
- Engineering Materials and Metallurgy

Course Objectives:

1. To UNDERSTAND safety norms required while using various machine tools and shop floor.
2. To understand the basic procedures, types of equipment, tooling used for sand casting and metal forming processes through demonstrations and/(or) Industry visits.
3. To acquire skills to produce a composite part by manual process.
4. To UNDERSTAND the principles & acquire skills to produce components using application of press operations and manufacturing / process plans.
5. To understand TIG/ MIG/ Resistance/Gas welding welding techniques.

Course Outcomes:

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

CO1. **IDENTIFY** and **ANALYZE** safety standards and safety measures applicable to various sections of mechanical workshops and effectively communicate these through the preparation of informative posters or reports.

CO2. **APPLY** the fundamental principles of design to create efficient, user-friendly, and safe product designs, supported with suitable real-world examples.

CO3. **PLAN** and **EXECUTE** the production of an assembly job by performing a sequence of machining operations while selecting appropriate materials and processes to meet functional and assembly requirements.

List of Experiments

Experiment 1	**02 hrs.**

Study and analyze the safety standards and safety measures implemented in various sections of a mechanical workshop, prepare informative posters or comprehensive reports.

Real World Assignment

1. Prepare a report/presentation on safety precautions in workshop/industry/power plants/service canters, etc.

Exemplars / Practical Applications

Mechanical workshop layout planning, Machine tool safety implementation, Welding and fabrication safety management, Material handling and storage safety, Personal protective equipment (PPE) compliance and training

Experiment 2	**02 hrs.**

Demonstration/Study of Industrial robot safety considerations, standards and best practices

Real World Assignment

1. Prepare a report/presentation on safety precautions while operating Robotic systems

Exemplars / Practical Applications

Robot cell design & practices

Experiment 3	**12 hrs.**

Production/machining of assembly job containing 2-3 components and suitable for assembly with standard components viz. nut, screw, bearing etc. consisting at least 4-5 operations from the following list:

1. Prepare a report/presentation on safety precautions in workshop/industry/power plants/service canters, etc.
2. Raw material selection (Suitable for job in assignment)
3. Raw material preparation like hacksaw cutting, etc.
4. Rough turning on lathe/CNC
5. Rough milling on Milling machine or VMC viz. machining flats, gear cutting, keyways, etc.
6. Drilling/tapping/threading
7. Finishing on CNC/VMC (or combined operations from step 3 to 6 on CNC/VMC)
8. Surface finishing using Grinding/Polishing/Buffing, etc.
9. Surface treatment for corrosion/wear resistance, aesthetics, etc.

Real World Assignment

Students are expected to perform following activities under this experiment:

a) Selection of suitable Engineering material viz. ferrous/non-ferrous/non-metallic material available easily in market at least cost considering energy & environmental aspects of Green Manufacturing
b) Select appropriate form of material for job under consideration e.g. Casting/Forging/Round Bar/Hex Bar/Sheet metal/flats, etc. (Refer Machinery Handbook/Westermann Table, or any available reliable sources, etc.)
c) Plan machining using Process Sheets
d) Select appropriate machines, cutting tools & machining parameters viz. Cutting Speed (Vc m/min), feed (mm/rev or mm/minute) & Depth of Cut (DoC)
e) Calculate Machining Power requirement, Material Removal Rate (MRR) and resulting Surface finish using online machining calculators available on cutting tools manufacturers sites
f) Select appropriate surface finishing process for surface protection for Surface treatment/finishing of any component manufactured above processes using grinding/ cylindrical grinding / buffing/honing/ burnishing operation
g) Estimate material & machining costs

Experiment 4	**04 hrs.**

Fabrication of a component by joining two similar or dissimilar metals using TIG, MIG, or gas welding techniques.

Real World Assignment

a) Comparative study of soldering, brazing & welding processes and respective applications
b) Study of defects and case studies
c) A job drawing to be prepared by an individual institute with details of welding process parameters with weld joint design such as edge preparation, type and size of electrode used, welding current, voltage etc.

Exemplars / Practical Applications

Automotive exhaust system fabrication, Aerospace frame assembly, Bicycle frame welding, Industrial piping and tubing fabrication, Custom metal furniture manufacturing

Experiment 5	**04 hrs.**

Manufacturing one engineering component using casting/forging in available workshop facilities of any engineering material like wax, tin, etc.

OR

Observe and demonstrate the manufacturing processes of castings and forgings during an industrial visit.

Real World Assignment

i. Casting considerations, study of defects in the cast product.

ii. Demonstration of defects/temperature distributions using suitable mold flow analysis or equivalent simulations

iii. Industrial visit report in case of demonstration

Exemplars / Practical Applications

Prototype component casting, Decorative metal item fabrication, Educational model making, Small gear or pulley forging, Custom bracket manufacturing

Experiment 6	**04 hrs.**

Real World Assignment

1. Calculation on sheet metal layout, finishing process of sheet metal parts.
2. Manufacture a simple component using a press machine involving operations such as punching, blanking, bending, and shearing, using any suitable engineering material.

OR

Observe and demonstrate the manufacturing processes of sheet metal components during an industrial visit.

Experiment 7	**04 hrs.**

Real World Assignment:

Self-study – Students will choose an engineering-related domestic product composed of at least 4–5 components and prepare detailed material selection and manufacturing plans, considering a broad range of materials including ferrous and non-ferrous metals, as well as non-metallic materials.

* Students are required to prepare a brief report summarizing the processes studied throughout the course and providing a cost analysis related to the selected project.

Students are expected to select available products viz.

i. Domestic products viz. Oven/Microwave/Blender/Cooker/Kitchen Sink, Kettle, etc.

ii. Robotic floor cleaner, Electric razors, etc.

iii. Ceiling fans/table fan/exhaust fans, etc.

***Note: Students can choose engineering products of their interest consisting of 4-5 components manufactured by verity of manufacturing processes and materials.

Savitribai Phule Pune University Second Year of Automation & Robotics (2024 Pattern)				
HSSM-232-AUR: Entrepreneurship Development and Innovation				
Teaching Scheme		**Credit**	**Examination Scheme**	
Theory	**1 Hours/Week**	**1**	**CCE**	**25 Marks**
Practical	**NA**		**End-Semester**	**NA**

Prerequisite Courses, if any:

- None (Open to all engineering branches)

Course Objectives:

1. APPLY innovation techniques to develop solutions to real-world problems.
2. DESIGN a viable business model using structured tools.
3. EVALUATE the feasibility of a startup idea from technical, financial, and market perspectives.
4. COLLABORATE in teams to develop and pitch an entrepreneurial solution.

Course Outcomes:

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

CO1: DESCRIBE entrepreneurial traits and innovation processes (Remember/Understand), and IDENTIFY business opportunities through design thinking (Apply).

CO2: DEVELOP a lean business model and MVP (Apply/Analyze) and CREATE a startup pitch and demonstrate entrepreneurial mindset (Create)

Course Contents

Unit I	**Entrepreneurial Mindset, Creativity and Innovation**	**(08 Hours)**

- Entrepreneurial mindset: curiosity, resilience, risk-taking, leadership
- Types of entrepreneurs – Technical, Non-technical, Social, Entrepreneur
- Innovation types: product, service, process, frugal (Jugaad) innovation
- Design Thinking: Empathize, Define, Ideate, Prototype, Test
- Creativity tools: Mind Mapping, SCAMPER, TRIZ
- Success stories from Indian innovators
- Case studies: Innovative Indian products/startups

Assignments and Exercises (Any Three, Community Engagement Project is compulsory)

1. **Guest Session + Reflection Report**

   Application: Invite an Indian entrepreneur (e.g., local start up founder or alumni) for a guest talk.
   Task: Students write a 1-page reflection/ Quiz on entrepreneurial mind-set, risks taken, and innovation style.

2. **Case Study Presentation**

   Activity: Select an Indian start-up and analyse:
   - The problem it solves
   - Type of innovation (product, process, frugal, etc.)
   - Entrepreneurial mind-set of the founder

   Deliverable: Present as a 5-minute video or a PPT with voice narration.

3. **Present any one Course Project/ Community Engagement Project(CEP) in context with Design Thinking**

   Activity: In small groups, students will solve a common college problem (e.g., canteen cleanliness, Wi-Fi issues, exam stress, long queues, absenteeism, lack of seating, etc.) using the Design Thinking process in 45–60 minutes:

a. Empathize (5–10 min): Talk to 2–3 students or staff to understand the issue
b. Define (5 min): Clearly write the problem in one sentence
c. Ideate (10–15 min): Brainstorm at least 5–7 possible solutions
d. Prototype (10–15 min): Create a quick sketch, model, or chart of the best solution
e. Test (10 min): Share the idea with another group and collect feedback
Deliverable: Student should present 1 page summary/ poster/ prototype of the Course Project / Community Engagement Project(CEP) in context with Design Thinking

4. **Campus Creativity Challenge**
   Application:
   - Use **Mind Mapping** to improve a college service (e.g., library hours, parking space).
   - Apply **SCAMPER** to redesign a student-used item (e.g., backpack, ID card).
   - Use **TRIZ** to resolve a contradiction (e.g., "How to make exams easy but still effective").
   - Use **Design Thinking** process to solve college problem (e.g., canteen cleanliness, Wi-Fi issues, exam stress, long queues, absenteeism, lack of seating, etc)

Deliverable: Student should present 1 page summary/ poster/ prototype of the Course Project in context with Design Thinking.

Exemplars / Practical Applications: Problem solving in Startups

Unit II	Opportunity Identification and Business Modelling	(08 Hours)

- Opportunity Recognition and Idea Generation - Problem identification and need analysis
- Market research: tools and techniques
- Business Model Canvas: customer segments, value proposition, channels
- Lean Startup methodology & Minimum Viable Product (MVP)
- Business plan components and structure
- Cost estimation, revenue models, and unit economics
- Funding options: Government schemes (Startup India, MSME), VC, Angel Investors,
- Crowd funding
- Basics of financial literacy: Profit-Loss, Break-even, cash flow.

Assignments and Exercises *(Any Three)*

1. **Conduct Start-up Financials Workshop**
   Application: Hands-on session using a fictional start-up (e.g., chai café):
   - Calculate fixed and variable costs
   - Identify breakeven point
   - Build a simple cash flow chart for 6 months

   Outcome: Submit an Excel sheet with key financial metrics and a one-page interpretation.
2. **Government Funding Scheme Research**
   Application:
   - Each group explores one government scheme (e.g., Start-up India Seed Fund, MUDRA loan, PMEG Scheme, MSME credit)
   - Analyse eligibility, application process, benefits, and success stories
3. **Opportunity Recognition and Need Analysis**
   Activity: Identify 3 real-life problems a community face (e.g., water waste, long queues, and costly transportation) or college.
   - Conduct informal interviews or surveys to understand the need.
   - Analyse user pain points and existing gaps.
   - Select one high-potential problem and formulate an idea to solve it.

   Deliverable: Opportunity report with problem statement, user quotes, and proposed idea.

4. **Business Model Canvas + MVP Design**
   Activity: Choose a start-up idea and:
   - Create a detailed **Business Model Canvas** (cover all 9 blocks).
   - Develop a basic **Minimum Viable Product (MVP)** – this could be a sketch, clickable prototype, or service flow.

   Deliverable: BMC template filled + MVP mock-up/photo.
5. **Business Plan + Funding Strategy + Pitch**
   Activity: Prepare a **business plan** including:
   - Executive summary
   - Product/service details
   - Market research insights
   - Costing and basic unit economics
   - Revenue model
   - Funding plan (choose and justify one: Government scheme, VC, angel, crowd funding)
   - Prepare elevator pitch / 1 minute pitch

   Deliverable: 4–6 page business plan document + pitch deck (5–7 slides).
   Outcome: Awareness of the Government start-up funding schemes and prepare a report of 3 to 4 pages.

Exemplars / Practical Applications: Arranging Mock Pitching Competitions

Learning Resources

Text Books:

1. Entrepreneurship Development – S.S. Khanka
2. Entrepreneurship Development and Small Business Enterprises – Poornima M. Charantimath
3. Entrepreneurship: New Venture Creation– David H. Holt (Indian Edition by Vikas Publishing)
4. Innovation and Entrepreneurship – Dr. R.G. Desai
5. Essentials of Entrepreneurship and Small Business Management – Nandan H.

Reference Books:

1. The Lean Startup – Eric Ries
2. Disciplined Entrepreneurship: 24 Steps to a Successful Startup – Bill Aulet (MIT)
3. Zero to One – Peter Thiel
4. The Startup Owner's Manual – Steve Blank & Bob Dorf
5. Jugaad Innovation – Navi Radjou, Jaideep Prabhu, and Simone Ahuja
6. Stay Hungry Stay Foolish – Rashmi Bansal
7. Connect the Dots – Rashmi Bansal
8. Innovation and Entrepreneurship – Peter F. Drucker
9. Startup Sutra – Rohit Prasad
10. Dream With Your Eyes Open – Ronnie Screwvala

MOOCs / NPTEL / SWAYAM Courses (Free): -

1. Entrepreneurship Essentials – Offered by IIT Kharagpur (NPTEL)
   Duration: 8 weeks | Level: UG/PG
   Covers: Entrepreneurial process, business models, marketing, funding.
2. Entrepreneurship and Innovation – IIT Roorkee
   Duration: 12 weeks
   Covers: Types of innovation, design thinking, ecosystem, and scaling.
3. Product Management and Entrepreneurship – IIM Bangalore
   Duration: 8 weeks
   Focus: Customer discovery, MVPs, and product-led growth.
4. Innovation, Business Models and Entrepreneurship – IIT Madras
   Explores innovation in products and services, and lean canvas approach.
5. Design Thinking - A Primer – IIT Madras

Ideal for teaching creativity and problem-solving using design thinking.

6. Coursera: Design Thinking for Innovation by University of Virginia
7. edX: Entrepreneurship in Emerging Economies by Harvard

YouTube Channels / Playlists :

1. Startup India Official Channel •
2. Regular videos on policies, funding opportunities, and success stories.
    a. IIT Madras – NPTEL Entrepreneurship Playlist
    Covers fundamentals of startup creation and innovation strategy.
    b. Dr. HYPERLINK "https://www.youtube.com/user/MrVivekBindra"Vivek HYPERLINK "https://www.youtube.com/user/MrVivekBindra" HYPERLINK "https://www.youtube.com/user/MrVivekBindra"Bindra HYPERLINK "https://www.youtube.com/user/MrVivekBindra" – Entrepreneur HYPERLINK "https://www.youtube.com/user/MrVivekBindra"& HYPERLINK "https://www.youtube.com/user/MrVivekBindra" Motivational Speaker
    c. Popular in India; motivational and strategic content (more business-oriented).
    d. Desh HYPERLINK "https://www.youtube.com/@DeshDeshpandeFoundation" Deshpande Foundation
    Videos on grassroots entrepreneurship and social innovation.
3. Stanford HYPERLINK "https://www.youtube.com/user/ecorner"eCorner

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
VEC233AUR: Universal Human Values		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 02 Hours/Week	**2**	**CCE:** 15 Marks
Practical: ---		**End-Semester:** 35 Marks

Prerequisite Courses, if any:

- UHV-1 of Student Induction Program (SIP) (desirable)

Course Objectives:

1. To HELP the students develop a holistic, humane world-vision, and appreciate the essential complementarity between values and skills to ensure mutual happiness and prosperity
2. To ELABORATE on 'Self-exploration' as the process for Value Education
3. To FACILITATE the understanding of harmony at various levels starting from self and going towards family and society.
4. To ELABORATE on the salient aspects of harmony in nature and the entire existence
5. To EXPLAIN how the Right understanding forms the basis of Universal human values and definitiveness of Ethical human conduct.
6. To PROVIDE the vision for a holistic way of living and facilitate transition from chaotic life to an orderly life.

Course Outcomes:

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

CO1- RECOGNIZE the concept of self-exploration as the process of value education and see they have the potential to explore on their own right.

CO2- EXPLORE the human being as the coexistence of self and body to see their real needs / basic aspirations clearly

CO3- EXPLAIN relationship between one self and the other self as the essential part of relationship and harmony in the family

CO4- INTERPRET the interconnectedness, harmony and mutual fulfilment inherent in the nature and the entire existence

CO5- DRAW ethical conclusions in the light of Right understanding facilitating the development of holistic technologies production systems and management models

Course Contents

Unit I	**Introduction to Value Education**	**(03 Hours)**

- Understanding Value Education
- Self-exploration as the Process for Value Education
- Continuous Happiness and Prosperity - the Basic Human Aspirations and their Fulfilment
- Right Understanding, Relationship and Physical Facility
- Happiness and Prosperity - Current Scenario
- Method to Fulfil the Basic Human Aspirations

Exemplars / Practical Applications

Explore real life applications using Practical No. 1, 2, 3, 4

Unit II	**Harmony in the Human Being**	**(03 Hours)**

- Understanding Human being as the Co-existence of the Self and the Body
- Distinguishing between the Needs of the Self and the Body
- The Body as an Instrument of the Self
- Understanding Harmony in the Self
- Harmony of the Self with the Body

- Programme to Ensure self-regulation and Health

Exemplars / Practical Applications
Explore real life applications using Practical No. 5, 6.

Unit III	Harmony in the Family and Society	(03 Hours)

- Harmony in the Family - the Basic Unit of Human Interaction
- "Trust' - the Foundational Value in Relationship
- 'Respect' - as the Right Evaluation
- Values in Human-to-Human Relationship
- Understanding Harmony in the Society
- Vision for the Universal Human Order

Exemplars / Practical Applications
Explore real life applications using Practical No. 7, 8

Unit IV	Harmony in the Nature (Existence)	(03 Hours)

- Understanding Harmony in the Nature
- Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature
- Realizing Existence as Co-existence at All Levels
- The Holistic Perception of Harmony in Existence

Exemplars / Practical Applications
Explore real life applications using Practical No. 9,10,11

Unit V	Implications of the Holistic Understanding - Professional Ethics Look	(03 Hours)

- Basis for Universal Human Values
- Definitiveness of (Ethical) Human Conduct
- Professional Ethics in the light of Right Understanding
- A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order
- Holistic Technologies, Production Systems and Management Models Typical Case Studies
- Strategies for Transition towards Value-based Life and Profession

Exemplars / Practical Applications
Explore real life applications using Practical No. 12,13,14

List of Practicals

Practical 1: Sharing about Oneself Introduction of students with following points yourself, family, friends, achievements and failures, your aspirations from life. How do you expect to fulfil these aspirations and live a life of fulfillment?
Expected Outcome: The students start exploring themselves; get comfortable with each other and with the teacher and start appreciating the need and relevance of the course.

Practical 2: Exploring Human Consciousness Watch and discuss the documentary video "Story of Stuff". It is a about the materials economy – its motivation, process and outcome. (Source: http://storyofstuff.org/movies/story-of-stuff)
Expected Outcome: The students start finding that right understanding is the basic need of human being; followed by relationship and physical facility. They also start feeling that lack of understanding of human values is the root cause

Practical 3: Exploring right understanding Make a list of your desires. Now for each item on the list, find out what would be necessary to fulfil it, i.e. will it require: (a) Right understanding? (b) Relationship (right feeling)? (c) Physical facility? *Expected Outcome*: Students start feeling that lack of understanding of human values is the root cause of all problems and the sustained solution could emerge only through understanding of human values and value-based living.
Practical 4: Exploring Natural Acceptance Observation within the faculty of 'Natural Acceptance', based on which you can verify what is right or what is not right for you. Make a list of the problems in your family. For each problem, find out the most significant reason: is it related to lack of right understanding, lack of feelings in relationship or lack of physical facility? Also, find out how much time and effort you have devoted for each in the last one week. *Expected Outcome*: The students are able to see that self-verification must be based on their natural acceptance. In many cases, their actual living is not in accordance with their natural acceptance. In addition, lack of feeling in relationship is the major cause of problems in their family and with friends.
Practical 5: Exploring the difference of Needs of Self and Body Take the list of desires you made in Practical 2. Update it if required. Now classify the desires as being related to the need of the Self or need of the Body. *Expected Outcome*: The students are able to relate their desires to need of the Self and the Body distinctly. They are able to see that the Self and the Body are two distinct realities, and large parts of their desires are related to the need of the Self (and not the Body).
Practical 6: Exploring Sources of Imagination in the Self Recall the times that your body has been ill (in disharmony) in the last 3 years. What steps were taken to restore the harmony of the Body? If you were to take full responsibility for your body, (i.e. you had the feeling of self-regulation), what kind of daily schedule would you have? Approximately how much time would you allocate for keeping your body in good health? *Expected Outcome*: The students are able to list down activities related to proper upkeep of the Body and practice them in their daily routine. They are also able to appreciate the plants growing in and around the campus, which can be beneficial in maintaining their health and even curing common ailments.
Practical 7: Exploring the Feeling of Trust Show & discuss the video "Right Here Right Now". It is a short film directed by Anand Gandhi about human behavior and its propagation. Part 1: https://www.youtube.com/watch?v=OVAokeqQuFM Part 2: https://www.youtube.com/watch?v=gIYJePEnvUY). *Expected Outcome*: The students are able to see that the natural acceptance (intention) of everyone is to be happy and make others happy! It is the competence is lacking in themselves and in others. They are able to distinguish between reaction and response, appreciate the need for 100% response in human interaction and make effort towards it.
Practical 8: Exploring the Feeling of Respect List out ten or more of your interactions with other people in your family and friends in the last one week. Now analyze these interactions were over-evaluation, under/ otherwise evaluation or right evaluation of the other? In each interaction, were you comfortable within, uncomfortable within or unaware of your state? *Expected Outcome*: The students are able to see that respect is the right evaluation (of intention and competence). Only right evaluation leads to fulfillment in relationship. Over evaluation leads to ego and under/otherwise evaluation leads to depression.

Practical 9: Exploring Systems to fulfil Human Goal Assuming that you would like to see your hostel/ educational institution/ workplace/ neighborhood as a model of human society, write down its goal(s) and the system to achieve these goals. *Expected Outcome*: The students are able to see that as a family, a society, the comprehensive human goal is naturally acceptable to all. They are able to see that the systems required for their fulfilment include; Education-Sanskar, Health Self-regulation, Production-Work, Justice-Preservation and Exchange-Storage. Meaningful participation by every individual, every family, every family cluster… every village, town, city… country and the whole world is required in these systems for the human goals to be fulfilled.
Practical 10: Exploring the Four Orders of Nature Watch and discuss the documentary video "An Inconvenient Truth". It is about global climate change presented by Former US Vice President Al Gore. He raises the question "What were you doing when you had the time to do something?" (Source: http://an-inconvenient-truth.com/) *Expected Outcome*: The students are able to appreciate the interconnectedness, interdependence and the relationship of mutual fulfilment existing in nature. They are able to see that they have a natural acceptance to participate in a mutually fulfilling manner in nature.
Practical 11: Exploring Co-existence in Existence Observe your Self. Are you in space? Are you getting energy from the body? Is your energy dependent on the body? When your body is sick, does your energy to think diminish? Are you energized in space? Is the body dictating you? Are you self-organized in space? *Expected Outcome*: The students are able to obtain a holistic vision about the existence. It is in the form of co-existence, rather than a chaos. Every unit is energized, self-organized and is participating with other units in an orderly manner for mutual-fulfilment. It is only the human being without right understanding, which is violating this underlying co-existence. They are able to appreciate the need to understand the co-existence in existence.
Practical 12: Exploring Ethical Human Conduct Watch and discuss the video "Hiware Bazaar". It is a documentary about a progressive village in Maharashtra, India about how good governance, along with the people of the village have made significant change in their society (Source: https://www.youtube.com/watch?v=cb0Qvh9BJ0s) *Expected Outcome*: The students are able to clearly visualize the co-relation between lack of Human Values and the prevailing problems. They are also able to visualize tangible steps and a roadmap for moving in the cherished direction – for a humane society.
Practical 13: Exploring Humanistic Models in Education By careful analysis, identify some important features to make our education more humanistic. What are the right expectations in terms of the outcome from humanistic education? Explain with justification. *Expected Outcome*: The students are able to detail out various social systems essential for their own fulfilment, as well as the fulfilment of future generations. In particular, they are able to visualize the education system required for individual, and then societal transformation. They are also able to appreciate those many efforts made in the tradition that were in line with desirable human goals. Thus, they are able to learn from tradition and develop a deep sense of gratitude for the effort, for the people, for the tradition, culture etc.
Practical 14: Exploring Steps of Transition towards Universal Human Order Suggest ways in which you can use your knowledge of Technology/ Engineering/ Management/Medicine etc. for universal human order, from your family order to the world family order. Evaluate your state before and after the course in terms of (a) Thought (b) Behavior (c) Work (d) Realization *Expected Outcome*: The students are able to visualize an appropriate utilization of the knowledge in their respective streams to ensure mutually enriching and sustainable systems. They are able to sincerely evaluate the course and the transformation achieved in this process. They are also able to make use of this understanding for moving towards a happy and prosperous life, including an ethical conduct of their profession

Learning Resources
Text Books: 1. A Foundation Course in Human Values and Professional Ethics, RR Gaur, R Asthana, GP Bagaria, 3rd revised edition, UHV Publications, 2023, ISBN: 978-81-957703-7-3 (Printed Copy), 978-81-957703-6-6 (e-book) 2. Teacher's Manual for A Foundation Course in Human Values and Professional Ethics, RR Gaur, R Asthana, GP Bagaria, 3rd revised edition, UHV Publications, 2023, ISBN: 978-81-957703-5-9 (Printed Copy), 978-81-957703-0-4 (e-Book)
Reference Books: 1. P. L. Dhar, R. R. Gaur (1990) Science and Humanism, Commonwealth Publishers. 2. A. Nagaraj (1999) Jeevan Vidya: Ek Parichaya, Jeevan Vidya Prakashan, Amarkantak. 3. B. P. Banerjee (2005) Foundations of Ethics and Management, Excel Books. 4. A. N. Tripathy (2003) Human Values, New Age International Publishers. 5. E. G. Seebauer & Robert L. Berry (2000) Fundamentals of Ethics for Scientists & Engineers, Oxford University Press. 6. B. L. Bajpai (2004) Indian Ethos and Modern Management, New Royal Book Co., Lucknow. 7. M. Govindrajran, S Natrajan & V.S. Senthil Kumar, Engineering Ethics and Human Values, Eastern Economy Edition, Prentice Hall of India Ltd. 8. M. K. Gandhi, "The Story of my Experiments with Truth", Discovery Publisher
MOOC / NPTEL/ YouTube Links: - 1. Swayam Course on "Understanding Human Being Nature and Existence Comprehensively" by Dr. Kumar Sambhav, Director, UP Institute of Design (UPID), Noida. https://onlinecourses.swayam2.ac.in/aic22_ge23/preview 2. NPTEL Course on "Exploring Human Values: Visions of Happiness and Perfect Society" by Prof. A. K. Sharma, Department of Humanities and Social Sciences, IIT Kanpur. https://nptel.ac.in/courses/109104068 **E-Resources:** 1. https://fdp-si.aicte-india.org/download.php#1/ 2. https://madhyasth-darshan.info/postulations/knowledge/knowledge-of-humane-conduct/ 3. https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
CEP241AUR: Community Engagement activity / Field Project		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: NA	**2**	**Term Work: 25 Marks**
Practical: 04 Hours/Week		**Oral: 25 Marks**

Prerequisite Courses, if any:

Students should have prior knowledge of

1. Basic understanding of social and ethical responsibilities
2. Teamwork and communication skills acquired in prior coursework or group activities
3. Familiarity with problem-solving methodologies and project planning
4. Conversation in local language

Companion Course :

1. CEP is an experiential learning approach that combines education, learning, community development, and meaningful community service.
2. Project involves students in community development and service activities and applies the experience to personal and academic development.
3. The targeted contribution of college students to the village/local development will benefit the community.
4. The college has an opportunity to help students become more socially conscious and responsible while simultaneously becoming a socially conscious organization

Course Objectives:

1. Establish a mutually beneficial relationship between the college and the community
2. Opportunities to engage with their local community, fostering empathy, teamwork, and problem solving skills while contributing positively to their surroundings.
3. An understanding of the challenges faced by the local community and the role of engineering in addressing those challenges.
4. The ability to apply technical knowledge and skills to design solutions or interventions that create a positive impact on the community.
5. The skills to evaluate and critically analyze the outcomes of their engagement activities, deriving actionable insights for sustainable impact

Course Outcomes:

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

CO1: Identify and Analyze local community needs and challenges by engaging with stakeholders and evaluating real-world problems.

CO2: Design and Implement practical, creative, and context-specific solutions using engineering principles to address community issues.

CO3: Reflect and Evaluate the effectiveness of their interventions and articulate lessons learned through reports and presentations.

Course Contents
Implementation
• A group of 3 to 4 students or a single student could be assigned for a particular habitation or village or municipal ward, as far as possible, in the near vicinity of their place of stay/college premise. • Each group is allotted to a faculty member of the department as a mentor. • The group of students will be associated with a government official / village authorities /NGOs etc. concerned, allotted by the district administration, during the duration of the project. • The Community Engagement Project should be different from the regular programmes of NSS/NCC/Green Club/Hobby Clubs, Special Interests Groups etc • An activity book has to be maintained by each of the students to record the activities undertaken/involved and will be countersigned by the concerned mentor/HoD. • Project report shall be submitted by each student/group of students. • An internal evaluation shall also be conducted by a committee constituted by the HoD. Evaluation to be done based on the active participation of the student and marks could be awarded by the mentor/HoD. • Students groups can conduct an awareness programme on Health and Hygiene or in Organic Farming or in Fisheries or in advocating prohibition of liquor or about renewable energy, e-waste management or any other activity in an area of their studies and as per his/her aptitude
Suggestive list of topics under Community Engagement Project
The below lists are not exhaustive and open for HoD's or mentors to add, delete or modify. It is expected that the focus should be on specific local issues in their nearby areas. The students are expected to carry out these projects with involvement, commitment, responsibility and accountability. The mentors of a student/group of students shall 1. Use/ miss-use of cell phones 2. Career orientation of youth 3. Water facilities and drinking water availability 4. Health and hygiene of the school going students, home makers and old personals 5. Health intervention and awareness programmes 6. Horticulture 7. Herbal and Nutrition 8. Traditional and Modern health care methods 9. Food habits 10. Air /Sound /Water pollution 11. Plantation and Soil protection 12. Renewable energy and Solar Systems 13. Yoga awareness and practice 14. Health care awareness programmes and their impact 15. Organic farming 16. Food adulteration 17. Incidence of Diabetes and other chronic diseases 18. Blood groups and blood levels 19. Chemicals in daily life 20. Music and dance 21. Women education and empowerment

Project Scope

• Conduct workshops or awareness drives on topics like digital literacy, environmental sustainability, mental health, or career planning for local stakeholders.
• Develop a simple prototype or solution that addresses a real-world problem (e.g., a water-saving device, simple mobile apps, or tools for community use).
• Organize clean-up drives, tree plantations, recycling campaigns, or energy conservation initiatives.
• Promote health through awareness programs on hygiene, nutrition, and exercise.
• Teach basic computer or technical skills to students, staff, or the community

Proposal Submission

CEP Group should Submit a two-page project proposal, preferably prior to the term commencement outlining the following:-
• Title of the project
• Aim, Objective and expected outcome
• Plan of execution (timeline and activities).
• Place of the CEP and involvement of any local authority, NGP
• Required resources (if any).
• Get approval from the designated faculty mentor.

Learning Resources

Text Books:

1. Waterman, A. Service-Learning: A Guide to Planning, Implementing, and Assessing Student Projects. Routledge, 1997.
2. Beckman, M., and Long, J. F. Community-Based Research: Teaching for Community Impact. Stylus Publishing, 2016.
3. Design Thinking for Social Innovation. IDEO Press, 2015.
4. Dostilio, L. D., et al. The Community Engagement Professional's Guidebook: A Companion to The Community Engagement Professional in Higher Education. Stylus Publishing, 2017

MOOC / NPTEL/ YouTube Links: -

1. NPTEL course: Ecology and Society, https://onlinecourses.nptel.ac.in/noc20_hs77/preview

Web Links: -

1. UNESCO: Education for Sustainable Development https://www.unesco.org
2. EPICS (Engineering Projects in Community Service) https://engineering.purdue.edu/EPICS
3. Ashoka: Innovators for the Public https://www.ashoka.org
4. Design for Change https://www.dfcworld.com

Savitribai Phule Pune University, Pune

Maharashtra, India

SE - Automation & Robotics Engineering

2024 Pattern

Semester IV Courses

With effect from Academic Year 2025-26

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
PCC251AUR: Principles of Robotics		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**3**	**CCE: 30 Marks**
Practical: NA		**End-Semester: 70 Marks**

Prerequisite Courses, if any:

- Materials & Machine Elements
- Industrial Electronics & Controls
- Engineering Physics
- Manufacturing Technology
- Product Development Laboratory

Course Objectives:

1. To introduce various types of Robots and the functional elements of Robotics
2. To introduce various types of the end effectors
3. To introduce the basic mathematical modeling of a robot
4. To impart knowledge of basics of Robot Programming and robotic Applications
5. To discuss future trends in Robotics and its applications

Course Outcomes:

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

CO1. UNDERSTAND basic concepts of robotics & SELECT appropriate configuration for application.
CO2. SELECT or DESIGN robot end effectors as per application
CO3. MODEL robotic arm for forward/inverse kinematics
CO4. UNDERSTAND fundamentals of robot programming and WRITE robot programs
CO5. ANALYSE robot program for troubleshooting and optimum operations using advanced robotic programming techniques.

Course Contents

Unit I	Introduction to Industrial Robotics	(08 Hours)

Fundamentals of Robotics: Definitions of Industrial Robot, functions, advantages, disadvantages, applications of robots, Asimov's laws of robotics, Robotic Work Cell
Robot Anatomy: Classification, Components – Introduction to drives, sensors, Controllers
Robot Degrees of Freedom, Robot Joints and symbols, Robot Coordinates, Robot Reference Frames
Robot Specifications: Work envelope, payload capacity, Resolution, accuracy, repeatability
Robot Applications: Material transfer and machine loading/unloading, processing operations assembly and inspection, Robot Economics.

Real World Assignment:

1. Demonstration of various robotic configurations using industrial robot
2. Choose right robot for manufacturing/non-manufacturing applications enlisted as exemplars.
3. Write specifications for selected robot.

Exemplars / Practical Applications:

1. Assembly: Assembly of components with high precision, reducing production bottlenecks and ensuring consistent product quality in electronics, automotive, and consumer goods manufacturing.
2. Material Handling: Picking, Packing, Palletizing for shipment, enhancing speed and accuracy in warehouses and distribution centers.
3. Welding: Industrial robots perform various welding processes viz. arc, spot, and laser welding, ensuring consistent weld quality and improving worker safety by handling hazardous tasks
4. Painting and Coating: Robotic arms apply paints and coatings uniformly, reducing waste and ensuring consistent finishes, especially in automotive and appliance manufacturing.
5. Machine loading and unloading into machines like CNCs, increasing productivity and allowing human workers to focus on more complex tasks

Unit II	End Effectors	(08 Hours)

Introduction, Type of End Effectors
Grippers, Types of Grippers - Mechanical, Pneumatic and Hydraulic, Magnetic, Vacuum Grippers with applications, Selection and Design Considerations for Grippers;
Design of Mechanical Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers;
Advance Grippers- Adaptive grippers, Soft Robotics Grippers, Tactile Sensor Grippers;
Various process tools as end effectors; Robot end effectors interface, Active and passive compliance,

Real World Assignment:

1. Design end effector for handling cylindrical/prismatic objects.
2. Design end effector for handling spherical objects.
3. Compare grippers designed for handling cylindrical/prismatic and spherical objects.

Exemplars / Practical Applications:

1. Grippers:
   - 1.1. Mechanical (parallel/claws): Two or more rigid fingers that grasp objects—fast, simple, and ideal for uniform parts, though less suited for fragile items
   - 1.2. Vacuum/Suction cups: Use suction to lift flat/smooth items—great for packaging, glass, and electronics, but less effective on porous surfaces
   - 1.3. Soft/adaptive grippers: Made from flexible materials or air-actuated fingers that conform to varied or delicate shapes (like food items or electronics)
   - 1.4. Magnetic/electrostatic: For handling ferrous materials or ultra-light components using atomic forces.
2. Tools that physically modify objects: welding torches (MIG/TIG/spot), paint sprayers, cutting/drilling/sanding tools, adhesive dispensers, etc.

Unit III	Mathematical Modeling of a robot	(08 Hours)

General Mathematical Preliminaries on Vectors & Matrices, Link Equations and relationships, Direct Kinematics, Co-ordinate and vector transformation using matrices, Rotation matrix, Inverse Transformations, Composite Rotation matrix, Homogenous Transformations, Robotic Manipulator Joint Co-ordinate System, inverse kinematics of two joints, D-H Parameters, Jacobian Transformation in Robotic Manipulation

Real World Assignment:

1. Use of computer facilities for direct and inverse kinematics of simple robot configuration

2. Demonstration of simple robotic system using available computational facilities

Exemplars / Practical Applications:

1. Forward and inverse kinematics let engineers derive the position/orientation of the end-effector from joint angles (and vice versa), enabling precise tasks like pick-and-place, assembly, welding, and medical robotics
2. Trajectory and path planning optimization computes efficient, safe joint-space paths that minimize forces or avoid obstacles

Unit IV	Fundamentals of Robot Programming and Applications	(08 Hours)

Introduction to Robotic Programming, On-line and off-line programming, programming examples. Various Teaching Methods, Survey of Robot Level Programming Languages

Path planning and Interpolation: A Robot Program as a Path in Space, Motion Interpolation, various Textual Robot Languages, Techniques for generating smooth robot motion paths between programmed points. Typical Programming Examples such as Palletizing, Loading a Machine, etc.

Sensor Integration: Tactile, position, velocity, and force sensors for robot interaction and feedback.

Real World Assignment:

1. Programming examples for common industrial applications (e.g., welding, painting, material handling, assembly).
2. One program using lead through programing for pick and place applications considering suitable sensor inputs

Exemplars / Practical Applications:

1. Lead through programing for applications like welding, brazing, etc.
2. Robot path planning and programming for pick and place, etc. operations.

Unit V	Advanced Robot Programming Techniques	(08 Hours)

Safety Programming: Functional Safety in Robotic Application, Emergency stop procedures, safety interlocks, robot programming considerations for safe operation.

Troubleshooting and Maintenance: Identifying and resolving common robot programming errors, basic robot maintenance procedures.

Future Trends in Industrial Robotics: Advanced programming techniques, collaborative robots (cobots), Humanoid Robots, and the integration of artificial intelligence (AI).

Real World Assignment:

1. Simulation and Offline Programming: Utilizing robot simulation software to create, test, and debug robot programs.
2.

Exemplars / Practical Applications:

1. Ethical considerations in ensuring robot safety.
2. ISO 10218 - Robots for Industrial Environments - Safety Requirements

Learning Resources

Text Books:

1. Groover, M.P. Weiss, M. Nagel, R.N. & Odrey, N.G., Ashish Dutta, Industrial Robotics, Technology, Programming & Applications, Tata McGraw Hill Education Pvt. Ltd. New Delhi
2. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.
3. Robot Programming: Robot Languages and Robot Communication by Richard D. Wright and

Matthew P. McLaughlin

Reference Books:

1. S B Niku, Introduction to Robotics, Analysis, Control, Applications, 2nd Edition, Wiley Publication, 2015.
2. Mikell P. Groover, Automation, Production Systems & Computer Integrated Manufacturing, PHI Learning Pvt. Ltd. , New Delhi, ISBN:987-81-203-3418-2, 2012
3. John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education, 2009
4. R K Mittal & I. J. Nagrath, Robotics and Control, McGraw Hill Publication, 2015. 5. Mike Wilson, Implementation of Robotic Systems, ISBN: 978-0-124-04733-4
5. Robotics, Vision & Control: Fundamentals & Advanced Applications by Farid Kendoul
6. Robot Programming: A Guide to Using RUIP with ABB Robots by Rick Young

MOOC / NPTEL/YouTube Links: -

1. https://onlinecourses.nptel.ac.in/noc20_de11/preview

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
PCC252AUR: Kinematics of Machines		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	3	**CCE:** 30 Marks
Practical: NA		**End-Semester:** 70 Marks

Prerequisite Courses, if any:

- Engineering Mathematics - I and II
- Engineering Physics
- Engineering Mechanics
- Product Development Laboratory

Course Objectives:

1. To make the students conversant with kinematic analysis of mechanisms applied to real life and industrial applications.
2. To develop the competency to analyze the velocity and acceleration in mechanisms using analytical and graphical approach
3. To develop the skill to propose and synthesize the mechanisms using graphical and analytical technique.
4. To develop the competency to understand & apply the principles of gear theory to design various applications.
5. To develop the competency to design a cam profile for various follower motions.

Course Outcomes:

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

CO1. APPLY kinematic analysis to simple mechanisms
CO2. ANALYZE velocity and acceleration in mechanisms by vector and graphical method
CO3. SYNTHESIZE a four bar mechanism with analytical and graphical methods
CO4. APPLY fundamentals of gear theory as a prerequisite for gear design
CO5. CONSTRUCT cam profile for given follower motion.

Course Contents

Unit I	Fundamentals of Mechanism	(08 Hours)

Kinematic link, Types of links, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Degree of freedom, Mobility of Mechanism, Inversion, Grashoff's law, Four-Bar Chain and its Inversions, Slider crank Mechanism and its Inversions, Double slider crank mechanism and its inversions

Mechanisms with Higher pairs, Equivalent Linkages and its Cases - Sliding Pairs in Place of Turning Pairs, Spring in Place of Turning Pairs, Cam Pair in Place of Turning Pairs

Real World Assignment: Identify mechanisms in the following domestic products viz. Bicycle, Door closure, Water Flush tank, etc. Investigate if current mechanism is replaced by other one.

Exemplars / Practical Applications:

1. Automotive: Suspension, steering, throttle controls, gear shifting, braking systems

2. Manufacturing: Presses, robotic arms, packaging machinery
3. Aerospace: Actuation of flaps, landing gear, engine controls
4. Household appliances: Washing machines, refrigerators, cam-driven valve

Unit II	Mechanisms in Automation Systems	(08 Hours)

Automation: Introduction, Types of Automation – Hard and Soft Automation

Rotary Power Transmission: Gears – Classification, terminology, direction, and speed ratios. Belts & Pulleys**:** Open and cross belt drives, Chains & Sprockets & their applications in Automation Systems, Gear trains

Linear Power Transmission: Screw, Rack-and-Pinion & Linear Guides

Cam-Follower Mechanisms: Introduction, Classification of Followers and Cams, Terminology of Cam Displacement diagram for the Motion of follower as Uniform velocity, Simple Harmonic Motion (SHM)

Indexing Mechanisms: Geneva Indexing Mechanism, Construction, Working & Application

Clutches, Brakes: Classification, Construction, Working & applications

Introduction to Harmonic drives and cycloidal reducers

Real World Assignment: Identify mechanisms for power transmission in domestic products viz. food processor, electric razor, etc. Investigate if current mechanism is replaced by other one.

Exemplars / Practical Applications:

1. Robotics: Harmonic and cycloidal gear reducers for backlash-free precision
2. Elevators: Pulleys and counterweights enable smooth motion and balance
3. Printing and shaping machines: Quick return and indexing used within shaper machines
4. Pantographs: Scale drawings up/down
5. Scotch-yoke: Valve actuators in oil & gas pipelines

Unit III	Kinematic Analysis of Mechanisms: Analytical Method	(06 Hours)

Analytical methods for displacement, velocity and acceleration analysis of slider crank Mechanism, Velocity and acceleration analysis of Four-Bar and Slider crank mechanisms using Vector and Complex Algebra Methods. Computer-aided Kinematic Analysis of Mechanism like Slider crank and Four-Bar mechanism, Analysis of Single and Double Hook's joint

Real World Assignment:

1. Computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for Kinematic Analysis of Slider Crank Mechanism using Analytical Method
2. Computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for Kinematic Analysis of Hooke's joint Mechanism using Analytical Method

Exemplars / Practical Applications:

1. High-Precision & Positioning Systems - Used in servo applications, robotics, positioning tables, and printing press drives that need accurate speed synchronization and positioning.
2. Trajectory planning: Kinematic modelling predicts the end-effector's position, enabling robots to execute precise pick-and-place, welding, or assembly tasks.
3. Inverse kinematics tells the robot joint angles needed to reach a target position—essential for multi-axis arms and humanoid robots.
4. Linkage design (e.g., windshield wipers, door mechanisms) depends on kinematics to cover the right motion range without collision.

5. Kinematic modelling enables CNC machines and milling centers to convert programmed tool paths into joint movements, ensuring accuracy and collision-free operation.
6. Presses and linkages, like punching or stamping lines, use position analysis to ensure timing synchronization and correct motion range.

Unit IV	Kinematic Analysis of Mechanisms: Graphical Method	(08 Hours)

Displacement, velocity and acceleration analysis mechanisms by Relative Velocity Method (Mechanisms up to 6 Links), Instantaneous Centre of Velocity, Kennedy's Theorem, Angular Velocity ratio Theorem, Analysis of mechanism by ICR method (Mechanisms up to 6 Links), Coriolis component of Acceleration (Theoretical treatment only)

Real World Assignment: Kinematic analysis of 4 bar mechanism, slider crank mechanism, etc. using graphical methods.

Exemplars / Practical Applications: Same as Unit III

Unit V	Synthesis of Mechanisms	(08 Hours)

Steps in Synthesis: Type synthesis, Number Synthesis, Dimensional synthesis, Tasks of Kinematic synthesis - Path, function and motion generation (Body guidance), Precision Positions, Chebychev spacing, Mechanical and structural errors

Graphical Synthesis: Inversion and relative pole method for three position synthesis of Four-Bar and Single Slider Crank Mechanisms.

Analytical Synthesis: Three position synthesis of Four-Bar mechanism using Freudenstein's equation, Blotch synthesis

Real World Assignment:

1. To synthesize the Four-Bar and Slider Crank Mechanism (Geogebra, SAM, any 2D/3D Modelling Software)
2. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for the Synthesis of Mechanism using Chebychevs spacing, Freudensteins equation and function generation

Exemplars / Practical Applications:

1. Robotics and Automation: Designing robotic arms and manipulators that require precise motion control.
2. Robotics and Automation: Implementing parallel and serial linkages for tasks like pick-and-place operations and welding.
3. Automotive Engineering: Developing suspension systems (e.g., double wishbone, four-bar linkages) to enhance ride comfort and handling and steering mechanisms and gear shifters that rely on linkages for smooth operation.
4. Medical Devices: Engineering prosthetic limbs and rehabilitation equipment that mimic natural human motion.
5. Medical Devices: Designing surgical tools with precise movement capabilities.

Learning Resources

Text 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. J. J. Uicker, G. R. Pennock, J. E. Shigley, "Theory of Machines and Mechanisms", Fifth

Edition, International Student Edition, Oxford Electronics and AC Drives", Pearson Education

Reference Books:

1. Paul E. Sandin, "Robot Mechanisms and Mechanical Devices Illustrated", Tata McGraw Hill Publication
2. M.P. Groover, "Automation, production systems and computer-integrated manufacturing", Prentice-Hall of India Pvt. Ltd, New Delhi
3. Stephen J. Derby, "Design of Automatic Machinery", 2005, Marcel Dekker, New York
4. Neil Sclater, "Mechanisms and Mechanical Devices Sourcebook", Fifth Edition, Tata McGraw Hill Publication
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. Sadhu Singh, "Theory of Machines", Pearson
9. Dr. V. P. Singh, "Theory of Machine", Dhanpatrai and Sons
10. C. S. Sharma &Kamlesh Purohit, "Theory of Machine and Mechanism", PHI

MOOC / NPTEL/YouTube Links: -

1. https://nptel.ac.in/courses/112104121/ (NPTEL1, Kinematics of Machines, Prof. Ashok K Mallik, IIT Kanpur)
2. https://nptel.ac.in/courses/112/106/112106270/ (NPTEL2, Theory of Mechanism, Prof. Sujatha Srinivasan, IIT Madras)
3. https://nptel.ac.in/courses/112/105/112105268/ (NPTEL3, Kinematics of Mechanisms and Machines, Prof. Anirvan Das Gupta, IIT Kharagpur)
4. https://nptel.ac.in/courses/112/105/112105236/ (NPTEL4, Mechanism and Robot Kinematics, Prof. Anirvan Das Gupta, IIT Kharagpur)
5. http://www.cdeep.iitb.ac.in/webpage_data/nptel/Mechanical/Robotics Course/Course_home_lect1.html (NPTEL5, Introduction to Robotics and Automation, IIT Bombay)

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
PCC253AUR: Electric Drives for Automation Systems		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	3	**CCE:** 30 Marks
Practical: NA		**End-Semester:** 70 Marks

Prerequisite Courses, if any:

1. Engineering Physics
2. Basic Electrical Engineering
3. Basic Electronics Engineering
4. Engineering Mathematics – I, II

Course Objectives:

1. Define the fundamental concepts, construction, and working principles of DC motors, induction motors, and synchronous machines.
2. Explain the performance characteristics, losses, and efficiency of different electric drives used in automation
3. Illustrate different speed control and braking techniques for DC and AC motors in industrial applications.
4. Compare and evaluate different types of motor drives based on their operating principles, control techniques, and applications.
5. Analyze motor-load dynamics and classify different types of loads in electric drive systems.

Course Outcomes:

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

CO1. Explain the construction, classifications, and operating principles of DC motors, induction motors, and synchronous machines.

CO2. Explain the significance of back EMF, torque equations, and power flow in electric drives.

CO3. Illustrate speed control methods for DC and AC motors using converters, choppers, and inverters.

CO4. Evaluate the performance of electric drives under various loading and braking conditions.

CO5. Differentiate between open-loop and closed-loop control strategies for electric drives and their industrial applications.

Course Contents

Unit I	DC Motors	(08 Hours)

Principles of working, Constructional details, Types of DC motors, significance of back E.M.F, torque equation, Types of DC motors (DC series and shunt), significance of back E.M.F, torque equation, Characteristics and Selection of DC Motors, working at no-load and on-load, Starting of DC Motors, Speed Control methods (Descriptive treatment), reversal of rotation, regenerative braking, Losses, power flow diagram and efficiency,

Permanent Magnet DC (PMDC) motors, applications in robotics.

Real World Assignment: Investigate and write specifications of DC motors used in various automotive and domestic applications. Study type, construction, working of DC motor.

Exemplars / Practical Applications:

1. Automotive Systems: DC motors are widely used in vehicles for functions such as power windows, windshield wipers, seat adjustments, and electric power steering, electric vehicles (EVs) and hybrid electric vehicles (HEVs)
2. Industrial Machinery: DC motors drive conveyor belts, hoists, cranes and machine tools. Their ability to provide precise speed and torque control makes them suitable for these applications
3. Consumer Electronics: Small DC motors power devices such as electric toothbrushes, shavers, and cooling fans in laptops. Their compact size and low voltage operation make them ideal for portable electronics
4. Medical Equipment: DC motors are used in medical devices like ventilators, infusion pumps, and surgical tools, where precise and reliable motion control is critical
5. Renewable Energy Systems: They are employed in solar tracking systems to adjust the position of solar panels for optimal sunlight exposure and in wind turbine pitch control mechanisms

Unit II	Induction Motors	(06 Hours)

Three-Phase Induction Motors: Types of induction motor, flux and mmf waves, development of circuit model, power across air gap, torque and power output, starting methods, speed control, applications, induction generator, induction machine dynamics, high efficiency induction motors.

Single-Phase Induction Motors: Types, construction, working principle of shaded-pole types. applications

Real World Assignment: Investigate and write specifications of Induction motors used in various domestic applications. Study type, construction, working of induction motor.

Exemplars / Practical Applications:

1. Industrial Machinery - Three-phase squirrel-cage motors power heavy-duty machines like conveyor belts, crushers, mixers, presses, lathes, and milling machines due to their self-starting capability, reliability, and cost-efficiency
2. Fans, blowers, and pumps in HVAC and industrial ventilation systems rely on these motors for continuous operation
3. Pumps & Compressors - Widely used in water pumps, submersible pumps, and air compressors
4. Household Appliances - Single-phase induction motors are found in refrigerators, washing machines, fans, garbage disposals, and small power tools.
5. Elevators & Hoists - Slip-ring (wound-rotor) induction motors provide variable-speed control and high torque at startup—ideal for cranes, elevators, and mine hoists
6. Oil, Gas & Refining - Robust three-phase induction motors drive pumps, compressors, and conveyors in environments that demand durability and resistance to harsh conditions

Unit III	Synchronous Machines and Special purpose motors	(08 Hours)

Construction, types, armature reaction, determination of synchronous reactance, phasor diagram, power angle characteristics, synchronous motor operation, PM synchronous machines.

Special purpose motors: Construction, working principle, characteristic and applications of stepper motors, A.C and D.C servomotors

Real World Assignment: Investigate and write specifications of synchronous motors used in various domestic applications. Study construction, working of synchronous motor. Also, comment on various industrial applications.

Exemplars / Practical Applications:

1. High-Precision & Positioning Systems - Used in servo applications, robotics, positioning tables, and printing press drives that need accurate speed synchronization and positioning.
2. Clocks, Turntables & Lab Instruments - In devices where unwavering speed precision means the difference between good and great performance.
3. Electric Power Generation: Operating as synchronous generators, they convert mechanical energy from turbines into electricity in thermal, hydro, and nuclear power plants.
4. Constant-Speed Drives - They run at precise, synchronous speed (locked to supply frequency)

Unit IV	Fundamentals of Electric Drives	(08 Hours)

Definition, Advantages of electrical drives, Components of Electric drive system, Selection Factors, speed control and drive classifications

Motor Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters. Load Torque Components, Nature and classification of Load Torques, Constant Torque and Constant Power operation of a Drive, Steady state stability.

3Ph Induction motor drives – Variable Frequency Drives (VFD)

Real World Assignment: Understand requirements of Electric drives and components of drives with functions in Automation & Robotics.

Exemplars / Practical Applications:

1. CNC machinery & cutting tools: Use servo drives for high precision in positioning and speed.
2. Robots & pick-and-place: Stepper and servo drives enable accurate, repeatable motion in manufacturing.
3. Conveyors & production lines: AC drives with VFDs regulate speed and torque to optimize throughput.
4. Hoisting drives: Heavy-duty induction or synchronous motors with VFD provide smooth start/stop, accurate positioning, and energy efficiency.

Unit V	Application of Electric Drives	(08 Hours)

DC Motor Drives: Single-phase and three-phase fully controlled converter drives and performance of converter fed separately excited DC Motor for speed control operations.
BLDC drive: Construction (Block diagram) and working for motoring and regenerative braking, Speed and torque Characteristics.
Induction Motor Drives: Regenerative braking, dynamic braking, Plugging, braking and speed control, voltage source inverter (VSI) control, Steady State Analysis.
Synchronous Motor drives: PMSM Drive: Construction (Block diagram) and working for motoring and regenerative braking, Speed and torque Characteristics.

Real World Assignment: Write difference between electric drives used in AC & DC systems. Discuss one application of each AC/DC drives with suitable domestic/industrial application.

Exemplars / Practical Applications:

1. Robotics and Automation - Small-to-midsize robots use DC motor drives (especially shunt-wound or separately excited types) for fine positional control and repeatability.

2. Drones & Model Aircraft - Their lightweight and high power-to-weight ratio make them ideal for UAV propellers—providing reliable, fast-response thrust for flight manoeuvres
3. Industrial Automation - Used in servo systems, cobots, and conveyor systems, BLDC drives enable accurate positioning, fast acceleration, and regenerative braking, all while maintaining compactness and reliability.

Learning Resources

Text Books:

1. V. K. Mehta and Rohit Mehta, Principles of Electrical Machines, S Chand Publication
2. Ashfaq Husain, Electrical Machines, Dhanpat Rai and Co.
3. B. L Theraja –Electrical Technology, Vol II , S. Chand publication.
4. G. K. Dubey, "Fundamentals of Electrical Drives", Second edition (sixth reprint), Narosa Publishing house,2001.
5. B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education
6. N. K. De, P. K. Sen, "Electric Drives", Prentice Hall of India Eastern Economy Edition

Reference Books:

1. A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, "Electrical Machines", TataMcGraw Hill Publication Ltd., Fifth Edition.
2. A.S. Langsdorf, "Theory and performance of DC machines", Tata McGraw Hill.
3. Smarajit Ghosh, "Electrical Machines", Pearson Education, New Delhi
4. P. C. Sen, "Principles of Electric Machines and Power Electronics ", John Wiley and Sons Publication, second edition 1997.
5. R. Krishnan, "Electric Motor Drives – Modeling Analysis and Control", PHI India
6. B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education
7. Austin Huges, "Electrical motor and drives: Fundamental, types and applications", Heinemann Newnes, London
8. Frank D. Petruzella – Programmable Logic Controllers (McGraw-Hill)
9. R.K. Rajput – Industrial Electronics and Control (S. Chand)
10. James A. Rehg & Glenn J. Sartori – Industrial Electronics (Pearson)

MOOC / NPTEL/YouTube Links: -

1. https://archive.nptel.ac.in/courses/108/104/108104140/
2. https://archive.nptel.ac.in/courses/108/108/108108077/
3. https://onlinecourses.nptel.ac.in/noc19_ee65/preview
4. https://onlinecourses.swayam2.ac.in/nou24_ee02/preview

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
PCC254AUR: Robots & Drive System Laboratory		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**1**	**Oral: 25 Marks**

Prerequisite Courses, if any:

- Engineering Mathematics
- Industrial Electronics & Controls
- Manufacturing Technology
- Workshop Practice
- Engineering Mechanics
- Product Development Laboratory

Course Objectives:

1. To understand ethical operations of robotics
2. Differentiate types of robots and robot grippers and compare & classify types of Sensors, drives & Grippers
3. Apply robot kinematics principals for understanding manipulators tracking
4. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation and learning by understanding AI, its current scope and limitations, and societal implications.
5. Model forward and inverse kinematics of robot manipulator.

Course Outcomes:

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

CO1. Study the fundamental concepts and terminologies related to standards and ethics in the context of robot applications.

CO2. Identify the key industry standards and regulatory frameworks governing robot design, safety, and performance.

CO3. MODEL robotic arm for forward/inverse kinematics

CO4. UNDERSTAND fundamentals of robot programming and WRITE robot programs

CO4. CO5. ANALYSE robot program for troubleshooting and optimum operations using advanced robotic programming techniques.

Guidelines for Laboratory Conduction

- The student shall complete the following activity as a Term Work of Total 8 experiments from the following list must be performed.
- Term Work of the student is evaluated based on the completion of Practical, Assignments using Drawing Aids, Assignments using Software & Programming Languages, Assignments using Virtual Laboratory and Detailed Industrial Visit Report.
- Use simulation tools such as MATLAB, Python, ROS, and Gazebo before hardware implementation.
- Encourage students to work on mini-projects related to real-world applications.
- Promote teamwork and interdisciplinary collaboration in labs.
- Focus on debugging techniques and best practices in programming robotic systems.
- There should be continuous assessment and timely submission of journal.

Practical 1:	**02 Hrs**
Introduction to Standards and Ethics in Robotics, Introduction to the field of robotics and its ethical dimensions, Overview of relevant industry standards and regulatory frameworks	
Exemplars / Practical Applications: The ISO (International Organization for Standardization) standard for robot safety is ISO 10218 - Robots for Industrial Environments - Safety Requirements	
Practical 2:	**02 Hrs**
Demonstration of various robotic configurations using industrial robot.	
Exemplars / Practical Applications: 1. Choose right robot for manufacturing or non-manufacturing applications based on robot configurations.	
Practical 3:	**02 Hrs**
Design and selection of Gripper / End effector.	
Exemplars / Practical Applications: 1. Material Handling & Pick-and-Place 1.1 Grippers (electric, pneumatic, mechanical): pick and move varied objects-boxes, parts, delicate items. 1.2 Vacuum suction cups: ideal for flat, non-porous surfaces like glass or metal sheets. 1.3 Magnetic grippers: perfect for ferrous materials; reliable in power loss since permanent magnets stay active 1.4 Inspection & Sensing - Cameras and sensors: 2D/3D vision systems, force/torque sensors, ultrasonic/infrared scanners used for quality control, alignment, collision detection 2. Packaging & Palletizing - Grippers combined with conveyors to load items into containers or onto pallets rapidly and accurately 3. Inspection & Sensing: Cameras and sensors: 2D/3D vision systems, force/torque sensors, ultrasonic/infrared scanners used for quality control, alignment, collision detection 4. Specialized Applications 4.1 Agriculture: fruit harvesters with multi-part grippers designed for gentle handling, trimming, spraying, or bagging (e.g., grape-picking end effectors) 4.2 Food processing: dexterous tools like chopstick-style grippers for delicate seafood handling 4.3 Surgical & rehabilitation robotics: robotic arms for precise medical operations or therapeutic exercises. 5. Machine Tending & Assembly 5.1 Load/unload CNC mills, presses, and other equipment—robot arms pick parts, post-process items, or conduct quality checks 5.2 For assembly, grippers or more specialized tools handle and insert components (e.g., PCB placement, screws)	
Practical 4:	**02 Hrs**
Design and control of a pick-and-place robotic arm.	
Exemplars / Practical Applications: 1. Arduino + servos + Bluetooth remote – beginner-friendly, low-speed, educational 2. PLC-based control – industrial-grade robustness and deterministic operation 3. ROS + MoveIt + hardware interface – full-featured precision; supports vision-driven pick-and-place	
Practical 5:	**02 Hrs**
Identify and selection of Sensors for Robotics/Automation applications. Comparison of various sensors based on Sensitivity, Accuracy, Precision (Repeatability), Linearity, Range (Span), Resolution, Response Time, Hysteresis, Drift and stability for given application.	

Exemplars / Practical Applications:

1. Predictive & Prescriptive Maintenance: Robots equipped with vibration, temperature, ultrasonic, and acoustic sensors continuously monitor equipment health.
2. Quality Control & Assembly Inspection: Vision sensors (cameras, machine vision) inspect products for defects at high speed and precision. Force-torque sensors and tactile sensors help robots assemble delicate components without damage
3. Collaborative Robots (Cobots): Cobots use proximity, force/torque, and thermal sensors to safely work alongside humans in tasks like welding, packing, and visual inspection
4. Precision Farming: Drones and ground robots employ multispectral cameras, gas, humidity, and soil sensors to monitor crop health, detect pests, and optimize irrigation
5. Environmental Analysis: Robots equipped with gas sensors, toxic monitors, temperature/humidity sensors, and radar are used for air-quality mapping, disaster assessment, and environmental surveillance

Practical 6:	**02 Hrs**

ROS based Mobile Robot Simulation using Gazebo.

Exemplars / Practical Applications:

1. CottonSim: Simulates an autonomous cotton-picking robot (based on Clearpath Husky) using ROS 1 + Gazebo.
2. HuNavSim: A ROS 2 toolkit that integrates Gazebo to simulate human movement patterns. Its goal is to benchmark mobile robots for socially-aware navigation—crucial for service robots in public spaces
3. MiniBot 3D: A ROS+Gazebo setup that supports SLAM, odometry, and localization across indoor/outdoor environments. Helps tune algorithms under realistic sensor-uncertainty scenarios
4. Simulink + Gazebo: MathWorks example shows simulating a warehouse robot that uses range sensors for path planning and collision avoidance—ideal for prototyping automated package delivery robots in logistic environments
5. Mobile Manipulator: Another demo integrates mobile base + arm in Gazebo/ROS, enabling pick-and-place tasks in warehouse-like settings, all coordinated via ROS2 + MATLAB/Simulink
6. DeepSim: A toolkit coupling ROS + Gazebo to create reinforcement learning environments. Offers modular elements like collision detection, spawners, and domain randomization

Practical 7:	**02 Hrs**

- Robot Programming – Walk through programming (Manual lead through programming)
- Robot Programming using Teach Pendant (Powered) - Lead through programming including Coordinate systems of Robot.

Practical 8:	**02 Hrs**

VAL language commands motion control, hand control, program control, pick and place applications. RAPID Language and AML

Practical 9:	**02 Hrs**

Programming using Robot simulation software

Practical 10:	**02 Hrs**

Industrial Visit

Learning Resources

Text Books:

1. Groover, M.P. Weiss, M. Nagel, R.N. & Odrey, N.G., Ashish Dutta, Industrial Robotics, Technology, Programming & Applications, Tata McGraw Hill Education Pvt. Ltd. New Delhi
2. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.

3. Robot Programming: Robot Languages and Robot Communication by Richard D. Wright and Matthew P. McLaughlin
4. Staple Danny, “Learn Robotics Programming”, Packt Publishing Limited, Feb 2021

Reference Books:

1. Industrial Robotics by Yoram Koren (5th Edition)
2. Robot Programming: Robot Languages and Robot Communication by Richard D. Wright and Matthew P. McLaughlin
3. Robotics, Vision & Control: Fundamentals & Advanced Applications by Farid Kendoul
4. Robot Programming: A Guide to Using RUIP with ABB Robots by Rick Young
5. Hughes Cameron, “Robot Programming”, Pearson Publishers, 2016
6. J. Srinivas, “Robotics: Control and Programming”, Narosa Publication, 2009
7. Lentin Joseph, “Learning Robotics Using Python”, Second Edition Design, simulate, program, and prototype an autonomous mobile robot using ROS, OpenCV, PCL, and Python, Packt Publishing Paperback – 1 January 2018
8. Kailashi Chandra Mahajan, Prashant Kumar Patnaik, Raghvendra Kumar, “Robotics for Engineers”, Vikas Publishing House , 2016

MOOC / NPTEL/YouTube Links:

1. https://onlinecourses.nptel.ac.in/noc19_me74/preview
2. https://onlinecourses.nptel.ac.in/noc20_de11/preview

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
PCC255AUR: Kinematics of Machines Laboratory		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**1**	**Term Work: 25 Marks**

Prerequisite Courses, if any:

- Engineering Mathematics - I and II
- Engineering Physics
- Engineering Mechanics
- Product Development Laboratory

Course Objectives:

1. To make the students conversant with kinematic analysis of mechanisms applied to real life and industrial applications.
2. To develop the competency to analyze the velocity and acceleration in mechanisms using analytical and graphical approach
3. To develop the skill to propose and synthesize the mechanisms using graphical and analytical technique.
4. To develop the competency to understand & apply the principles of gear theory to design various applications.
5. To develop the competency to design a cam profile for various follower motions.

Course Outcomes:

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

CO1. APPLY kinematic analysis to simple mechanisms

CO2. ANALYZE velocity and acceleration in mechanisms by vector and graphical method

CO3. SYNTHESIZE a four bar mechanism with analytical and graphical methods

CO4. APPLY fundamentals of gear theory as a prerequisite for gear design

CO5. CONSTRUCT cam profile for given follower motion.

Guidelines for Laboratory Conduction

- The student shall complete the following activity as a Term Work Total 10 experiments from the following list must be performed.
- Term Work of the student is evaluated based on the completion of Practical, Assignments using Drawing Aids, Assignments using Software & Programming Languages, Assignments using Virtual Laboratory and Detailed Industrial Visit Report.

Group 1: Practical **06 Hrs**

- *Experiment # 4 is compulsory and Select any Two from Experiment # 1 to 3*

1. Study gear nomenclature and Construct involute profile using rack as a cutter to understand various gear manufacturing processes.
2. Speed and torque analysis to determine holding torque of epicyclic gear train.
3. To study and verify cam jump phenomenon.
4. To make a model of any mechanism by using waste material by the group of 4 to 6 students and to give a presentation using PPTs.

Exemplars / Practical Applications:

1. Automotive: Suspension, steering, throttle controls, gear shifting, braking systems
2. Manufacturing: Presses, robotic arms, packaging machinery
3. Aerospace: Actuation of flaps, landing gear, engine controls

4. Household appliances: Washing machines, refrigerators, cam-driven valve

Group 2: Assignments using Drawing Aids on half imperial drawing sheet (08 Hrs)

- *Assignment#1 to 4 are compulsory and Select any one from 5 & 6*

1. Identify mechanisms in real life and Analyze for types and number of links, pairs, obtain degrees of freedom. Submit the sheet and working video of the mechanism.
2. To solve two problems on velocity and acceleration analysis using relative velocity and acceleration method.
3. To solve two problems on velocity analysis using the ICR method.
4. To draw cam profile for any two problems with combination of various follower motion with radial and off-set cam.
5. To draw conjugate profile for any general type of gear tooth.
6. To study various types of gearboxes.

Exemplars / Practical Applications:

1. Robotics: Harmonic and cycloidal gear reducers for backlash-free precision
2. Elevators: Pulleys and counterweights enable smooth motion and balance
3. Printing and shaping machines: Quick return and indexing used within shaper machines
4. Pantographs: Scale drawings up/down
5. Scotch-yoke: Valve actuators in oil & gas pipelines

Group 3: Assignments using Software (08 Hrs)

- *Any Three Assignments - Minimum one computer programming based and Minimum one based on use of software*
- *Assignment#1 to 4 are compulsory and Select any one from 5 & 6*

Do following assignments by using Software or by using Coding/Programming Languages:

1. To design a simple Planer Mechanism by using any software (Geogebra, SAM, Working Model, any 3D Modelling Software, etc.)
2. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for Kinematic Analysis of Slider Crank Mechanism using Analytical Method
3. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for Kinematic Analysis of Hooke's joint Mechanism using Analytical Method
4. To generate a Cam Profile using any Modelling Software (MechAnalyser, any 3D Modelling Software)
5. To synthesize the Four-Bar and Slider Crank Mechanism (Geogebra, SAM, any 2D/3D Modelling Software)
6. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for the Synthesis of Mechanism using Chebychevs spacing, Freudensteins equation and function generation

Exemplars / Practical Applications:

1. High-Precision & Positioning Systems - Used in servo applications, robotics, positioning tables, and printing press drives that need accurate speed synchronization and positioning.
2. Trajectory planning: Kinematic modelling predicts the end-effector's position, enabling robots to execute precise pick-and-place, welding, or assembly tasks.
3. Inverse kinematics tells the robot joint angles needed to reach a target position—essential for multi-axis arms and humanoid robots.
4. Linkage design (e.g., windshield wipers, door mechanisms) depends on kinematics to cover the right motion range without collision.
5. Kinematic modelling enables CNC machines and milling centers to convert programmed tool paths into joint movements, ensuring accuracy and collision-free operation.
6. Presses and linkages, like punching or stamping lines, use position analysis to ensure timing

synchronization and correct motion range.

Group 4: Industrial Visit (Mandatory)

- *Any Three Assignments - Minimum one computer programming based and Minimum one based on use of software*
- *Assignment#1 to 4 are compulsory and Select any one from 5 & 6*

A Compulsory industrial visit must be arranged to industries/ establishments consisting automation and mechanization during semester to provide awareness and understanding of the course.

The Industrial Visit must be preferably to

- Manufacturing industries with Assembly-line Automation
- Jigs- fixtures design/manufacturing
- Automation industries
- Automobile garages, etc.

Student must submit properly documented Detailed Industrial Visit Report in his/her own words.

Group 5: Assignments on content beyond syllabus

- *Additional credits to be given to students*

Following assignments can be attempted:

1. Forward and Inverse Kinematics of 2R/2P/RP/PR Manipulators using Software (Geogebra, Robo Analyser, Vlab, etc.)
2. Kinematic Analysis of 6 DOF Industrial Robot using Software (Robo Analyzer, Vlab, etc.)

Learning Resources

Text 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. J. J. Uicker, G. R. Pennock, J. E. Shigley, “Theory of Machines and Mechanisms”, Fifth Edition, International Student Edition, Oxford Electronics and AC Drives”, Pearson Education

Reference Books:

1. Paul E. Sandin, “Robot Mechanisms and Mechanical Devices Illustrated”, Tata McGraw Hill Publication
2. M.P. Groover, “Automation, production systems and computer-integrated manufacturing”, Prentice-Hall of India Pvt. Ltd, New Delhi
3. Stephen J. Derby, “Design of Automatic Machinery”, 2005, Marcel Dekker, New York
4. Neil Sclater, “Mechanisms and Mechanical Devices Sourcebook”, Fifth Edition, Tata McGraw Hill Publication
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. Sadhu Singh, “Theory of Machines”, Pearson
9. Dr. V. P. Singh, “Theory of Machine”, Dhanpatrai and Sons
10. C. S. Sharma &Kamlesh Purohit, “Theory of Machine and Mechanism”, PHI

MOOC / NPTEL/YouTube Links: -

1. https://nptel.ac.in/courses/112104121/ (NPTEL1, Kinematics of Machines, Prof. Ashok K Mallik, IIT Kanpur)
2. https://nptel.ac.in/courses/112/106/112106270/ (NPTEL2, Theory of Mechanism, Prof. Sujatha

Srinivasan, IIT Madras)
3. https://nptel.ac.in/courses/112/105/112105268/ (NPTEL3, Kinematics of Mechanisms and Machines, Prof. Anirvan Das Gupta, IIT Kharagpur)
4. https://nptel.ac.in/courses/112/105/112105236/ (NPTEL4, Mechanism and Robot Kinematics, Prof. Anirvan Das Gupta, IIT Kharagpur)
5. http://www.cdeep.iitb.ac.in/webpage_data/nptel/Mechanical/Robotics Course/Course_home_lect1.html (NPTEL5, Introduction to Robotics and Automation, IIT Bombay)

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
MDM271AUR: Artificial Intelligence & Machine Learning		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 02 Hours/Week	**2**	**CCE: 50 Marks**
Practical: NA		**End-Semester: NA**

Prerequisite Courses, if any:

- Linear Algebra, Probability, Statistics, Logical Reasoning

Course Objectives:

1. To ACQUAINT with fundamentals of artificial intelligence and machine learning.
2. To LEARN feature extraction and selection techniques for processing data set.
3. To UNDERSTAND basic algorithms used in classification and regression problems.
4. To OUTLINE steps involved in development of machine learning model.
5. To FAMILIARIZE with concepts of reinforced and deep learning.

Course Outcomes:

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

CO1. DEMONSTRATE fundamentals of artificial intelligence and machine learning.
CO2. APPLY feature extraction and selection techniques.
CO3. APPLY machine learning algorithms for classification and regression problems.
CO4. DEVELOP a machine learning model using various steps.
CO5. APPLY concepts of reinforced and deep learning.

Course Contents

Unit I	Introduction to AIML and Feature Extraction and Selection	(06 Hours)

Introduction to AI & ML, Need of AI in Mechanical Engineering, Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical, Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning. Introduction to Data, Elements of Dataset, Introduction to various types of data Feature extraction: Statistical Features, Principal Component Analysis, Feature selection: Ranking, Decision tree - Entropy reduction and information gain (Numerical 2-3 Features- Preference (IG), Exhaustive, best first, Greedy forward & backward, Multi collinearity – Heatmap

Real World Assignment

1. Machine Failure Prediction
2. Decision Tree-Based Fault Detection in CNC Machines

Practical Applications

1. AI in Industry: Fault Diagnosis in Turbines / Identifying Wear Patterns in Engines
2. Predictive Maintenance of Machinery

Unit II	ML Algorithms: Classification & Regression	(06 Hours)

Supervised Learning: Linear Regression (Line, Plane & Hyperplane) Concept, Multi-Variable Linear Regression, Poly Regression, Logistic Regression, Naive Bayes Classifiers, k-NN Classification, Support Vector Machines **Ensemble Techniques** (Regression & Classification): Decision tree (ID3-IG), Random Forest, Bagging & Boosting, XGB Classifier.

Unsupervised Learning: K-means Clustering, Hierarchical Clustering, Dimension Reduction-PCA

Classification Algorithm & Regression Algorithms: Bias-Variance Trade off, Distance Parameters in Machine Learning (Formula).

Real World Assignment

1. Predicting Machine Wear & Tear Using Linear Regression
2. Classification of Defective vs. Non-Defective Components Using SVM

Practical Applications

1. Predictive Maintenance Using Regression & Classification
2. Fault Detection in Rotating Equipment Using Clustering

Unit III	Feature Engineering, Development of ML Model & Evaluation	(06 Hours)

Feature Engineering, Model Selection & Tuning: Feature engineering, Model selection, Model tuning, Model performance measures, Regularizing the Linear models, ML pipeline, Bootstrap sampling, Grid search CV, Randomized search CV, K fold cross-validation.

Problem identification: classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (Accuracy, Precision, Recall, True Positive, False Positive, etc.), Hyper parameter Tuning: 1) Probability 2) Hypothesis 3) Confusion Matrix (Common dataset – Common problem statement), Influence of Type 1 & Type 2 error

Real World Assignment

1. Machine Condition Monitoring Using Feature Engineering
2. Fault Detection Using Confusion Matrix Analysis

Practical Applications

1. Predictive Maintenance of Industrial Machines
2. Optimizing Engine Performance Using Regression Models

Unit IV	Reinforced and Deep Learning	(06 Hours)

Neural Network: Introduction to Perceptron & NN, Activation Function & Loss Function, Gradient Descent & Gradient Acescent, Batch Normalization, Hyper Parameter Tuning

Characteristics of reinforced learning; Algorithms: Framework of RL, characteristics, Exploration Vs. Exploitation Trade-off, Bellman Optimality Principle, Types of RL: Value Based, Policy Based, Model Based; Positive vs Negative Reinforced Learning; Models: Markov Decision Process, Q Learning, SARSA.

Computer Vision: Introducing Image Dataset, Introduction to CNN, Convolution, Pooling & Padding, CNN Forward & Backward Propagation, CNN architectures, Transfer Learning.

Applications of Reinforced, Computer Vision and Deep Learning in Mechanical Engineering (Jobs), Industry 5.0

Real World Assignment

1. Computer Vision-Based Defect Detection in Mechanical Parts
2. Reinforcement Learning for Robotic Arm Optimization

Practical Applications

1. AI in Automobiles/ Agriculture/ Robotics/ Health science/ Computer Vision for Analysis, Quality Assessment & Security, etc.
2. Computer Vision: Object Detection

Learning Resources

Text Books:

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3. Parag Kulkarni and Prachi Joshi, “Artificial Intelligence – Building Intelligent Systems”, PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015

4. Stuart Russell and Peter Norvig (1995), "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003

Reference Books:

1. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
3. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
4. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
5. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH

MOOC / NPTEL/ YouTube Links: -

1. http://nptel.ac.in/courses/111101003/
2. https://nptel.ac.in/courses/106/106/106106202/
3. https://nptel.ac.in/courses/112/103/112103280/
4. https://www.analyticsvidhya.com/

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
VSE281AUR: Product Development Laboratory		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**1**	**Practical: 50 Marks**

Prerequisite Courses, if any:

- Engineering Graphics
- Manufacturing Practice Workshop
- Design Thinking and Idea Lab

Course Objectives:

1. To draw freehand sketches, drawings using dimensional and geometric constraints
2. To understand basic structure of CAD systems and their use to create geometric models of simple engineering parts
3. To create assemblies using CAD modeled components and standard parts available online
4. To calculate surface areas, mass properties of components and assemblies
5. To understand data exchange standards and translators for exporting data to various applications for simulations using modern computational tools
6. To create engineering drawings, design documentation and use in manufacturing activities

Course Outcomes:

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

CO1. DRAW sketches using basic geometric entities including spline curves

CO2. CREATE solid models using basic extrusion, revolve, sweep & loft techniques

CO3. ASSEMBLE three and more components, modelled or imported geometries for fulfilment of functional requirements of engineering products

CO4. PERFORM mass property analysis, including creating and using a coordinate system

CO5. USE CAD model data for various CAD based engineering applications viz. production drawings, 3D printing, FEA, CFD, MBD, CAE, CAM, etc.

CO6. USE PMI & MBD approach for communication

Course Contents

Tutorial:

1. Study of drawing sheet layout, Principles of Drawing and various IS Standards & Conventions in Machine Drawing, Dimensioning practices - Terminology & Basic Rules, Styles, Conventions.
2. Study and reading of Industrial Drawings to understand standard industrial practices viz. Dimensioning, GD&T, Surface finish, welding symbols, etc.
   (a) Machine Drawing,
   (b) Production Drawing,
   (c) Part Drawing,
   (d) Assembly Drawing - (i) Assembly Drawing for Design, (ii) Assembly Drawing for Instruction Manuals, (iii) Exploded Assembly Drawing, (iv) Schematic Assembly
3. Study of basic concepts of Geometric Dimensioning & Tolerances (GD&T) - (a) Terminology, Maximum and Minimum Material conditions, Features, Rules for GD&T, Datum Control (b) Adding GD&T to a

Design, Form Tolerances (c) Orientation Tolerances, Profile Tolerances (d) Location Tolerances, Run out Tolerances

4. Surface finish, Welding symbols
5. Study of basics of Design for Manufacturing (DFM), Design for Assembly and Dis-assembly and Design for Safety with suitable examples.

Practical (Any 5):

1. 2-D sketching with geometrical and dimensional constraints using CAD software (Min. 4 sketches including at least 5 dimensional and geometric constraints)
2. Solid & Surface modeling for simple mechanical components (Output file as Production drawing and Model Based Definition (MBD) for following engineering manufacturing practices (any two):
   (i) Casting/forging
   (ii) Plastic molding
   (iii) Manufacturing using CNC machines (up to 4 axes)
   (iv) Fabrication
   (v) Sheet Metal
3. Calculation of raw material and machining/manufacturing/surface treatment/painting costs using CAD software
4. Assembly modeling (Output file as Assembly drawing and detailing) of the parts modeled in Practical assignment-2 using proper assembly constraint/mate conditions and generation of exploded view for assemblies like Couplings, Clutches, Gear Assemblies, Robot arms, Machine Tools, Automobile Components, Gear-Box, etc.
5. Build CAD models of existing components using Reverse Engineering approach
6. Assembly Modeling by importing parts/components from free online resources like CAD and Product development software websites, forums, blogs, etc.
7. Industrial visit

Real World Assignment –

CAD Modeling for the following:

1. Couplings
2. Robot manipulator assembly using 3 or more links
3. Power drives – belt, chain or gear drives
4. Single plate, multi-plate clutch assemblies

Learning Resources

Text Books:

1. Engineering Drawing by N.D. Bhatt
2. Engineering Drawing and Design by David A. Madsen & David P. Madsen
3. "Computer Aided Design and Manufacturing" by Mikell P. Groover & Emory W. Zimmers
4. "Product Design and Development" by Karl T. Ulrich & Steven D. Eppinger

Reference Books:

1. ASME Y14.5 – 2018 Dimensioning and Tolerancing, American Society of Mechanical Engineers (ASME)
2. "Engineering Graphics Essentials" by Kirstie Plantenberg
3. "Product Realization: A Comprehensive Approach" *by M. F. Ashby & K. Johnson*

4. Bordegoni, Monica and Rizzi, Caterina, (2011), "Innovation in Product Design: From CAD to Virtual Prototyping", Springer, ISBN-13: 978-1447161875
5. Vukašinovic, Nikola and Duhovnik, Jože, (2019), "Advanced CAD Modeling: Explicit, Parametric, Free-Form CAD and Re-engineering", Springer, ISBN-13: 978-3030023980

MOOC / NPTEL/YouTube Links: -

1. https://youtu.be/Q9CXsOoy2Ls?si=JXNtNdxYq959y319
2. https://youtu.be/7oKBdfOEAw0?si=lRSp6ucfaRpVmHwz
3. https://youtu.be/hCiu-NERMy4?si=rxlvZ3ns5mj-b6AF
4. https://youtu.be/EXq6Du0kwJg?si=WgaqoEp-RDOfpTLb

Guidelines for Instructor's Manual

The instructor's manual is to be developed as a hands-on resource and reference. The instructor's manual needs to include prologue (about University/program/ institute/ department/foreword/ preface etc), copy of curriculum, conduction & Assessment guidelines, topics under consideration- concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student's Lab Journal

The laboratory assignments are to be submitted by students in the form of an electronic journal only. Journal consists of prologue, Certificate, table of contents, and model/sketch of each assignment (Title, Objectives, Problem Statement, Outcomes, Software & Hardware requirements, Date of Completion as per applicability. Assessment grade/marks and assessor's sign, As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journals may be avoided. Use of Drive/Google classroom/Moodle platform containing students programs maintained by lab In-charge is highly encouraged. For reference one or two journals may be maintained with program prints at Laboratory.

Guidelines for Lab /TW Assessment

Continuous assessment of laboratory work is done based on overall performance and lab assignments performance of students. Each lab assignment assessment will assign grade/marks based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as each lab assignment assessment include- timely completion, performance, innovation, efficient codes, punctuality and neatness.

Guidelines for Laboratory Conduction

List of laboratory assignments is provided below for reference. The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic. The assignment framing policy should address the average students and inclusive of an element to attract and promote the intelligent students. The instructor may set multiple sets of assignments and distribute them among batches of students. It is appreciated if the assignments are based on real world problems/applications. Encourage students for appropriate use of coding style, proper indentation and comments.

Use of open source software and recent versions is to be encouraged.

In addition to these, instructors may assign one real life application in the form of a mini-project. Based on the concepts learned. Instructors may also set one assignment or mini-project that is suitable to each branch beyond the scope of the syllabus.

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
VEC282AUR: Data Science & Artificial Intelligence Laboratory		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**1**	**Practical: 50 Marks**

Prerequisite Courses, if any:

- Linear Algebra, Probability, Statistics, Logical Reasoning

Course Objectives:

1. To INTRODUCE students to supervised, unsupervised, and reinforcement learning techniques.
2. To GUIDE students in acquiring, visualizing, and analyzing real-world datasets.
3. To ENABLE students to perform feature extraction, selection, and dimensionality reduction.
4. To FACILITATE the development and evaluation of classification and regression models.
5. To EXPOSE students to practical applications of Markov processes, RL, GA, and NN in engineering.

Course Outcomes:

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

CO1. UNDERSTAND different machine learning paradigms and their use cases.
CO2. ANALYZE and VISUALIZE datasets for machine learning applications.
CO3. APPLY feature engineering techniques including PCA and selection methods.
CO4. DEVELOP and EVALUATE classification and regression models.
CO5. IMPLEMENT Markov models, RL, GA, or NN for solving real-world problems

Guidelines for Practical's Conduction

Instruction to students:

1. The student shall complete the following activity as a Practical's
2. Students need to apply the computational algorithms using suitable software / programming language.
3. Experiment 1, 2, 3, 6 & 7 are compulsory. Experiment 2 to 7 to be taken on same data set.

List of Experiments

Experiment 01

To study supervised/unsupervised/reinforcement learning approach.

1. Group customers by shopping behavior
2. Classify emails as spam or not spam

Practical Applications

1. Email Filtering
2. Autonomous Driving

Experiment 02

To acquire, visualize and analyze the data set (from time-domain/frequency-domain/ etc.)

1. Comparison of engine vibration frequencies
2. Analyze motion sensor (accelerometer) data from a smartphone

Practical Applications

1. Vibration Monitoring in Engines
2. Voice Recognition

Experiment 03

To extract features from given data set and establish training data.

1. Extract color histograms from images

2. Extract word counts from news articles
Practical Applications 1. Face Recognition Systems 2. Speech-to-Text Systems
Experiment 04
To select relevant features using suitable technique 1. Sales prediction 2. Use Recursive Feature Elimination (RFE) with Logistic Regression
Practical Applications 1. Medical Diagnosis 2. Stock Price Prediction
OR
Experiment 05
To use PCA for dimensionality reduction 1. Apply PCA on air pollution data 2. Use PCA on climate data to analyze trends
Practical Applications 1. Fault Detection in Manufacturing 2. Handwriting Recognition
Experiment 06
To classify features/ To develop classification model and evaluate its performance (any one classifier). 1. Classify different bank customers 2. Classify flower species
Practical Applications 1. Credit Scoring 2. Image-based Quality Inspection
Experiment 07
To develop regression model and evaluate its performance (any one algorithm). 1. Predict house price 2. Predict student marks based on tests
Practical Applications 1. House Price Prediction 2. Energy Demand Forecasting
Experiment 08
Markov process for modelling manufacturing processes. 1. Inventory Simulation 2. Machine Maintenance
Practical Applications 1. Predictive Maintenance 2. Customer Behavior Modeling
OR
Experiment 09
Reinforced Learning for optimizing engineering designs / Robot Guidance and Navigation. 1. Optimize energy consumption 2. Optimize robot movement

Practical Applications

1. Warehouse Robotics
2. Optimize air conditioning systems

Experiment 10

GA for optimization of multi-dimensional function / path planning in robotics

1. Use GA to plan shortest path
2. Function Optimization

Exemplars / Practical Applications

1. Logistics & Route Optimization
2. Antenna Design Optimization

OR

Experiment 11

NN for parameter and model identification / tuning of Control Algorithms.

1. Predict student grades
2. Use NN for tuning or control

Practical Applications

1. Autonomous Vehicle Control
2. Industrial Process Modeling

Learning Resources

Text Books:

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3. Parag Kulkarni and Prachi Joshi, “Artificial Intelligence – Building Intelligent Systems”, PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015
4. Stuart Russell and Peter Norvig (1995), “Artificial Intelligence: A Modern Approach,” Third edition, Pearson, 2003.

Reference Books:

1. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
3. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
4. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
5. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH

MOOC / NPTEL/ YouTube Links: -

1. http://nptel.ac.in/courses/111101003/
2. https://nptel.ac.in/courses/106/106/106106202/
3. https://nptel.ac.in/courses/112/103/112103280/
4. https://www.analyticsvidhya.com

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
AEC283AUR: Modern Indian Language: 02		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**2**	**CCE: 15 Marks**
Tutorial: 01 Hours/Week		**End-Semester: 35 Marks**

❖ **अभ्यासक्रमाचे उद्दिष्ट :**

१. प्रगत भाषिक कौशल्यांची क्षमता विकसित करणे.
२. प्रसारमाध्यमांतील संज्ञापनातील स्वरूप आणि स्थान स्पष्ट करणे.
३. व्यक्तिमत्व विकास आणि भाषा यांच्यातील सहसंबंध स्पष्ट करणे.
४. लोकशाहीतील जीवनव्यवहार आणि प्रसारमाध्यमे यांचे परस्पर संबंध स्पष्ट करणे.
५. प्रसारमाध्यमांसाठी लेखनक्षमता विकसित करणे.

Course Contents

Unit I and II

घटक	तपशील	श्रेयांक	तासिका
१.	१. भाषा आणि व्यक्तिमत्त्व विकास : सहसंबंध २. लोकशाहीतील जीवनव्यवहार आणि प्रसारमाध्यमे	१	१५
२.	प्रसारमाध्यमांसाठी लेखन १. वृत्तपत्रासाठी बातमीलेखन आणि मुद्रितशोधन २. नभोवाणीसाठी भाषणाचे संहितालेखन ३. दूरचित्रवाणीसाठी माहितीपटासाठी संहितालेखन	१	१५

Unit III and IV

घटक	तपशील	श्रेयांक	तासिका
३.	१. भाषा, जीवन व्यवहार आणि नवमाध्यमे, समाजमाध्यमे २. नवमाध्यमे आणि समाजमाध्यमांचे प्रकार : ब्लॉग, फेसबुक, ट्विटर ३. नवमाध्यमे आणि समाजमाध्यमांविषयक साक्षरता, दक्षता, वापर आणि परिणाम	१	१५
४.	१. वेबसाईट आणि ब्लॉग, ट्विटरसाठी लेखन २. व्यावसायिक पत्रव्यवहार	१	१५

Learning Resources

संदर्भ ग्रंथ :

१. सायबर संस्कृती, डॉ. रमेश वरखेडे
२. उपयोजित मराठी, संपादक डॉ. केतकी मोडक, संतोष शेणई, सुजाता शेणई
३. ओळख माहिती तंत्रज्ञानाची, टिमोथी जे. ओ. लिअरी
४. संगणक, अच्युत गोडबोले, मौज प्रकाशन, मुंबई
५. इंटरनेट, डॉ. प्रबोध चौबे, मनोरमा प्रकाशन, मुंबई
६. व्यावहारिक मराठी, डॉ. ल. रा. नसीराबादकर, फडके प्रकाशन, कोल्हापूर
७. आधुनिक माहिती तंत्रज्ञानाच्या विश्वात, शिक्रापुरकर दीपक, मराठे उज्ज्वल, उत्कर्ष प्रकाशन, पुणे

Guidelines for Ability Enhancement Courses - Modern Indian Language (Marathi)

Term Work Evaluation

1. Subject teacher should frame minimum 08 assignments-based covering on all four units.

2. They can identify students depending upon the degree of difficulty in understanding the Marathi language and frame the assignments accordingly.

Suggested List of Assignments (Marathi/Hindi):

1. **"Samvad Sadara Kara" (Present a Dialogue): Role-Playing Everyday Scenarios:** Objective is to practice conversational Marathi, understanding social cues. In pairs or small groups, students create and perform a short dialogue based on a given scenario.
2. **Read a daily Newspapers column** (Sports, political, finance, editorial, education, international news, etc.) in the daily Marathi newspapers, summarize and present in the practical. A summary should be added as part of the journal.
3. **Creative writing:** Write blogs and posts on social media upto 200 words on recent development in their field of study
4. Mala He Sangayche Aahe" (I Want to Say This): Students show the object describe it to the class in Marathi. They should mention its color, size, use, why it's important to them, etc.
5. **Professional letter / report writing**
    a. Write a letter to the principal/director for organizing NSS camp in nearby village. Preparation of the budget, permission letters and report submission in the University
    b. Write a letter for internship sponsorship to any organization.
6. **Book Review** – Students are expected to read any novel, fiction or literature book of their choice and write a review on post it on social media of their choice.
7. **Participation in Competitions** (in college/outside the college) debate, declamation, elocution – A Report should be submitted
8. **Group Activity:** Road show, skit play, one-act play
9. **Participation in One-Act-Play -** Participation in Purushottam karandam, Firodia karandak, Dajikaka Gadgil Karandak and Shreetej Karandak.
10. **Marathi Film Review** – Watch the Marathi movie widely available on an OTT (Over-The-Top) platform, broadcaster in Television or available on YouTube and write a review.

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
HSSM284AUR: Engineering Economics and Financial Management		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 01 Hours/Week	**1**	**CCE: 50 Marks**
Practical: NA		**End-Semester: NA**

Prerequisite Courses, if any:

- Knowledge of company Operations, Design and Manufacturing, Basic principles and practices of Accounting and Budgeting, Analytical and Logical Thinking

Course Objectives:

1. To INTRODUCE the fundamental principles of economics and finance relevant to core engineering industries.
2. To DEVELOP an understanding of basic financial management concepts and enhance analytical skills for interpreting financial statements.
3. To FAMILIARIZE students with key financial terminologies and enable them to prepare and analyze various financial statements.
4. To PROVIDE insights into the budgeting process, including formulation, implementation, and control mechanisms.
5. To EXPLORE the financial dimensions of national and international business environments and their implications on engineering decisions.

Course Outcomes:

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

CO1: DEMONSTRATE an understanding of the business environment, fundamental economic concepts, and the demand-supply framework.

CO2: COMPREHEND accounting principles and effectively ANALYSE financial statements through ratio analysis.

CO3: INTERPRET key financial terms and ratios, and competently PREPARE various types of financial statements.

CO4: DEVELOP and SELECT appropriate budgeting techniques, understand budgetary control, and EVALUATE the influence of government policies, taxation, and inflation on financial decision-making.

CO5: UNDERSTAND the structure and functioning of national and international trade systems and their financial implications

Course Contents

Unit I	**Introduction to Business Economics and Finance**	**(06 Hours)**

Business Economics Basics: Definition, scope, and role in engineering, Microeconomics vs. Macroeconomics Demand, Supply & Market Equilibrium: Laws of demand & supply, elasticity, market forces.

Cost Concepts & Decision Making: Fixed, variable, marginal, sunk costs, Break-even analysis, profit maximization.

Basics of Financial Management: Financial statements (Balance Sheet, Income Statement, Cash Flow), Financial planning & decision-making for engineers.

Time Value of Money (TVM): Present & future value, simple & compound interest. Business & Financial Decisions in Engineering: Capital investment, risk assessment, Sources of financing (debt, equity, venture capital).

Real World Assignment (Any One)

1. Case study on micro economics business environment.

2. Analyze demand and supply fluctuations for any business of your choice and Propose pricing or inventory strategies based on findings.

3. Understand and apply break-even analysis to a real-world business scenario.

Exemplars / Practical Applications

Market Structure Analysis for Business Decision Making, Budgeting and Financial Planning, Understanding Economic Indicators for Investment Decisions.

Unit II	Cost Accounting	(05 Hours)

Introduction: Importance and difference between cost and financial accounting.

Cost Accounting: Types of costs: Fixed, variable, direct, indirect.

Costing methods: Job costing, process costing. Break-even analysis & budgeting for cost control.

Engineering Applications: Cost estimation, project budgeting, financial decision-making

Real World Assignment

1. List and classify the different types of costs involved in manufacturing a mechanical part.
2. Calculate the cost per unit by considering material cost, labor, and overheads of any mechanical element. Also estimate the total cost to produce 500 units.
3. For the nearby industry, using fixed and variable costs, calculate the break-even point for their production setup for any one item and suggest how many items must be sold to cover all costs

Exemplars / Practical Applications

All kind of industries where need to prepare standard costing and marginal costing of product, project based costing in EPC industries.

Unit III	Financial Accounting	(05 Hours)

Introduction: Importance of financial accounting.

Financial Accounting: Key financial statements: Balance Sheet, Income Statement, Cash Flow Statement.

Key Financial Terms: Revenue, Cost of Goods Sold (COGS), Operating Expenses like rent, utilities, salaries. Depreciation in asset value over time, Capital Expenditure.

Financial ratios: Profitability, liquidity, efficiency

Real World Assignment

1. Prepare financial statement of any organization.
2. Choose a company or firm and analyze its latest financial statements.
3. Prepare a balance sheet for any engineering organization.

Exemplars / Practical Applications

Engineering Industries, Banking sectors, Oil Gas industries, NGO for proper planning of cash flow.

Unit IV	Budget and Budgetary Control	(06 Hours)

Introduction to Budgeting: Definition, purpose, and importance in engineering and business.

Types of budgets: Fixed, flexible, zero-based, capital, and operational budgets.

Budgetary Control: Concept and objectives of budgetary control. Steps in budget preparation and implementation. Variance analysis: Comparing actual vs. budgeted performance.

Engineering Applications: Budgeting in manufacturing and project management. Cost control and resource allocation in engineering firms. Taxes and Financial Planning, Impact of government policies, Taxation and Inflation on Financial Management.

Real World Assignment (Any One)

1. Prepare and Interpret Budget and Standard Costs for any real business.
2. How can technology improve budget preparation and control? Discuss tools like Excel, ERP systems, or budgeting software.
3. How can businesses run against inflation and manage tax burdens efficiently? Suggest your financial strategies.

Exemplars / Practical Applications

To prepare Flexible Budgeting in all Engineering Industries, Zero budgeting in Government sectors, Sales and Operating Budgets for Retail Sector

Unit V	National and International Business and Finance	(06 Hours)

National Income (National Income Accounting – GDP, GNP, Real and Nominal Income) Fiscal Policy (Government Revenue, Expenditure and Financing). Concept of globalization, factors influencing globalization, concept of international business and motives, international trade, institutional framework in international business, the significance of foreign trade policy, export-import procedures.

Real World Assignment (Any One)

1. Choose any industry sector and research how GDP growth or decline has affected investments and job opportunities in this sector.
2. Visit an official economic data website (e.g., World Bank, IMF, National Bureau of Statistics) and collect the latest GDP and GNP data of our country. Compare the values and explain your findings about the country's economy.
3. Discuss the need of Foreign Capital and international finance.

Exemplars / Practical Applications

National Financing is needed in Small and Medium Enterprises, Calculation of GDP, National Stock Exchanges, Public Infrastructure Projects and International Financing is needed in Foreign Direct Investment (FDI), International Trade Financing, Global Financial Institution.

Learning Resources

Text Books:

1. Hay, Donald A. and Derek J. Morris. Industrial Economics and Organization: Theory and Evidence, 2nd Edition (Oxford: Oxford University Press), 1991.
2. Lall, Sanjaya. Competitiveness, Technology and Skills (Cheltenham: Edward Elgar), 2001.
3. Scherer, F. M. and D. Ross. Industrial Market Structure and Economic Performance, 3rd Edition (Houghton: Mifflin), 1990.
4. Financial Accounting", Dr. Kaustubh Sontakke [Himalaya Publishing House]
5. Chandra, Prasanna (2004). Financial Management: Theory and Practice. New Delhi: TATA McGraw Hill

Reference Books:

1. Accounting Theory & Practice Prof Jawahar Lal [Himalaya Publishing House] 79 | Page
2. Brearley, Richard A. and Myers, Stewart C. (1988). "Principles of Corporate Finance", New Delhi: McGraw-Hil
3. Engineering Economics, Tara Chand, Nem Chand and Brothers, Roorkee
4. Engineering Economy, Thuesen, G. J. and Fabrycky, W. J., Prentice Hall of India Pvt. Ltd.
5. Mechanical Estimating and Costing, T. R. Banga and S. C. Sharma, Khanna Publishers, Delhi
6. Industrial Organization and Engineering Economics, T. R. Banga and S. C. Sharma, Khanna Publishers, New Delhi
7. Mechanical Estimating and Costing, D. Kannappan et al., Tata McGraw Hill Publishing Company Ltd., New Delhi
8. A Text Book of Mechanical Estimating and Costing, O. P. Khanna, Dhanpat Rai Publications Pvt. Ltd., New Delhi
9. Industrial Engineering and Management, O. P. Khanna, Dhanpat Rai and Sons, New Delhi
10. Financial Management, I. M. Pandey, Vikas Publishing House Pvt. Ltd., New Delhi
11. Engineering Economics, James L. Riggs, David D. Bedworth and Sabah U. Randhawa, Tata McGrawHill Publishing Co. Ltd., New Delhi
12. Engineering Economy, Paul DeGarmo, Macmillan International Inc., New York

MOOC / NPTEL/ YouTube Links: -

1. https://onlinecourses.nptel.ac.in/noc22_ma44/
2. https://onlinecourses.nptel.ac.in/noc22_hs72/
3. https://onlinecourses.nptel.ac.in/noc22_mg63/

Savitribai Phule Pune University Second Year of Automation & Robotics Engineering (2024 Pattern)		
VEC285AUR: Environmental Science and Sustainable Development		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 02 Hours/Week	**2**	**CCE:** 15 Marks
Practical: ----		**End-Semester:** 35 Marks

Prerequisite Courses, if any:

- Knowledge of Chemistry, Biology and Earth Sciences

Course Objectives:

1. To INTRODUCE students to the fundamental concepts of environmental science, including the relationship between natural systems and human activities, concept of sustainable development and its significance in the day today life.
2. To FOSTER critical thinking skills regarding environmental issues such as climate change, pollution, resource depletion, deforestation, and habitat destruction.
3. To STUDY sustainable practices in energy use, agriculture, waste management, and urban planning, emphasizing the importance of balancing development with environmental preservation.
4. To EVALUATE the role of renewable energy, green technologies, and conservation efforts in promoting sustainability.
5. To ENCOURAGE students to apply their knowledge to real-world environmental challenges and sustainable development problems, through case studies, projects, and fieldwork.

Course Outcomes:

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

CO.1 To UNDERSTAND and EVALUATE the interdependence between environment, ecology, and natural resources, assess the impact of air pollution and ecological footprints, and ANALYZE the dynamic interactions between socio-economic systems.

CO. 2 To EVALUATE the causes of soil degradation and apply effective soil conservation and management practices to maintain soil health, enhance agricultural productivity, and promote sustainable land use.

CO.3 To IDENTIFY various water sources, ANALYZE issues related to water availability and quality, and APPLY sustainable water management practices to support environmental conservation and meet societal needs.

CO.4 To UNDERSTAND the principles of sustainability, EVALUATE environmental, social, and economic challenges, and APPLY practical sustainability practices to promote responsible resource use.

CO.5 To ANALYZE the principles of sustainable habitat design and sustainable energy systems, and APPLY environmentally responsible solutions such as green buildings, energy-efficient technologies, and renewable energy sources to promote sustainable living and reduce ecological impact.

Course Contents

Unit I	**Introduction to ESD**	**(06 Hours)**

Environment, ecology, natural resources, Air pollution, Ecological footprint, Interactions between socio-economic systems and eco-systems, Human health and the environment

Real World Assignment

1) Weather survey of your region of last 10 years
2) Air pollution and its effect on human health.

Exemplars / Practical Applications

1) Air purifiers
2) Air quality index indicators

Unit II	Soil Conservation and Management	(06 Hours)

Types and causes of soil degradation; Losses of soil moisture and its regulation, Nutrient depletion; impact of soil degradation on agriculture and food production , toxic organic chemicals, and organic contaminants in soils, Fertilizers and fertilizer management, Recycling of soil nutrients.

Inorganic and organic components of soils. Biogeochemical cycles – nitrogen, carbon, phosphorus and sulphur.

Real World Assignment

1. Analysis of soil texture, Ph and organic matter content
2. Effect of chemical fertilizers on soil biogeochemical cycles and on human health

Composting of organic waste

Exemplars / Practical Applications

1. Contour farming
2. Strip forming
3. Natural fertilizers.

Unit III	Water Sources and Management	(06 Hours)

Hydrological cycle and water resources- surface, ground, desalination, Water pollution, Integrated water resources management, Usage and efficiency

Real World Assignment

Development of greywater recycling system

Exemplars / Practical Applications

1. Water source management in desert area
2. Recycling and reuse of waste water
3. Rainwater harvesting

Unit IV	Sustainability and Sustainability Practices	(06 Hours)

Sustainability- concept, needs and challenges-economic, social, Aspects of sustainability- from unsustainability to sustainability, Climate change- Global, Regional and local environmental issues and possible solutions-case studies. Zero waste concept, ISO 14000 Series, Material Life cycle assessment, Environmental Impact Assessment.

Real World Assignment

1. Effect of global warming on human health
2. Indian government policies for sustainable development.

Exemplars / Practical Applications

Green roofs and Vertical Gardens

Unit V	Sustainable Habitat and Sustainable Energy	(06 Hours)

Sustainable habitat: Green buildings, Green materials, Energy efficiency, Sustainable transports, Sustainable energy: Non-conventional Sources, Energy Cycles- carbon cycle, emission and sequestration

Real World Assignment

Calculation of carbon foot print.

Exemplars / Practical Applications

Energy efficient buildings

Learning Resources

Text Books:

1. P. D. Sharma; Ecology and Environment; Volume 22 of Popular Biology Text Books Rastogi Publications, 2007
2. D.D. Mishra-Fundamental of Environmental Studies, S Chand & Co Ltd (1 December 2010).
3. M. Dayal- Renewable Energy; Environment and Development, Konark Pub.Pvt.Ltd.
4. Fulekar; Fundamental of Air pollution. 4th Edition, Daniel Vallero, Academic Press, Elsevier .

5. Ambasht R.S.; Environment and Pollution: An Ecological Approach, CBS Publishers & Distributors; 1st Ed. edition 2014

Reference Books:

1. Stanley E. Manahan; Fundamentals of Environmental Chemistry; Publisher: CRC Press 1993
2. E.D. Enger, B. E. Smith; Environmental Sciences-A study of Inter relationships, WCB Publication.
3. Kathy Wilson Peacock; Natural Resources and Sustainable Development.
4. Elizabeth Berner, Robert Berner; Global Enviroment - Water, Air, and Geochemical Cycles, Princeton University Press; 2nd Revised edition edition 2012.
5. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.
6. Andrew Dessler, Introduction to Modern Climate Change, 2nd Edition, Cambridge University Press, 2015.
7. Bruce Glavovic, Mick Kelly, Robert Kay, Ailbhe Travers, Climate Change and the Coast: Building Resilient Communities, CRC Press, 2015.

MOOC / NPTEL/ YouTube Links: -

1. Environmental and Sustainability Studies - Raquel Friedmann - YouTube
2. Lecture 1 - Sustainable Development Concepts - YouTube
3. Climate Change - A Short Film [4K]

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Index