Savitribai Phule Pune University, Pune

Maharashtra, India

Faculty of Science and Technology

National Education Policy (NEP)-2020 Compliant Curriculum

TE -Third Year Engineering (2024 Pattern)

Mechatronics Engineering

(With effect from Academic Year 2026-27)

Table of Contents

Nomenclature

AEC	Ability Enhancement Course
AICTE	All India Council for Technical Education
CCE	Comprehensive Continuous Evaluation
CEP	Community Engagement Project
EEM	Entrepreneurship/Economics/Management Courses
MDM	Multidisciplinary Minor (Courses from other programs within faculty)
MOOC	Massive Open Online Course
NEP	National Educational Policy
NPTEL	National Programme on Technology Enhanced Learning
OEL	Open Elective (Courses from other Faculties)
PCC	Program Core Course
PEO	Programme Educational Objectives
PSO	Program Specific Outcomes
VEC	Value Education Course
VSE	Vocational and Skill Enhancement Course
WK	Knowledge and Attitude Profile

Preface by Board of Studies

Dear Students and Teachers,

We, the members of Board of Studies Mechatronics Engineering, are very happy to present Third Year Mechatronics Engineering syllabus effective from the Academic Year 2026-27. The present curriculum will be implemented for Third Year of Engineering from the academic year 2026-27. Subsequently this will be carried forward for BE in AY 2027-28.

Mechatronics Engineering is a field that integrates mechanical, electrical, electronics, instrumentation and computer engineering principles to design and build intelligent systems. It focuses on creating automated systems and devices that combine mechanical components with electronics and software. Mechatronics engineers work in various industries, including manufacturing, automotive, healthcare, automation and robotics. This curriculum is designed to provide students with a comprehensive understanding of the fundamental principles, theories, and practices related to Mechatronics engineering, while also preparing them for the ever-evolving technological landscape.

The revised syllabus falls in line with the objectives of NEP-2020, Savitribai Phule Pune University, AICTE New Delhi, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements. Wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided at the end of each course. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

This curriculum is the result of extensive consultation with academic experts, industry professionals, and alumni to ensure relevance and excellence. It is designed not only to meet the current industry standards but also to prepare students for higher studies and research in the field of Mechatronics Engineering.

We hope that this curriculum will inspire students to become competent professionals, responsible citizens, and contributors to the technological advancement of society.

Dr. Vaibhav V. Dixit
Chairman
Board of Studies
Mechatronics Engineering

Member of Board of Studies- Mechatronics Engineering
1. Dr. Nitin B. Dhaigude
2. Dr. Dhananjay Khankal
3. Shri. Ajay Nagarkar
4. Dr. Kailas Karande

Program Specific Outcomes (PSO)

- **PSO1:** Inculcate professional skills: Ability to adapt a multi-disciplinary approach to develop solutions for industrial and societal related problems.
- **PSO2:** Cultivate employability and entrepreneurship: Entrepreneurship and inculcation of continuous learning towards professional career.

Programme Educational Objectives (PEO)

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

PEO	PEO Focus	PEO Statements
PEO1	Core competence	To prepare a graduate to inculcate Knowledge of Basic Engineering Sciences and Fundamentals of Mechanical, Electrical and Computer Systems.
PEO2	Skills and Ethics	To Design, Develop Product and applications in the field of Automation and Mechatronics and be able to use Engineering Tools that will Enhance their Productivity.
PEO3	Professionalism and Lifelong Learning	To prepare a graduate for acquiring Professional Ethics and Oral, Written and Graphical Communication Skills..

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.

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 Mechatronics Engineering, graduating stu-dents/graduates will be able to:

PO1	Engineering knowledge	Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
PO2	Problem analysis	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/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
PO4	Conduct Investigations of Complex Problems	Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modeling, 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 modeling 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/multidisciplinary 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 and 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)

General Rules and Guidelines

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

Guidelines for Examination Scheme

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

Comprehensive Continuous Evaluation (CCE) of 30 marks based on all the Units of course syllabus to be scheduled and conducted at institute level. To design a Comprehensive Continuous Evaluation (CCE) scheme for a theory subject of 30 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr.	Parameters	Marks	Coverage of Units
1	Unit Test	12 Marks	Units 1 & Unit 2 (6 Marks/Unit)
2	Assignments / Case Study	12 Marks	Units 3 & Unit 4 (6 Marks/Unit)
3	Seminar Presentation / Open Book Test/ Quiz	06 Marks	Unit 5

Format and Implementation of Comprehensive Continuous Evaluation (CCE)

- **Unit Test**
  - **Format:** Questions designed as per Bloom's Taxonomy guidelines to assess various cognitive levels (Remember, Understand, Apply, Analyze, Evaluate, Create).
  - **Implementation**: Schedule the test after completing Units 1 and 2. Ensure the question paper is balanced and covers key concepts and applications.
- **Sample Question Distribution**
  - Remembering (2 Marks): Define key terms related to [Topic from Units 1 and 2].
  - Understanding (2 Marks): Explain the principle of [Concept] in [Context].
  - Applying (2 Marks): Demonstrate how [Concept] can be used in [Scenario].
  - Analyzing (2 Marks): Compare & contrast [Two related concepts] from Units 1 and 2.
  - Evaluating (2 Marks): Evaluate the effectiveness of [Theory/Model] in [Situation].
  - Create (2 Marks): Design a suitable solution/model using [Concept] from Units 1 and 2 for [Given Problem/Scenario]
- **Assignments / Case Study** : Students should submit one assignment or one Case Study Report based on Unit 3 and one assignment or one Case Study Report based on Unit 4.
  - **Format:** Problem-solving tasks, theoretical questions, practical exercises, or case studies that require in-depth analysis and application of concepts.
  - **Implementation:** Distribute the assignments or case study after covering Units 3 and 4. Provide clear guidelines and a rubric for evaluation.

- **Seminar Presentation:**
  - **Format:** Oral presentation on a topic from Unit 5, followed by a Q&A session.

    Deliverables: Presentation slides, a summary report in 2 to 3 pages, and performance during the presentation.
  - **Implementation:** Schedule the seminar presentations towards the end of the course. Provide stu-dents with ample time to prepare and offer guidance on presentation skills.
- **Open Book Test:**
  - **Format:** Analytical and application-based questions to assess depth of understanding.
  - **Implementation:** Schedule the open book test towards the end of the course, ensuring it covers critical aspects of Unit 5.
- **Quiz :**
  - **Format:** Quizzes can help your students practice existing knowledge while stimulating interest in learning about new topic in that course. You can set your quizzes to be completed individually or in small groups.
  - **Implementation:** Online tools and software can be used create quiz. Each quiz is made up of a variety of question types including multiple choice, missing words, true or false etc
- **Example Timeline for conducting CCE:**
  - Weeks 1-4 : Cover Units 1 and 2
  - Week 5 : Conduct Unit Test (12 marks)
  - Weeks 6-8 : Cover Units 3 and 4
  - Week 9 : Distribute and collect Assignments / Case Study (12 marks)
  - Weeks 10-12 : Cover Unit 5
  - Week 13 : Conduct Seminar Presentations or Open Book Test or Quiz (6 marks)
- **Evaluation and Feedback:**
  - **Unit Test:** Evaluate promptly and provide constructive feedback on strengths and areas for improvement.
  - **Assignments / Case Study:** Assess the quality of submissions based on the provided rubric. Offer feedback to help students understand their performance.
  - **Seminar Presentation:** Evaluate based on content, delivery, and engagement during the Q&A session. Provide feedback on presentation skills and comprehension of the topic.
  - **Open Book Test**: Evaluate based on the depth of analysis and application of concepts. Provide feedback on critical thinking and problem-solving skills.

End-Semester Examination (ESE)

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

- **Format and Implementation:**
  - **Question Paper Design:** Below structure is to be followed to design an End-Semester Examination (ESE) for a theory subject of 70 marks on all 5 units of the syllabus with questions set as per Bloom's Taxonomy guidelines and 14 marks allocated per unit.
  - **Balanced Coverage**: Ensure balanced coverage of all units with questions that assess different cognitive levels of Bloom's Taxonomy: Remember Understand, Apply, Analyze, Evaluate, and Create. The questions should be structured to cover:

* Remembering: Basic recall of facts and concepts.
* Understanding: Explanation of ideas or concepts.
* Applying: Use of information in new situations.
* Analyzing: Drawing connections among ideas.
* Evaluating: Justifying a decision or course of action.
* Creating: Producing new or original work (if applicable).

- **Detailed Scheme 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 combinations 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.

Open Electives and Value Education Evaluation

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

Sr. No	Parameters	Marks	Coverage of units
1.	Unit Test	10 Marks	Unit- 1 and Unit-2 (5 Marks per Unit)
2.	Seminar Presentation/ Open Book Test/ Assignment/ Case Study	5 Marks	Unit- 3 and Unit- 4

Curriculum Structure- Semester V

Third Year Engineering (2024 Pattern) – Mechatronics Engineering

Course Code	Course Type	Course Name	Teaching Scheme (Hrs/Week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE	End Sem	Term Work	Oral	Practical	Total	Theory	Tutorial	Practical	Total
PCC-301-MXE	Program core Course 1	Kinematics of Machinery	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-302-MXE	Program core Course 2	Design of Mechatronics System	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-303-MXE	Program core Course 3	Embedded System Design	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-304-MXE	Program core Course Lab 1	Kinematics of Machinery Lab	-	-	2	-	-	25	25	-	50	-	-	1	1
PCC-305-MXE	Program core Course Lab 2	Design of Mechatronics System Lab	-	-	2	-	-	25	-	25	50	-	-	1	1
PCC-306-MXE	Program core Course Lab 3	Embedded System Design Lab	-	-	2	-	-	-	-	25	25	-	-	1	1
PEC-321-MXE	Programme Elective Course	Elective - I	3	-	-	30	70	-	-	-	100	3	-	-	3
PEC-322-MXE	Programme Elective Course Lab	Elective – I Lab	-	-	2	-	-	25	25	-	50	-	-	1	1
MDM-331-MXE	Multidisciplinary Minor	Programming Lab	-	2	2	-	-	25	-	25	50	-	2	1	3
	Open Elective		2	-	-	15	35	-	-	-	50	2	-	-	2
ELC-342-MXE	Experiential Learning Course (Research Methodology)	Technical Seminar	-	-	2	-	-	-	25	-	25	-	-	1	1
Total			**14**	**2**	**12**	**135**	**315**	**100**	**75**	**75**	**700**	**14**	**2**	**6**	**22**

***Note:** Students can opt for Open Electives offered by different discipline/faculty like Arts, Science, Commerce and Management, Humanities or Inter-Disciplinary studies. Example - IPR and Cyber Laws, Sustainability Development, Digital Personal Data Protection, The Constitution of India, etc.

PEC-321-MXE: Programme Elective Course
PEC-321A-MXA Electric Vehicles
PEC-321B-MXA Signals & Systems
PEC-321C-MXA Modern Control Theory

Curriculum Structure- Semester VI

Third Year Engineering (2024 Pattern) – Mechatronics Engineering

Course Code	Course Type	Course Name	Teaching Scheme (Hrs/Week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE	End Sem	Term Work	Oral	Practical	Total	Theory	Tutorial	Practical	Total
PCC-351-MXE	Programme core Course 1	Machine Design	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-352-MXE	Programme core Course 2	Digital Signal Processing	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-353-MXE	Programme core Course Lab 1	Machine Design Lab	-	-	2	-	-	25	25	-	50	-	-	1	1
PCC-354-MXE	Programme core Course Lab 2	Digital Signal Processing Lab	-	-	2	-	-	25	-	25	50	-	-	1	1
PEC-361-MXE	Programme Elective Course	Elective-II	3	-	-	30	70	-	-	-	100	3	-	-	3
PEC-362-MXE	Programme Elective Course	Elective-III	3	-	-	30	70	-	-	-	100	3	-	-	3
PEC-363-MXE	Programme Elective Course Lab 3	Elective – II Lab	-	-	2	-	-	25	25	-	50	-	-	1	1
MDM-371-MXE	Multidisciplinary Minor	Artificial Intelligence & Machine Learning	-	1	2	-	-	25	25	-	50	-	1	1	2
MDM-372-MXE	Vocational and Skill Enhancement Course	Solar Technology and Maintenance	-	-	2	-	-	50	-	-	50	-	-	1	1
ELC-381-MXE	Experiential Learning Course	Internship / OJT	-	-	8	-	-	-	50	-	50	-	-	4	4
Total			**12**	**01**	**18**	**120**	**280**	**150**	**125**	**25**	**700**	**12**	**1**	**9**	**22**

PEC-361-MXE : Elective-II	PEC-362-MXE : Elective-III
PEC-361A-MXA Digital Image Processing	PEC-362A-MXA Smart Manufacturing
PEC-361B-MXA Automotive Engineering	PEC-362B -MXA Internet of Things

Savitribai Phule Pune University, Pune

Maharashtra, India

TE - Mechatronics Engineering

2024 Pattern

Semester - V

With effect from Academic Year 2026-27

Savitribai Phule Pune University
Third Year of Mechatronics Engineering (2024 Course)

PCC-301-MXE: Kinematics of Machinery

Teaching Scheme			Credits		Examination Scheme	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites Courses

Systems in Mechanical Engineering, Engineering Mathematics - I and II, Engineering Physics, Engineering Mechanics

Course Objectives:

This course aims to:

1. To make the students conversant with kinematic analysis of mechanisms applied to real life and industrial applications.
2. To analyze displacement, velocity, and acceleration of mechanisms using analytical and graphical methods.
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 completion of the course, learner will be able to

CO1	APPLY the kinematic concept to analyze simple mechanisms used in Engineering application.
CO2	ANALYZE displacement velocity and acceleration in mechanisms by analytical and graphical method
CO3	SYNTHESIZE and DESIGN mechanism for specified motion and path generation problems.
CO4	APPLY kinematic principle in power transmission application.
CO5	DESIGN cam profiles for required follower motion considering practical constraints

Unit 01	**Fundamentals of Mechanism**	**08 hrs**

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

Unit 02	**Kinematic Analysis of Mechanisms:**	**08 hrs**

Analytical Method: 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.

Graphical Method: 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).

Unit 03	Synthesis of Mechanisms	08 hrs
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		
Unit 04	**Kinematics of Gears**	**08 hrs**
Gear: Classification **Spur Gear**: Terminology, law of gearing, Involute and cycloidal tooth profile, path of contact, arc of contact, sliding velocity, Interference and undercutting, Minimum number of teeth to avoid interference, Force Analysis (theoretical treatment only) **Helical and Spiral Gears**: Terminology, Geometrical Relationships, virtual number of teeth for helical gears **Bevel Gear & Worm and Worm Wheel**: Terminology, Geometrical Relationships **Gear Train**: Types, Analysis of Epicyclic gear Trains, Holding torque - simple, compound and Epicyclic gear Trains, Torque on Sun and Planetary gear Train, compound Epicyclic gear Train		
Unit 05	**Cams & Followers**	**08 hrs**
Cams & Followers: Introduction, Classification of Followers and Cams, Terminology of Cam Displacement diagram for the Motion of follower as Uniform velocity, Simple Harmonic Motion (SHM), Uniform Acceleration and Retardation Motion (UARM), Cycloid motion, Cam Profile construction for Knife-edge Follower and Roller Follower, Cam jump Phenomenon		

Text Books:	
[T1]	S. S. Rattan, "Theory of Machines", Third Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
[T2]	Bevan T, "Theory of Machines", Third Edition, Longman Publication
[T3]	G. Ambekar, "Mechanism and Machine Theory", PHI
[T4]	J. J. Uicker, G. R. Pennock, J. E. Shigley, "Theory of Machines and Mechanisms", Fifth Edition, International Student Edition, Oxford
Reference Books:	
[R1]	Paul E. Sandin, "Robot Mechanisms and Mechanical Devices Illustrated", Tata McGraw Hill Publication
[R2]	Stephen J. Derby, "Design of Automatic Machinery", 2005, Marcel Dekker, New York
[R3]	Neil Sclater, "Mechanisms and Mechanical Devices Sourcebook", Fifth Edition, Tata McGraw Hill Publication
[R4]	Ghosh Malik, "Theory of Mechanism and Machines", East-West Pvt. Ltd

MOOC / NPTEL/ YouTube Links: -

	1. Kinematics of Machines – IIT Kanpur (NPTEL): https://nptel.ac.in/courses/112104121 2. Kinematics of Mechanisms and Machines – IIT Kharagpur (NPTEL): https://onlinecourses.nptel.ac.in/noc25_me46/preview 3. Theory of Mechanisms – IIT Madras (NPTEL): https://nptel.ac.in/courses/112106270 4. Mechanism and Robot Kinematics – NPTEL: https://onlinecourses.nptel.ac.in/noc22_me108/preview

Savitribai Phule Pune University
Third Year of Mechatronics Engineering (2024 Pattern)

PCC-302-MXE: Design of Mechatronics System

Teaching Scheme			Credits		Examination Scheme	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites Courses

Basic electronics + mechanics, Elementary programming, Basic physics and mathematics, Fundamental control concepts

Course Objectives:

By the end of this course, students will be able to:

1. To introduce the fundamentals and design principles of mechatronics systems and their components
2. To develop the ability to model and simulate mechanical, electrical, thermal and fluid systems using modern tools such as MATLAB and LabVIEW.
3. To understand dynamic behaviour and performance characteristics of engineering systems including first and second order systems.
4. Understand the design and integration of mechatronic systems, along with basics of automation, PLC, and robotics.
5. To develop the ability to design and analyze practical mechatronic applications through case studies such as motor control, robotics and automated systems.

Course Outcomes:

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

CO1	Explain the basic elements, design process and ergonomics considerations in mechatronics system design.
CO2	Develop mathematical models of mechanical, electrical, fluid and thermal systems and perform simulation using software tools.
CO3	Analyze dynamic response characteristics of engineering systems including first and second order systems.
CO4	Design and evaluate simple mechatronic systems integrating sensors, actuators, controllers, and automation concepts including PLC and robotics.
CO5	Design and analyze practical mechatronic systems such as motion control systems, temperature control systems and robotic mechanisms.

Unit 01	**Introduction to Mechatronics System**	**08 hrs**

Key elements, Mechatronics design process, design parameters, mechatronics and traditional design, Advanced approaches in mechatronics design, Introduction to industrial design, modelling, simulation and analysis, Ergonomics and safety.

Unit 02	**Concepts of System Modelling**	**08 hrs**

Introduction, model categories, model development, simulation using software tools (MATLAB / LabVIEW /HDL), verification and validation, Mathematical modelling: Basic system modelling – mechanical, electrical, fluid and thermal.

Unit 03	Mechatronics System Modelling	08 hrs
Engineering systems: Rotational, translational, electro-mechanical, pneumatic-mechanical, hydraulic-mechanical, micro electro mechanical system, Dynamic responses of system: first order, second order system – Performance measures.		
Unit 04	**Introduction to Robotics & Automation**	**08 hrs**
Industrial Automation, Basics of PLC (Programmable Logic Controller), Ladder logic programming, SCADA basics, Sensors & actuators in automation **Robotics Basics,** Robot anatomy and classification, Basics of kinematics, End effectors and actuators, Applications of industrial robots		
Unit 05	**Applications DMS**	**08 hrs**
Motion control using DC Motor, AC Motor and Servomotor, Temperature control of hot/cold reservoir, Pick and place robot, Car parking barriers, Motion and temperature control of washing machine, Auto focus camera, Surface measurement using image processing, Virtual Instrumentation and monitoring using LabVIEW.		

Text Books:	
[T1]	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering – W. Bolton
[T2]	Mechatronics System Design – Devdas Shetty & Richard A. Kolk
[T3]	Introduction to Mechatronics and Measurement Systems – David G. Alciatore & Michael B. Histand
[T4]	Bolton, W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education.
[T5]	Devdas Shetty & Richard A. Kolk, Mechatronics System Design, PWS Publishing Company.
[T6]	Georg pelz, "Mechatronic Systems: Modeling and simulation" with HDL's, John wiley and sons Ltd, 2003.
Reference Books:	
[R1]	Sensors and Transducers – D. Patranabis
[R2]	Principles of Measurement Systems – John P. Bentley
[R3]	The 8051 Microcontroller and Embedded Systems – Muhammad Ali Mazidi
[R4]	Embedded Systems: Real-Time Interfacing – Jonathan W. Valvano

MOOC Courses/e- Learning:	
1	NPTEL Course on Design of Mechatronic Systems, By Prof. Prasanna Gandhi, IIT Bombay https://nptel.ac.in/courses/112101304

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PCC-303-MXE: Embedded System Design						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites Courses
Sensors and Instrumentation and Linear Integrated Circuits

Course Objectives:
By the end of this course, students will be able to: 1. To introduce the fundamental concepts, components, architecture, and applications of embedded systems. 2. To provide knowledge of the architecture and features of 8051 and ARM7 microcontrollers used in embedded system design. 3. To develop programming skills for microcontrollers using assembly language and embedded programming techniques. 4. To understand the interfacing of various peripherals such as LED, LCD, keyboard, ADC, stepper motor, and serial communication with microcontrollers. 5. To enable students to design and implement microcontroller-based embedded systems for real-world applications.

Course Outcomes:	
After successful completion of the course, learner will be able to:	
CO1	**Understand** the fundamentals and architecture of embedded systems.
CO2	**Analyze** the architecture of 8051 and implement peripheral interfacing and programming.
CO3	**Develop** programs for the 8051-microcontroller using assembly language and implement peripheral interfacing.
CO4	**Analyze** the architecture and programming concepts of ARM7 microcontrollers and embedded software development.
CO5	**Design and implement** microcontroller-based embedded systems for various real-world applications.

Unit 01	**General Concepts**	**08 hrs**
Basic Concepts: Microprocessor and Microcontroller, Von Neumman and Harward, Intel 8085 microprocessor architecture (only) Introduction to Embedded systems: Design Metrics, Examples of embedded systems, hardware/software co-design, Embedded micro controller cores (ARM, RISC, CISC, and SOC), Embedded memories, Architecture of Embedded Systems Introduction to IOT		

Unit 02	**8051 Microcontroller**	**08 hrs**

Architecture: Features, architecture and pin configurations, CPU timing and machine cycle, Input / Output ports, Memory organization, Counters and timers, Interrupts, Serial data input and output 8051 Assembly Language Programming: Instruction set, Addressing mode, Assembler directives and programs 8051 Interfacing: LED, LCD, Seven Segment Display, keyboard, ADC, Stepper Motor, Relay and Serial Communication

Unit 03	**Advanced Microcontrollers**	**08 hrs**

Architecture: Features of ARM Microcontroller, Operating modes, Architecture, Registers, CPSR, Pipeline, Exceptions, interrupt vector table, memory management, ARM7 processor families ARM7 Programming: Instruction set, Addressing mode and programs MSP 430: Features, architecture and programming

Unit 04	**Embedded Software Development**	**08 hrs**

Assemblers, linkers and loaders. Binary file formats for processor executable files. Typical structure of timer-interrupt driven programs. GNU-GCC compiler introduction Embedded C-programming concepts: Optimizing for Speed/Memory needs, Interrupt service routines, macros, functions, modifiers, data types, device drivers

Unit 05	**Real Time Operating Systems and Embedded Applications**	**08 hrs**

Real Time Operating System (RTOS): RTOS concepts, kernel structure, critical sections, multitasking, task and time management, schedulers, event control blocks, priorities, deadlocks, synchronization, semaphore management, mutual exclusion, and RTOS implementation.
Embedded System Applications – Case Studies: Consumer and home applications such as IoT-based home automation using Android application, medical applications like health monitoring using embedded systems, and robotics applications such as pick-and-place robot or autonomous surveillance robot.

Text books	
[T1]	Microprocessor architecture and applications with 8085: By Ramesh Gaonkar (Penram International Publication).
[T2]	M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay, “The 8051 Microcontroller & Embedded systems”, Pearson Publications, Second Edition 2006
[T3]	C. Kenneth J. Ayala and D. V. Gadre, “The 8051 Microcontroller & Embedded system using assembly & ‘C’, Cengage Learning, Edition 2010.
[T4]	Andrew Sloss, Dominic Symes, and Chris Wright, “ARM System Developer’s Guide” Morgan Kaufmann Publishers, First Edition 2004.
Reference Books:	
[R1]	James A. Langbridge, “Professional Embedded Arm Development”, Wrox, John Wiley Brand& Sons Inc., Edition 2014
[R2]	Frank Vahid and tony Gavages “Embedded system design – A unified hardware / software introduction”, Wiley publication, Third edition 2002.
[R3]	Embedded/Real-Time Systems: Concepts, Design & Programming – Dr. K. V. K. K. Prasad, Dreamtech Press, India.
[R4]	Rajkamal, Embedded Systems - Architecture, Programming and Design, Tata McGraw Hill, Second edition, 2009
MOOC Courses/e- Learning:	
[1]	Introduction to Embedded system design : https://nptel.ac.in/courses/108102169
[2]	Embedded Systems: https://nptel.ac.in/courses/108105057
[3]	Microprocessors & Microcontrollers : https://nptel.ac.in/courses/106108100
[4]	Microcontrollers & Applications: https://nptel.ac.in/courses/117104072

Savitribai Phule Pune University
Third Year of Mechatronics Engineering (2024 Pattern)

PCC-304-MXE: Kinematics of Machinery Lab

Teaching Scheme			Credits		Examination Scheme	
Practical	02	Hrs/Week/Batch	Practical	01	Term Work	25
					Oral	25

Prerequisites Courses

Systems in Mechanical Engineering, Engineering Mathematics - I and II, Engineering Physics, Engineering Mechanics, Geometric Modeling & Drafting

Course Objectives:

This course aims to:

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 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.

Practical

(Experiment # 1 is compulsory and Select any Two from Experiment # 2 to 4)

1. To make a model of any mechanism by using waste material by the group of 3 to 4 students and to give a presentation using PPTs.
2. Speed and torque analysis of epicyclic gear train to determine holding torque.
3. To study and verify cam jump phenomenon.
4. To study manufacturing of gear using gear generation with rack as a cutter and to generate an involute profile.

Assignments using Drawing Aids
(Experiment #1 to 3 and 6 are compulsory and Select any One from Experiment #4-5)
Do following graphical assignments on Half Imperial drawing sheet:

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 conjugate profile for any general type of gear tooth.
5. To study various types of gearboxes.
6. To draw cam profile for any two problems with combination of various follower motion with radial and off-set cam.

Assignments using Software
(Any Three Assignments - Minimum one computer programming based and Minimum one based on use of software)
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 (Mech Analyser, 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

Assignments using Virtual Laboratory
(minimum Two experiments)
Please visit the links given below for exploring experiments on Kinematics of Machinery using Virtual Laboratory. Write a Brief Reports of using Virtual Laboratory to perform following assignment:

1. Mechanics-of-Machines Lab (All Experiments), http://mm-nitk.vlabs.ac.in/index.html
2. Mechanisms and Robotics - Oldham Coupling Mechanism, http://vlabs.iitkgp.ernet.in/mr/index.html

Mechanisms and Robotics - Quick Return Mechanism, http://vlabs.iitkgp.ernet.in/mr/index.html

Text Books:	
[T1]	S. S. Rattan, "Theory of Machines", Third Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
[T2]	Bevan T, "Theory of Machines", Third Edition, Longman Publication
[T3]	G. Ambekar, "Mechanism and Machine Theory", PHI
[T4]	J. J. Uicker, G. R. Pennock, J. E. Shigley, "Theory of Machines and Mechanisms", Fifth Edition, International Student Edition, Oxford

Reference Books:	
[R1]	Paul E. Sandin, “Robot Mechanisms and Mechanical Devices Illustrated”, Tata McGraw Hill Publication
[R2]	Ghosh Malik, “Theory of Mechanism and Machines”, East-West Pvt. Ltd
[R3]	Hannah and Stephans, “Mechanics of Machines”, Edward Arnolde Publication
[R4]	R. L. Norton, “Kinematics and Dynamics of Machinery”, First Edition, McGraw Hill Education (India) P Ltd. New Delhi
[R5]	Dr. V. P. Singh, “Theory of Machine”, Dhanpatrai and Sons
[R6]	C. S. Sharma & Kamlesh Purohit, “Theory of Machine and Mechanism”, PHI

Savitribai Phule Pune University
Third Year of Mechatronics Engineering (2024 Pattern)

PCC-305-MXE: Design of Mechatronics System Lab

Teaching Scheme			Credits		Examination Scheme	
Practical	02	Hrs/Week/Batch	Practical	01	Practical	25

Prerequisites Courses

Basic electronics + sensors, Microcontroller programming (Arduino), Motor control fundamentals, Control systems basics, Basic simulation tools

Course Objectives:

By the end of this course, students will be able to:

1. To understand the fundamentals of mechatronics systems and their interdisciplinary components.
2. To develop the ability to model and simulate engineering systems using modern tools such as MATLAB or LabVIEW.
3. To study sensors, actuators, PLCs, and automation systems used in industrial applications.
4. To analyze industrial robotic systems and ladder logic programming for automation control.
5. To design and implement simple mechatronic systems integrating mechanical, electrical, and control elements.

Course Outcomes:

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

CO1	Identify and explain the working of sensors, actuators, microcontrollers, PLCs, and other components used in mechatronic systems.
CO2	Model and simulate mechanical, electrical, first-order, and second-order systems using MATLAB/Simulink
CO3	Perform sensor interfacing, calibration, and measurement techniques for displacement and temperature sensing applications
CO4	Demonstrate basic PLC programming, industrial automation concepts, and industrial robot operations.
CO5	Design and implement a simple mechatronic system by integrating mechanical, electrical, electronic, and control elements.

List of Experiments

Experiment 1 and 2 compulsory and from 3 to 11 any 6 from the list given below as study, demonstration & performance type

1. Study of Mechatronics System Components, (Identification and study of sensors, actuators, microcontrollers, signal conditioning circuits and data acquisition systems used in mechatronic applications.)
2. Ergonomics and Safety Analysis of a Mechatronic Product. (Study of ergonomic design and safety considerations in a selected product such as an automatic washing machine, robotic arm or automated gate system.)
3. Simulation of Mechanical System (Modelling and simulation of a mass–spring–damper system using MATLAB / Simulink)
4. Simulation of Electrical System Simulation of an RLC circuit and analysis of system response using MATLAB/Simulink.
5. Simulation of First and Second Order Systems (Study the time response characteristics such as rise time, settling time and overshoot using simulation tools.

6. Sensor Interfacing and Calibration (Measurement of displacement using LVDT or potentiometer sensor and temperature measurement using RTD/Thermocouple.)
7. Study of PLC and basic ladder logic programming
8. To study the basic components and working of an industrial automation system.
9. To study basic components and operation of an industrial robot.
10. To develop and test a simple ladder logic program for motor control.
11. Mini project: Design of simple mechatronic system

Text Books:	
[T1]	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering – W. Bolton
[T2]	Mechatronics System Design – Devdas Shetty & Richard A. Kolk
[T3]	Introduction to Mechatronics and Measurement Systems – David G. Alciatore & Michael B. Histand
[T4]	Mechatronics – HMT Limited
Reference Books:	
[R1]	Sensors and Transducers – D. Patranabis
[R2]	Principles of Measurement Systems – John P. Bentley
[R3]	The 8051 Microcontroller and Embedded Systems – Muhammad Ali Mazidi
[R4]	Embedded Systems: Real-Time Interfacing – Jonathan W. Valvano

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PCC-306-MXE: Embedded System Design Lab						
Teaching Scheme			**Credits**		**Examination Scheme**	
Practical	02	Hrs/Week/Batch	Practical	01	Practical	25

Prerequisites Courses

Basic Electronics Laboratory, Digital Electronics Laboratory, C programming

Course Objectives:

By the end of this course, students will be able to:

1. To develop background knowledge and core expertise in area of embedded systems.
2. To teach applications of microcontrollers in embedded systems

Course Outcomes:

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

CO1	Analyze the architecture of 8051 microcontrollers and implement peripheral interfacing and programming.
CO2	Analyze the architecture of ARM7 microcontrollers and develop programs with peripheral interfacing.
CO3	Explain and apply the basic terminologies of software development and Real-Time Operating Systems (RTOS).
CO4	Design and develop microcontroller-based embedded systems for various applications.

List of Experiments

1. **8051 Programming:**
   Write and execute assembly programs for basic operations using the 8051 microcontrollers.

2. **8051 Interfacing – I:**
   Interface LED or seven segment display with 8051 and display patterns or numbers.

3. **8051 Interfacing – II:**
   Interface LCD or keyboard with 8051 and display characters or detect key inputs.

4. **ARM Programming:**
   Develop basic programs on ARM microcontroller for arithmetic and data manipulation.

5. **ARM Interfacing – I:**
   Interface LED or switches with ARM microcontroller and control output based on input.

6. **ARM Interfacing – II:**
   Interface LCD or sensor with ARM microcontroller and display sensor data.

7. **MSP430 Programming & Interfacing:**
   Develop programs and interface LED or sensor modules with MSP430 microcontroller.

8. **RTOS Experiment:**
   Study RTOS concepts by configuring QNX Neutrino on a virtual machine and analyze task scheduling.

9. **Mini Project:**
   Design a simple microcontroller-based embedded system for a real-world application.

Term Work:
Term work shall consist of 8 experiments mentioned above and should be set to have well predefined inference and conclusion. The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Distribution of marks for Term work shall be as follows:
Laboratory work (experiments/assignments): 15 marks
Mini Project: 05 marks
Attendance (Theory and practical's): 05 marks

Practical Examination:
Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Text books:	
[T1]	Microprocessor architecture and applications with 8085: By Ramesh Gaonkar (Penram International Publication).
[T2]	M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay, "The 8051 Microcontroller & Embedded systems", Pearson Publications, Second Edition 2006
[T3]	C. Kenneth J. Ayala and D. V. Gadre, "The 8051 Microcontroller & Embedded system using assembly & 'C', Cengage Learning, Edition 2010.
[T4]	Andrew Sloss, Dominic Symes, and Chris Wright, "ARM System Developer's Guide" Morgan Kaufmann Publishers, First Edition 2004.
Reference Books:	
[R1]	James A. Langbridge, "Professional Embedded Arm Development", Wrox, John Wiley Brand& Sons Inc., Edition 2014
[R2]	Frank Vahid and tony Gavages "Embedded system design – A unified hardware / software introduction", Wiley publication, Third edition 2002.
[R3]	Embedded/Real-Time Systems: Concepts, Design & Programming – Dr. K. V. K. K. Prasad, Dreamtech Press, India.
[R4]	Rajkamal, Embedded Systems - Architecture, Programming and Design, Tata McGraw Hill, Second edition, 2009
MOOC Courses/e- Learning:	
[1]	Introduction to Embedded system design : https://nptel.ac.in/courses/108102169
[2]	Embedded Systems: https://nptel.ac.in/courses/108105057
[3]	Microprocessors & Microcontrollers : https://nptel.ac.in/courses/106108100
[4]	Microcontrollers & Applications: https://nptel.ac.in/courses/117104072

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-321A-MXA: Elective –I Electric Vehicle						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites:

Basic Electrical Engineering, Electrical and Electronics Engineering, Kinematics of Machinery

Course Objectives:

This course aims to:

1. Describe the structure, key components, and operational principles of electric and hybrid vehicles and recognize their advantages over conventional vehicles.
2. Illustrate the construction, materials, and operational characteristics of lithium-ion batteries and their role in EV energy storage systems.
3. Differentiate various electric motors, power electronic converters, and control systems used in EV propulsion.
4. Perform basic calculations related to tractive force, torque, and power required for electric vehicle motion and understand hybrid drivetrain configurations.
5. Summarize EV charging methods, battery management functions, and government initiatives supporting electric mobility.

Course Outcomes:

At the end of this course, students will be able to:

CO1	Explain the fundamentals, architecture, and classification of Electric and Hybrid Vehicles and their environmental impact.
CO2	Analyze lithium-ion battery technology, energy storage systems, and battery management systems used in EVs.
CO3	Evaluate EV powertrain components including motors, power converters, and control strategies.
CO4	Apply vehicle dynamics principles to calculate forces, torque, and power requirements of electric vehicles.
CO5	Interpret EV charging infrastructure, policies, and emerging technologies for sustainable electric mobility.

Unit 01	**Electric Mobility Systems and EV Architecture**	**08 hrs**

History and evolution of Electric Vehicles, comparison of Electric Vehicles with Internal Combustion Engine Vehicles (ICEV), limitations of ICE vehicles, exhaust emissions and global warming, environmental importance of electric and hybrid vehicles, classification of EVs and HEVs. Overview of EV technologies and architecture, EV subsystems and configurations, case studies of two-wheelers, three-wheelers, and four-wheelers, electric buses and electric trucks. Emerging EV technologies including battery swapping systems, wireless charging, and solid-state batteries, introduction to autonomous and connected electric vehicles, overview of EV challenges and future trends.

Unit 02	**Advanced Battery Technologies and Energy Storage for EVs**	**08 hrs**

Materials used for Lithium-ion batteries, nanostructured electrode materials, Panasonic 18650 and 2170 cells, construction and working of Li-ion batteries. Battery pack design and configuration, battery protection systems, battery performance parameters, battery thermal management and cooling techniques. Battery capacity calculation, life cycle assessment of Li-ion batteries, solid-state batteries and future energy storage technologies, hybridization of energy storage devices such as ultra capacitors and flywheels.

Unit 03	Electric Powertrain Systems and Motor Drive Control	08 hrs
Electric motors used in EVs: Induction Motor, PMSM, BLDC, Switched Reluctance Motor – construction, working and characteristics. Motor selection criteria for EVs, torque and power rating, structural configuration and motor placement. Power electronic converters used in EVs, motor controllers (MCU), battery control unit (BCU). Motor control techniques: Induction motor control and PMSM control, torque- speed characteristics and constant torque/constant power operation. Introduction to EV sensors, in-vehicle communication networks (CAN bus), and basic EV control architecture.		
Unit 04	**Vehicle Dynamics and Hybrid Electric Powertrains**	**08 hrs**
Mechanics of vehicle movement and tractive effort, forces acting on electric vehicles: rolling resistance, aerodynamic drag, gradient resistance and acceleration resistance. Calculation of tractive force, motor torque and power requirement, dynamic equation of motion. Hybrid Electric Vehicles: classification, hybridization of drivetrains and energy sources, series, parallel and series-parallel hybrid architectures. Power flow control in hybrid drive trains, power management strategies in HEV, modeling of series hybrid vehicles and fuel efficiency analysis.		
Unit 05	**EV Charging Infrastructure, Battery Management Systems and Policies**	**08 hrs**
Battery charging techniques: CC-CV, CV-CC charging, charging standards and charger architectures. Public EV charging stations, solar powered EV charging stations, grid integration and Vehicle-to-Grid (V2G) concept. Battery Management System (BMS): structure, functions and standards, State of Charge (SoC) estimation methods using Kalman Filter, Neural Network and Fuzzy Logic. EV charging infrastructure guidelines, FAME-II policy, BEE star labeling for Li-ion battery packs, EV tariffs, EV startup ecosystem and battery recycling policies.		

Text Books:	
[T1]	Electric and Hybrid Vehicles: Design Fundamentals – Iqbal Husain, CRC Press
[T2]	Electric Vehicle Technology Explained – James Larminie & John Lowry, Wiley
[T3]	Lithium-Ion Batteries: Fundamentals and Applications – Yuping Wu, CRC Press
[T4]	Battery Management Systems for Large Lithium-Ion Battery Packs – Davide Andrea, Artech House
[T5]	Electric Motor Drives: Modeling, Analysis and Control – R. Krishnan, Prentice Hall
[T6]	Power Electronics: Converters, Applications, and Design – Mohan, Undeland & Robbins
Reference Books:	
[R1]	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design – Mehrdad Ehsani, CRC Press
[R2]	Energy Storage for Power Systems – A. Ter-Ghazarian, IET Press
[R3]	Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives – Chris Mi, Wiley
[R4]	Modern Power Electronics and AC Drives – Bimal K. Bose, Prentice Hall
[R5]	Vehicle Dynamics and Control – Rajesh Rajamani, Springer
Online Resources:	
[O1]	NPTEL Course on" EV - Vehicle Dynamics and Electric Motor Drives" By Prof. Amit Jain, Prof. Avanish Tripathi https://nptel.ac.in/courses/108102121

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-321B-MXA: Elective –I Signals and System						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites:

Fundamentals of calculus

Course Objectives:

This course aims to:

1. To introduce the fundamental concepts of signals and systems, including classification and properties of continuous-time and discrete-time signals.
2. To provide knowledge of Fourier series, Fourier transform, and Laplace transform for the analysis of signals and linear time-invariant (LTI) systems.
3. To understand system modeling techniques such as block diagrams, signal flow graphs, and stability analysis of systems.
4. To familiarize students with sampling theory and Z-transform techniques used for the analysis of discrete-time systems.
5. To develop the ability to analyze sampled data systems and discrete-time signal processing techniques for engineering applications.

Course Outcomes:

At the end of this course, students will be able to:

CO1	Apply the mathematical equations of continuous and discrete time signals and perform fundamental operations on signals and classify systems
CO2	Find response of a system for any arbitrary input signal using the convolution process and aware of its modern applications. Test the system stability using the impulse response.
CO3	Analyze and resolve the signals in frequency domain using Fourier Transform
CO4	Apply Laplace transform for continuous time signals and perform system analysis.
CO5	Apply z-transform to discrete time signals and perform the system analysis

Unit 01	**Fundamentals of Signals & Systems**	**08 hrs**

Signal: Definition, Continuous Time signal, Sampling Theorem, Discrete Signal, Signal Representation: Graphical, Functional, Tabular and Sequence. Basic Elementary signals and their relationships: Unit Impulse, Unit step, Unit ramp, Unit parabolic, rectangular pulse, Triangular, Signum, Sinusoidal, Real exponential, Complex exponential, Sinc and Gaussian function, Operations on signals such as addition, subtraction, shifting, scaling. System: Definition, Classification, static and dynamic systems, causal and non- causal systems, Linear and Non- linear systems, time variant and time invariant systems, stable and unstable systems, invertible and non- invertible systems. System interconnections.

Unit 02	**Time Domain Representation of LTI System**	**08 hrs**

System Input-output relation, definition of impulse response, Introduction to convolution, convolution sum, methods of finding convolution sum: tabular and graphical, convolution integral, computation of convolution integral using graphical method for unit step to unit step, unit step to exponential, exponential to exponential, unit step to rectangular and rectangular to rectangular only. Properties of convolution sum and

convolution integral. System interconnection, system properties in terms of impulse response, step response in terms of impulse response. Concept of correlation, Autocorrelation, Cross Correlation, significance.

Unit 03	**Fourier Transform and Application**	08 hrs

Introduction to Fourier Series: Fourier Series (FS) representation of periodic Continuous-Time (CT) signals using trigonometric and exponential forms, Dirichlet conditions for the existence of Fourier Series, Gibbs phenomenon.
Fourier Transform (FT): Fourier Transform representation of aperiodic CT signals; Dirichlet conditions for the existence of Fourier Transform; evaluation of magnitude and phase response; Fourier Transform of standard CT signals; properties and their significance; interplay between time and frequency domains using sine and rectangular signals; Fourier Transform for periodic signals

Unit 04	**Laplace Transform**	08 hrs

Definition of Laplace transform, Limitations of Fourier transform and need of Laplace transform, ROC, Properties of ROC, Laplace transform of standard periodic and aperiodic functions, properties of Laplace transform and their significance, Laplace transform evaluation using properties, Inverse Laplace transform based on partial fraction expansion, stability considerations in S domain, Application of Laplace Transforms: RL, RC, RLC Circuit analysis, transfer function and impulse response.

Unit 05	**Z Transform**	08 hrs

Introduction to Z transform and its definition, ROC, Z transform applications to discrete-time signal and system analysis. Properties of the Z-transform, standard Z-transform pairs, inverse Z-transform by partial fraction method, the relationship between the Z-transform and the Fourier transform.

Text Books:	
[T1]	Oppenheim A.V., Willsky A.S. & Nawab S.H., Signals and Systems, 2/e, Prentice Hall
[T2]	Nagrarth I. J, Saran S. N and Ranjan R, Signals and Systems, 2/e, Tata McGraw Hill
[T3]	Haykin S. & Veen B.V., Signals & Systems, 2/e, John Wiley
[T4]	Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern
[T5]	Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
Reference Books:	
[R1]	Bracewell R.N., Fourier Transform & Its Applications, McGraw Hill
[R2]	Farooq Husain, Signals and Systems, Umesh publications
[R3]	Papoulis A., Fourier Integral & Its Applications, McGraw Hill
[R4]	Taylor F.J., Principles of Signals & Systems, McGraw Hill
Online Resources:	
[O1]	NPTEL Course on Signals and Systems, By Prof. Aditya K. Jagannatham, IIT Kanpur. https://onlinecourses.nptel.ac.in/noc26_ee37/preview
[O2}	NPTEL Course on Principles of Signals and Systems, By Prof. Aditya K. Jagannatham, IIT Kanpur. https://onlinecourses.nptel.ac.in/noc21_ee14/preview
[O3}	**NPTEL Course on Signals and Systems**, By **Prof. Hitesh Shrimali**, IIT Mandi. https://onlinecourses.nptel.ac.in/noc26_ee79/preview
[O4}	**NPTEL Course on Digital Signal Processing, By Prof. S. C. Dutta Roy, IIT Delhi. https://onlinecourses.nptel.ac.in/noc20_ee67/preview**
[O5}	**NPTEL Course on Analog and Digital Signal Processing, By Prof. S. C. Dutta Roy, IIT Delhi. https://onlinecourses.nptel.ac.in/noc19_ee56/preview**

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-321C-MXA: Elective –I Modern Control Theory						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites:

Course Objectives:

This course aims to:

1. To understand state-space representation and analysis of dynamic systems.
2. To analyze controllability, observability, and stability of systems.
3. To study state feedback and observer design techniques.
4. To understand optimal and digital control concepts.
5. To apply modern control techniques to engineering systems.

Course Outcomes:

At the end of this course, students will be able to:

CO1	Develop state-space models for dynamic systems.
CO2	Analyze controllability and observability of systems
CO3	Apply stability analysis and state feedback techniques.
CO4	Design observers and optimal controllers
CO5	Analyze discrete-time systems and modern control applications

Unit 01	**Introduction to State Space Analysis**	**08 hrs**

Review of classical control concepts, Limitations of classical control theory, Concept of state, state variables, and state model, State-space representation of continuous-time systems, Physical variable and phase variable forms, Conversion of transfer function into state-space model, State transition matrix and properties, Solution of state equations

Unit 02	**Controllability and Observability**	**08 hrs**

Concepts of controllability and observability, Controllability tests using Kalman criterion, Observability tests using Kalman criterion, Duality principle, Controllable and observable canonical forms, Decomposition of systems, Practical significance of controllability and observability, Examples and case studies

Unit 03	**Stability Analysis and State Feedback**	**08 hrs**

Stability concepts in state space, Lyapunov stability analysis, Lyapunov's direct and indirect methods, State feedback control, Pole placement technique, Ackermann's formula, Design examples using state feedback, Introduction to servo systems

Unit 04	State Observer and Optimal Control	08 hrs
Need for state observers, Full-order and reduced-order observers, Observer design using pole placement, Separation principle, Introduction to optimal control, Performance indices, Linear Quadratic Regulator (LQR), Applications of optimal control		
Unit 05	**Digital and Advanced Control Concepts**	**08 hrs**
Introduction to digital control systems, Sampling and reconstruction, Z-transform basics, State-space representation of discrete-time systems, Stability analysis of discrete systems, Introduction to adaptive and robust control, Applications in robotics and automation, Case studies using MATLAB and Simulink		

Text Books:	
[T1]	Control System Engineering – Norman S. Nise
[T2]	Digital Control and State Variable Methods – M. Gopal
Reference Books:	
[R1]	Modern Control Engineering – Katsuhiko Ogata
[R2]	Control System Engineering – Norman S. Nise
[R3]	Linear State Space Control Systems – Robert L. Williams II
[R4]	Modern Control System Theory – M. Gopal
[R5]	Digital Control and State Variable Methods – M. Gopal
Online Resources:	
[O1]	NPTEL: State Space Approach to Control System Analysis and Design
[O2}	IIT Guwahati: Advanced Control Systems Video Lectures
[O3}	IIT Madras: Introduction to State Space Systems
[O4}	MATLAB Control System Tutorials
[O5}	Simulink Tutorials

Savitribai Phule Pune University
Third Year of Mechatronics Engineering (2024 Pattern)

PEC-322A-MXA: Elective –I Electric Vehicle Lab

Teaching Scheme			Credits		Examination Scheme	
Practical	02	Hrs/Week/Batch	Practical	01	Term Work	25

Prerequisites:

Basic Electrical Engineering, Electrical and Electronics Engineering, Kinematics of Machinery

Course Objectives:

This course aims to:

1. Describe the structure, key components, and operational principles of electric and hybrid vehicles and recognize their advantages over conventional vehicles.
2. Illustrate the construction, materials, and operational characteristics of lithium-ion batteries and their role in EV energy storage systems.
3. Differentiate various electric motors, power electronic converters, and control systems used in EV propulsion.
4. Perform basic calculations related to tractive force, torque, and power required for electric vehicle motion and understand hybrid drivetrain configurations.
5. Summarize EV charging methods, battery management functions, and government initiatives supporting electric mobility.

Course Outcomes:

At the end of this course, students will be able to:

CO1	Explain the fundamentals, architecture, and classification of Electric and Hybrid Vehicles and their environmental impact.
CO2	Analyze lithium-ion battery technology, energy storage systems, and battery management systems used in EVs.
CO3	Evaluate EV powertrain components including motors, power converters, and control strategies.
CO4	Apply vehicle dynamics principles to calculate forces, torque, and power requirements of electric vehicles.
CO5	Interpret EV charging infrastructure, policies, and emerging technologies for sustainable electric mobility.

List of Experiments:

Any 8 of the following

1. Introduction to battery modeling MATLAB Simulink
2. Introduction to BLDC motor control MATLAB Simulink
3. Introduction to Induction Motor control MATLAB Simulink
4. Power Converter selection in MATLAB Simulink
5. Study of EV subsidies in different states.
6. Measurement of charging and discharging characteristics of a battery.
7. Visit to the Electric Vehicle Charging Station / Industries / Manufacturer.
8. Study of Harmonics issues of EV charging.
9. Fuel efficiency evaluation of a series HEV in city and high-way.
10. Various strategies for improving vehicle energy/fuel efficiency regenerating braking.
11. Study of various Battery Recycling Methods.
12. Study of thermal management system in EV battery packs.

Guidelines for Instructor's Manual:
The Instructor's Manual should contain following related to every experiment ● Brief theory related to the experiment. ● Circuit diagram and apparatus with their detail specification as per IS code. ● Students should be encouraged to visit industries/ laboratories/ Manufacturing company. ● Students should be encouraged to use virtual labs. ● Few short questions related to each practical.
Guidelines for Student's Lab Manual:
The Students lab journal should contain: ● Brief theory related to the experiment. ● Circuit diagram and apparatus with their detail specification as per IS code. ● Observations, result tables and proper inferences/ conclusions from each experiment conducted. ● Reports on visit to industries/ laboratories/ Manufacturing company ● Simulations and print outs of use of virtual labs. ● Few short questions and answers related to each practical.
Guidelines for Laboratory Conduction:
There should be continuous assessment for the TW. ● Assessment must be based on understanding of theory, attentiveness during practicals. ● Session, how efficiently the student is able to do connections and get the results. ● Timely submission of journal.

Text Books:	
[T1]	Electric and Hybrid Vehicles: Design Fundamentals – Iqbal Husain, CRC Press
[T2]	Electric Vehicle Technology Explained – James Larminie & John Lowry, Wiley
[T3]	Lithium-Ion Batteries: Fundamentals and Applications – Yuping Wu, CRC Press
[T4]	Battery Management Systems for Large Lithium-Ion Battery Packs – Davide Andrea, Artech House
[T5]	Electric Motor Drives: Modeling, Analysis and Control – R. Krishnan, Prentice Hall
[T6]	Power Electronics: Converters, Applications, and Design – Mohan, Undeland & Robbins
Reference Books:	
[R1]	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design – Mehrdad Ehsani, CRC Press
[R2]	Energy Storage for Power Systems – A. Ter-Ghazarian, IET Press
[R3]	Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives – Chris Mi, Wiley
[R4]	Modern Power Electronics and AC Drives – Bimal K. Bose, Prentice Hall
[R5]	Vehicle Dynamics and Control – Rajesh Rajamani, Springer
[R6]	Electric Vehicle Integration into Modern Power Networks – Rodrigo Garcia-Valle
Online Resources:	
[O1]	NPTEL Course on" EV - Vehicle Dynamics and Electric Motor Drives" By Prof. Amit Jain, Prof. Avanish Tripathi https://nptel.ac.in/courses/108102121

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-322B-MXA: Elective –I Signals and System Lab						
Teaching Scheme			**Credits**		**Examination Scheme**	
Practical	02	Hrs/Week/Batch	Practical	01	Term Work	25

Prerequisites:

1. Basic knowledge of signals and systems concepts
2. Fundamentals of engineering mathematics (differential equations, complex numbers)
3. Basic understanding of MATLAB / GNU Octave programming
4. Knowledge of continuous-time and discrete-time signals

Course Objectives:

This course aims to:

1. To introduce the fundamental concepts of signals and systems, including classification and properties of continuous-time and discrete-time signals.
2. To provide knowledge of Fourier series, Fourier transform, and Laplace transform for the analysis of signals and linear time-invariant (LTI) systems.
3. To understand system modeling techniques such as block diagrams, signal flow graphs, and stability analysis of systems.
4. To familiarize students with sampling theory and Z-transform techniques used for the analysis of discrete-time systems.
5. To develop the ability to analyze sampled data systems and discrete-time signal processing techniques for engineering applications.

Course Outcomes:

At the end of this course, students will be able to:

CO1	Generate and analyze basic continuous-time and discrete-time signals using MATLAB/Octave.
CO2	Apply signal operations and convolution to analyze LTI systems.
CO3	Analyze frequency domain characteristics of signals using Fourier transform techniques.
CO4	Apply sampling and Z-transform techniques for discrete-time signal analysis.
CO5	Simulate and analyze signals and systems models using MATLAB/Octave for engineering applications.

List of Experiment

Any 8 Experiments from the following.

1. Generation of basic signals (unit step, ramp, impulse, sinusoidal, exponential) and plotting them using MATLAB/Octave.
2. Perform basic operations on signals such as time shifting, scaling, and signal addition for continuous-time and discrete-time signals.
3. Verification of system properties such as linearity, time invariance, causality, and stability using MATLAB/Octave.
4. Implementation of convolution for continuous-time and discrete-time signals and verification using MATLAB/Octave.
5. Computation and analysis of Fourier Series for periodic signals using MATLAB/Octave.
6. Analysis of Fourier Transform and plotting magnitude and phase spectrum of signals.
7. Analysis of Laplace Transform and system transfer function using MATLAB/Octave.

8. Verification of sampling theorem and demonstration of aliasing effect.
9. Implementation of Z-transform and inverse Z-transform for discrete-time signals.
10. Analysis of difference equations and discrete convolution of LTI systems.
11. Frequency response analysis of simple systems using MATLAB/Octave.
12. Mini Project: Simulation and analysis of signals and systems using MATLAB/Octave for an engineering application.

Term Work:
Term work shall consist of 8 experiments mentioned above and should be set to have well predefined inference and conclusion. The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Distribution of marks for Term work shall be as follows:
Laboratory work (experiments/assignments): 15 marks
Mini Project: 05 marks
Attendance (Theory and practical's): 05 marks

Text Books:	
[T1]	Oppenheim A.V., Willsky A.S. & Nawab S.H., Signals and Systems, 2/e, Prentice Hall
[T2]	Nagrarth I. J, Saran S. N and Ranjan R, Signals and Systems, 2/e, Tata McGraw Hill
[T3]	Haykin S. & Veen B.V., Signals & Systems, 2/e, John Wiley
[T4]	Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern
[T5]	Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
Reference Books:	
[R1]	Bracewell R.N., Fourier Transform & Its Applications, McGraw Hill
[R2]	Farooq Husain, Signals and Systems, Umesh publications
[R3]	Papoulis A., Fourier Integral & Its Applications, McGraw Hill
[R4]	Taylor F.J., Principles of Signals & Systems, McGraw Hill
Online Resources:	
[O1]	NPTEL Course on Signals and Systems, By Prof. Aditya K. Jagannatham, IIT Kanpur. https://onlinecourses.nptel.ac.in/noc26_ee37/preview
[O2}	NPTEL Course on Principles of Signals and Systems, By Prof. Aditya K. Jagannatham, IIT Kanpur. https://onlinecourses.nptel.ac.in/noc21_ee14/preview
[O3}	**NPTEL Course on Signals and Systems**, By **Prof. Hitesh Shrimali**, IIT Mandi. https://onlinecourses.nptel.ac.in/noc26_ee79/preview
[O4}	**NPTEL Course on Digital Signal Processing, By Prof. S. C. Dutta Roy, IIT Delhi. https://onlinecourses.nptel.ac.in/noc20_ee67/preview**
[O5}	**NPTEL Course on Analog and Digital Signal Processing, By Prof. S. C. Dutta Roy, IIT Delhi. https://onlinecourses.nptel.ac.in/noc19_ee56/preview**

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-322C-MXA: Elective –I Modern Control Theory Lab						
Teaching Scheme			**Credits**		**Examination Scheme**	
Practical	02	Hrs/Week/Batch	Practical	01	Term Work	25

Prerequisites:

Course Objectives:

This course aims to:

1. To understand state-space representation and analysis of dynamic systems.
2. To analyze controllability, observability, and stability of systems.
3. To study state feedback and observer design techniques.
4. To understand optimal and digital control concepts.
5. To apply modern control techniques to engineering systems.

Course Outcomes:

At the end of this course, students will be able to:

CO1	Develop state-space models for dynamic systems.
CO2	Analyze controllability and observability of systems
CO3	Apply stability analysis and state feedback techniques.
CO4	Design observers and optimal controllers
CO5	Analyze discrete-time systems and modern control applications

List of Experiments

Any 8 Experiments from the following.

1. State-space modeling using MATLAB
2. Conversion of transfer function to state-space representation
3. Controllability analysis of dynamic systems
4. Observability analysis of dynamic systems
5. State transition matrix computation
6. Pole placement using state feedback
7. Observer design using MATLAB
8. Simulation of Lyapunov stability analysis
9. Implementation of LQR controller
10. Discrete-time system analysis using Simulink

Text Books:

[T1]	Control System Engineering – Norman S. Nise
[T2]	Digital Control and State Variable Methods – M. Gopal

Reference Books:	
[R1]	Modern Control Engineering – Katsuhiko Ogata
[R2]	Control System Engineering – Norman S. Nise
[R3]	Linear State Space Control Systems – Robert L. Williams II
[R4]	Modern Control System Theory – M. Gopal
[R5]	Digital Control and State Variable Methods – M. Gopal
Online Resources:	
[O1]	NPTEL: State Space Approach to Control System Analysis and Design
[O2}	IIT Guwahati: Advanced Control Systems Video Lectures
[O3}	IIT Madras: Introduction to State Space Systems
[O4}	MATLAB Control System Tutorials
[O5}	Simulink Tutorials

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
MDM-331-MXE; Programming Lab						
Teaching Scheme			**Credits**		**Examination Scheme**	
Practical	02	Hrs/Week/Batch	Practical	01	Practical	25
Tutorial	02	Hrs/Week/Batch	Tutorial	02	Term Work	25

Prerequisites

Engineering Graphics, Solid Mechanics, Engineering Materials and Metallurgy

Course Objectives:

This course aims to:

1. To introduce the basic principles of solid modeling and computer-aided drafting (CAD) with an emphasis on industry-relevant applications.
2. To impart capabilities of solid modeling software for creating 2D drawings and 3D models of mechanical components and assemblies.
3. To inculcate understanding abilities of reading, interpreting, and creating standard engineering drawings with appropriate dimensions, tolerances, and annotations according to BIS/ISO standards.
4. To develop the ability to apply geometric and dimensional constraints in part modeling and to analyze how these constraints influence the design intent and functionality

Course Outcomes:

On completion of the course, learner will be able to

CO1	Apply the tools from CAD software's to complete 2D sketches of the mechanical components.
CO2	Build a complete 3D model of components by applying different commands and constraints.
CO3	Conclude on appropriate constraints between different parts of the assemblies for generating the complete model
CO4	Create a complete working drawing of mechanical components/Assembly

List of Experiments

Experiment 1 : Introduction to CAD Software

Introduction to user interface of CAD software, Drawing tools (line, circle, arc, polygon, etc.) Modifying tools (move, copy, trim, offset, mirror, etc.) and Constraints Simple sketching of any objects (like orthographic projection) by using the above mentioned commands

Exemplars / Practical Applications

Mechanical part design, Architectural drafting, Electrical circuit layout, Automotive component modeling etc.

Experiment 2 : Part Modeling

Sketch-based modeling (by using commands like extrude, revolve, sweep, loft etc.) Constraints (geometric and dimensional) Parametric modeling, Analytical modeling. Creating any 2 simple machine parts by using 3D modeling software.

Exemplars / Practical Applications

Automotive body and chassis design, Aerospace structural component modeling, Mechanical

part/components modeling, Industrial machinery and equipment design, Architectural modeling.

Experiment 3 : Assembly Modeling

Types of assemblies, significance and limitations, Inserting components into an assembly, mates and constraints, Assembly motion and interference checking Creating assembly of model consisting of minimum 5 parts (Such as Knuckle joint, Flange coupling, C- Clamp, Vice etc.)

Exemplars / Practical Applications

Automotive engine assembly design, Aerospace system integration, Consumer electronics product assembly, Industrial machinery assembly planning, Robotics and automation system design.

Experiment 4 : Drafting from 3D Models

Generating views from 3D parts and assemblies, Exploded views, GD&T symbols, Dimensioning.
Generation of 2D working drawings (minimum 2 views) of parts and assembly created in experiment 3 above

Exemplars / Practical Applications

Automotive manufacturing documentation, Aerospace component assembly instructions, Consumer electronics product manuals, Industrial equipment fabrication, Construction and architectural detailing

Text Books:

[T1]	Zeid, I and Sivasubramania, R., (2009), "CAD/CAM : Theory and Practice", 2nd edition, McGraw Hill Education, ISBN-13: 978-0070151345
[T2]	Rao, P. N., (2017), "CAD/CAM: Principles and Applications", 3rd edition, McGraw Hill Education, ISBN-13: 978-0070681934
[T3]	Chang, Kuang-Hua, (2015), "e-Design: Computer-Aided Engineering Design", Academic Press, ISBN13: 978-0123820389

Reference Books:

[R1]	Lee, Kunwoo, (1999), "Principles of CAD/CAM/CAE Systems", Pearson/Addison-Wesley, ISBN- 13: 978-0201380361
[R2]	Bordegoni, Monica and Rizzi, Caterina, (2011), "Innovation in Product Design: From CAD to Virtual Prototyping", Springer, ISBN-13: 978-1447161875
[R3]	Vukašinovic, Nikola and Duhovnik, Jože, (2019), "Advanced CAD Modeling: Explicit, Parametric, Free-Form CAD and Re-engineering", Springer, ISBN-13: 978-3030023980
[R4]	Um, Dugan, (2018), "Solid Modeling and Applications: Rapid Prototyping, CAD and CAE Theory", 2nd edition, Springer, ISBN-13: 978-3319745930
[R5]	Rogers, D. and Adams, J. A., (2017), "Mathematical Elements for Computer Graphics", 2nd edition, McGraw Hill Education, ISBN-13: 978-0070486775

List of Experiments:

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
Third Year of Mechatronics Engineering (2024 Pattern)

ELC-342-MXE: Technical Seminar

Teaching Scheme			Credits		Examination Scheme	
Practical	02	Hrs/Week/Batch	Practical	01	Oral	25

Course Objectives:

This course aims to:

1. Gaining of actual knowledge (terminology, classification, methods and advanced trends)
2. Learning fundamental principles, generalization or theories.
3. Discussion and critical thinking about topics of current intellectual importance.
4. Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to the course.

Course Outcomes:

On completion of the course, learner will be able to

CO1	Relate with the current technologies and innovations in Mechatronics engineering.
CO2	Improve presentation and documentation skill
CO3	Apply theoretical knowledge to actual industrial applications and research activity.
CO4	Communicate effectively.

Seminar should be based on a detailed study of any topic related to the advance areas/applications of Mechatronics Engineering. Topic should be related to Mechatronics Engineering. However, it must not include contents of syllabus of Mechatronics Engineering. It is expected that the student should collect the information from journals, internet and reference books in consultation with his/her teacher/mentor, have rounds of discussion with him/her. The report submitted should reveal the student assimilation of the collected information. Mere compilation of information from the internet and any other resources is discouraged.

Format of the Seminar report should be as follows:

1. The report should be neatly typed on white paper. The typing shall be with normal spacing, Times New Roman (12 pt) font and on one side of the paper. (A-4 size).
2. Illustrations downloaded from internet are not acceptable.
3. The report should be submitted with front and back cover of card paper neatly cut and bound together with the text.
4. Front cover: This shall have the following details with Block Capitals
   a. Title of the topic.
   b. The name of the candidate with roll no. and Exam. Seat No. at the middle.
   c. Name of the guide with designation below the candidate's details.
   d. The name of the institute and year of submission on separate lines at the bottom
5. Certificate from institute as per specimen, Acknowledgement and Contents.

6. The format of the text of the seminar report should be as follows
    a. The introduction should be followed by literature survey.
    b. The report of analytical or experimental work done, if any.
    c. The discussion and conclusions shall form the last part of the text.
    d. They should be followed by nomenclature and symbols used.
    e. The Reference Books are to be given at the end.
7. The total number of typed pages, excluding cover shall from 20 to 25 only.
8. All the pages should be numbered.
9. Two spiral bound copies of the seminar report shall be submitted to the college.
10. Candidate shall present the seminar before the examiners.
11. The total duration of presentation and after-discussion should be about 30 minutes. The assessment for the subject shall be based on:
    a. Content.
    b. Presentation
    c. Report

Savitribai Phule Pune University, Pune

Maharashtra, India

TE - Mechatronics Engineering

2024 Pattern

Semester - VI

With effect from Academic Year 2026-27

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PCC-351-MXE: Machine Design						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites Courses

The basics of material elastic behavior, stress, strain, its relationship, failure modes, different theories of failure and its applications. The design cycle, basis of design considerations like strength, rigidity, manufacture, assembly and cost, standards and codes. The preferred sizes and series, tolerances and types of fits. Construction of SMD and BMD. Roots of equations, Interpolation rule.

Course Objectives:

This course aims to:

1. Understand various design considerations, design procedures.
2. Select materials for a specific application.
3. Evaluate the stresses in machine components due to various types of loads and failure.
4. Design various machine components such as shafts, couplings, keys, screws, joints, springs.
5. Analyze machine components subjected to variable loading for finite and infinite life.

Course Outcomes:

On completion of the course, learner will be able to

CO1	Design levers and components subjected to eccentric loading by selecting appropriate material.
CO2	Design shafts, keys and couplings under static loading conditions
CO3	Analyze different stresses in power screws and apply its knowledge to design screw jack.
CO4	Evaluate dimensions of machine components under fluctuate loading conditions.
CO5	Apply the design and development procedure for different types of springs.

Unit 01	**Design of Simple Machine Elements**	**08 hrs**

Factor of safety, Selection of Factor of Safety, Service factor, Design of Cotter joint, Knuckle joint, Design of hand / foot lever, lever for safety valve, bell crank lever, Design of components subjected to eccentric loading

Unit 02	**Design of Shafts, Keys and Couplings**	**08 hrs**

Shaft design on the Strength basis, torsional rigidity basis and lateral rigidity basis, Design of shaft as per A.S.M.E. code. Design of square and rectangular keys, Kennedy key and splines. Design of Flange Coupling and Bushed-Pin Flexible Coupling.

Unit 03	**Design of Power Screws**	**08 hrs**

Terminology of Power Screw, Torque analysis and Design of power screws with square and trapezoidal threads, Collar friction torque, Self-locking screw, Efficiency of square threaded screw, Efficiency of self-locking screw, Design of screw, nuts and C-Clamp. Design of screw jack

Unit 04	**Design against Fluctuating loads**	**08 hrs**

Stress concentration and its factors, Reduction of stress concentration factors, fluctuating stresses, fatigue failures, endurance limit, S-N curve, Notch sensitivity, Endurance limit, Endurance strength modifying factors, Reversed stresses – Design for Finite and Infinite life, Cumulative damage in fatigue failure, Soderberg, Gerber, Goodman Lines, Modified Goodman diagrams, Fatigue design under combined stresses:- (Theoretical treatment only)

Unit 05	**Design of Springs**	**08 hrs**

Types and applications of springs, Stress and deflection equations for helical compression Springs, Springs in series and parallel, Design of helical springs, concentric helical springs, surge in spring, Design of Multi-leaf springs, Nipping of Leaf springs, Shot Peening.

Text Books:

[T1]	Bhandari V.B., Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.
[T2]	Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. Ltd.

Reference Books:

[R1]	Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International.
[R2]	Juvinal R.C., Fundamentals of Machine Components Design, John Wiley and Sons.
[R3]	Black P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc.
[R4]	Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.
[R5]	Hall A.S., Holowenko A.R. and Laughlin H.G, Theory and Problems of Machine Design, Schaum's Outline Series.

MOOC / NPTEL/YouTube Links: -

https://www.youtube.com/watch?v=SL21aDqgs8Q
https://www.youtube.com/watch?v=yH04FSBiCdk&list=PL3D4EECEFAA99D9BE&index=4
https://www.youtube.com/watch?v=TPURJnlekeo

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PCC-352-MXE: Digital Signal Processing						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites Courses
Signals and System

Course Objectives:
This course aims to: 1. To provide background and fundamental material for the analysis and processing of digital signals. 2. To understand the fast computation of DFT and appreciate the FFT processing. 3. To study the designs and structures of digital (IIR and FIR) filters and analyze and synthesize for a given specifications. 4. To acquaint in Multi-rate signal processing techniques and finite word length effects.

Course Outcomes:	
On completion of the course, learner will be able to	
CO1	Understand the LTI system characteristics and Multirate signal processing.
CO2	Understand the inter-relationship between DFT and various transforms.
CO3	Design a IIR filter for a given specification.
CO4	Design a FIR filter for a given specification.
CO5	Understand the significance of various digital filter structures and analyze the effects of finite word length and round-off errors in DSP processor implementation.

Unit 01	**Introduction**	**08 hrs**
Introduction to Digital Signal Processing: Discrete Time Signals & Sequences, conversion of continuous to discrete signal, Normalized Frequency, Linear Shift Invariant Systems, Stability, and Causality, linear differential equation to difference equation, Linear Constant Coefficient Difference Equations, Frequency Domain Representation of Discrete Time Signals and Systems Multirate Digital Signal Processing: Introduction, Down Sampling, Decimation, Up sampling, Interpolation, Sampling Rate Conversion.		

Unit 02	**Discrete Fourier series**	**08 hrs**
Fourier Series, Fourier Transform, Laplace Transform and Z Transform relation, DFS Representation of Periodic Sequences, Properties of Discrete Fourier Series, Discrete Fourier Transforms: Properties of DFT, Linear Convolution of Sequences using DFT, Computation of DFT: Over-Lap Add Method, Over-Lap Save Method, Relation between DTFT, DFS, DFT and Z- Transform. Fast Fourier Transforms: Fast Fourier Transforms (FFT) - Radix-2 Decimation-in-Time and Decimation-in-Frequency FFT Algorithms, Inverse FFT.		

Unit 03	**IIR Digital Filters**	**08 hrs**
Analog filter approximations – Butterworth and Chebyshev, Design of IIR Digital Filters from Analog Filters, Step and Impulse Invariant Techniques, Bilinear Transformation Method, Spectral Transformations.		

Unit 04	FIR Digital Filters	08 hrs
Characteristics of FIR Digital Filters, Frequency Response. Design of FIR Filters: Fourier Method, Digital Filters using Window Techniques, Frequency Sampling Technique, Comparison of IIR & FIR filters		
Unit 05	**Realization of Digital Filters and Implementation Issues**	**08 hrs**
Realization of Digital Filters: Applications of Z–Transforms, solution of difference equations of digital filters, system function, stability criterion, frequency response of stable systems, realization of digital filters – Direct form, Canonic form, Cascade form and Parallel form structures. **Finite Word Length Effects:** Limit cycles, overflow oscillations, round-off noise in IIR digital filters, computational output round-off noise, methods to prevent overflow, trade-off between round-off and overflow noise, measurement of coefficient quantization effects through pole-zero movement, dead band effects. **Implementation Aspects:** Brief introduction to finite precision arithmetic and implementation issues in digital hardware/DSP processors while implementing digital filters.		
Text Books:		
[T1]	Discrete Time Signal Processing – A. V. Oppenheim and R.W. Schaffer, PHI, 2009	
[T2]	Digital Signal Processing, Principles, Algorithms, and Applications: John G. Proakis, Dimitris G.Manolakis, Pearson Education / PHI, 2007.	
Reference Books:		
[R1]	Digital Signal Processing – Fundamentals and Applications – Li Tan, Elsevier, 2008	
[R2]	Fundamentals of Digital Signal Processing using MATLAB – Robert J. Schilling, Sandra L.Harris, Thomson, 2007	
[R3]	Digital Signal Processing – S. Salivahanan, A. Vallavaraj and C. Gnanapriya, TMH, 2009	
[R4]	Digital Signal Processing - A Practical approach, Emmanuel C. Ifeachor and Barrie W. Jervis,2 nd Edition, Pearson Education, 2009	
MOOC Courses/e- Learning:		
[OE1]	**NPTEL Course on Digital Signal Processing**, By **Prof. C. S. Ramalingam**, IIT Madras. https://onlinecourses.nptel.ac.in/noc23_ee33/preview	
[OE2]	**NPTEL Course on Digital Signal Processing and its Applications**, By **Prof. V. M. Gadre**, IIT Bombay. https://onlinecourses.nptel.ac.in/noc24_ee16/preview	
[OE3]	**NPTEL Course on Digital Signal Processing**, By **Prof. S. C. Dutta Roy**, IIT Delhi. https://nptel.ac.in/courses/117102060	

Savitribai Phule Pune University
Third Year of Mechatronics Engineering (2024 Pattern)

PCC-353-MXE Machine Design lab

Teaching Scheme			Credits		Examination Scheme	
Practical	02	Hrs/Week/Batch	Practical	01	Term Work	25
					Oral	25

Prerequisites Courses

The basics of material elastic behavior, stress, strain, its relationship, failure modes, different theories of failure and its applications. The design cycle, basis of design considerations like strength, rigidity, manufacture, assembly and cost, standards and codes. The preferred sizes and series, tolerances and types of fits. Construction of SMD and BMD. Roots of equations, Interpolation rule.

Course Objectives:

This course aims to:

1. Understand the various design considerations, design procedure and select materials for a specific application
2. Calculate the stresses in machine components due to various types of loads and failure
3. Analyze machine components subjected to variable loading for finite and infinite life
4. Design various machine components such as shafts, couplings, keys, screws, joints, springs

Course Outcomes:

On completion of the course, learner will be able to

CO1	Design and analyze the cotter and knuckle Joints, levers and components subjected to eccentric loading
CO2	Design shafts, keys and couplings under static loading conditions
CO3	Analyze different stresses in power screws and apply its knowledge to design screw jack.
CO4	Evaluate dimensions of machine components under fluctuate loading conditions.
CO5	Apply the design and development procedure for different types of springs.

Term Work

The student shall complete the following activity as a Term Work;
The term work shall consist of three design projects. The design project shall consist of assembly drawing, with a bill of material and overall dimensions and drawings of individual components. The Project should be assigned to a group of maximum four students. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components should be submitted in a separate file. Design data book shall be referred for selection of materials and standard components for given loading conditions. All three design projects should be carried out using suitable software.
Project 1: - Cotter joint/ knuckle joint/turn buckle for a specified application.
Project 2: - Bush Pin Flexible Coupling for specified application.
Project 3: - Bottle type/toggle jack for vehicles.

OR

Project 3: - A Design Project to develop and apply the knowledge of Machine Design and drafting software for any mechanical system on the basis of: (1) Idea generation, (2) Creativity, Reliability and safety, (3) Design parts of the system (4) Ergonomic Considerations (5) Use of International
Standards.

Text Books:	
[T1]	Bhandari V.B., Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.
[T2]	Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. Ltd.
Reference Books:	
[R1]	Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International.
[R2]	Juvinal R.C., Fundamentals of Machine Components Design, John Wiley and Sons.
[R3]	Black P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc.
[R4]	Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.
[R5]	Hall A.S., Holowenko A.R. and Laughlin H.G, Theory and Problems of Machine Design, Schaum's Outline Series.

Savitribai Phule Pune University
Third Year of Mechatronics Engineering (2024 Pattern)

PCC-354-MXE: Digital Signal Processing Lab

Teaching Scheme			Credits		Examination Scheme	
Practical	02	Hrs/Week/Batch	Practical	01	Term Work	25
					Practical	25

Prerequisites Courses

1. Basic knowledge of signals and systems concepts
2. Fundamentals of engineering mathematics (differential equations, complex numbers)
3. Basic understanding of MATLAB / GNU Octave programming
4. Knowledge of continuous-time and discrete-time signals

Course Objectives:

This course aims to:

1. To provide practical understanding of discrete-time signals and linear time invariant (LTI) systems using simulation tools.
2. To familiarize students with frequency domain analysis techniques such as DFT and FFT using MATLAB/GNU Octave.
3. To enable students to design and analyze IIR and FIR digital filters using appropriate design methods.
4. To study digital filter realization structures and finite word length effects in DSP systems.
5. To develop skills in implementing basic DSP algorithms on DSP processor platforms and building DSP-based applications

Course Outcomes:

On completion of the course, learner will be able to

CO1	Understand and generate basic discrete-time signals and analyze properties of LTI systems using MATLAB/GNU Octave.
CO2	Apply transform techniques such as DFT and FFT for frequency domain analysis of discrete-time signals.
CO3	Design and analyze IIR and FIR digital filters using appropriate design methods and simulation tools.
CO4	Analyze different digital filter realization structures and evaluate the effects of finite word length and round-off errors.
CO5	Implement basic digital signal processing algorithms on DSP processor and develop DSP-based applications.

List of Experiments

Software Experiments (MATLAB / GNU Octave) (Any 5)

1. Generation and analysis of basic discrete-time signals and sequences (unit impulse, unit step, ramp, sinusoidal).
2. Verification of properties of LTI systems (linearity, time invariance, stability and causality).
3. Conversion of differential equation to difference equation and computation of system response.
4. Implementation of multirate signal processing (down sampling, up sampling, decimation and interpolation).
5. Computation of Discrete Fourier Transform (DFT) and magnitude/phase spectrum analysis.
6. Implementation of Fast Fourier Transform (FFT) using Radix-2 algorithm.
7. Design of IIR digital filters using Butterworth and Chebyshev methods.
8. Design of FIR digital filters using window technique.

9. Realization of digital filters using direct, cascade and parallel structures.
10. Analysis of finite word length effects (round-off noise, overflow).

Hardware Experiments (DSP Processor / DSP Trainer Kit)(Compulsory)

11. Implementation of basic signal processing operations on DSP processor such as signal generation, addition and multiplication.
12. Implementation of digital filtering or FFT on DSP processor for real-time signal processing.

Mini Project:(Compulsory)

13. DSP based application such as noise removal, audio signal filtering, speech enhancement, or simple spectrum analyzer.

Term Work:

Term work shall consist of 8 experiments mentioned above and should be set to have well predefined inference and conclusion. The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Distribution of marks for Term work shall be as follows:

Laboratory work (experiments/assignments): 15 marks
Mini Project: 05 marks
Attendance (Theory and practical's): 05 marks

Practical Examination:

Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Text Books:	
[T1]	Discrete Time Signal Processing – A. V. Oppenheim and R.W. Schaffer, PHI, 2009
[T2]	Digital Signal Processing, Principles, Algorithms, and Applications: John G. Proakis, Dimitris G.Manolakis, Pearson Education / PHI, 2007.
Reference Books:	
[R1]	Digital Signal Processing – Fundamentals and Applications – Li Tan, Elsevier, 2008
[R2]	Fundamentals of Digital Signal Processing using MATLAB – Robert J. Schilling, Sandra L.Harris, Thomson, 2007
[R3]	Digital Signal Processing – S. Salivahanan, A. Vallavaraj and C. Gnanapriya, TMH, 2009
[R4]	Digital Signal Processing - A Practical approach, Emmanuel C. Ifeachor and Barrie W. Jervis,2 nd Edition, Pearson Education, 2009
MOOC Courses/e- Learning:	
[OE1]	**NPTEL Course on Digital Signal Processing**, By **Prof. C. S. Ramalingam**, IIT Madras. https://onlinecourses.nptel.ac.in/noc23_ee33/preview
[OE2]	**NPTEL Course on Digital Signal Processing and its Applications**, By **Prof. V. M. Gadre**, IIT Bombay. https://onlinecourses.nptel.ac.in/noc24_ee16/preview
[OE3]	**NPTEL Course on Digital Signal Processing**, By **Prof. S. C. Dutta Roy**, IIT Delhi. https://nptel.ac.in/courses/117102060

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-361A-MXA: Elective – II Automotive Engineering						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites Courses
Physics, Mathematics, Engineering Graphics, Solid Mechanics, Engineering Materials and Metallurgy

Course Objectives:
This course aims to: 1. To understand the basic construction and working of automotive systems. 2. To study the transmission, steering, suspension and braking systems used in vehicles. 3. To explain the construction and working of internal combustion engines used in automotives. 4. To understand modern automotive technologies including electric and hybrid vehicles. 5. To analyze vehicle performance parameters, safety and emission control techniques.

Course Outcomes:	
On completion of the course, learner will be able to	
CO1	Explain the construction, layout and classification of automotives.
CO2	Describe the working principles of automotive transmission systems.
CO3	Analyze steering, suspension and braking systems used in automotives..
CO4	Explain the construction and working of IC engines and their subsystems.
CO5	Understand vehicle components, vehicle performance and safety aspects.

Unit 01	**Introduction to Automotive and Vehicle Construction**	**08 hrs**
History and development of automotive, Classification of vehicles - Vehicles are classified according to purpose, fuel used, number of wheels, load capacity, and driving system, Vehicle layout (FR, FF, RR, 4WD etc.) Chassis and frame construction – Function, Components, Importance of chassis & Function, types & importance of frames, Types of vehicle bodies, Materials used in automotive construction, Vehicle specifications and dimensions		

Unit 02	**Automotive Transmission System**	**08 hrs**
Clutch: construction and types, Gearbox: sliding mesh, constant mesh, synchromesh, Automatic transmission (basic concept), Propeller shaft and universal joints, Differential and final drive, Rear axle construction		

Unit 03	**Steering, Suspension and Braking Systems**	**08 hrs**
Steering geometry and steering mechanism, Wheel alignment and wheel balancing, Types of suspension systems, Leaf spring, Coil spring, Independent suspension, Air suspension, Braking systems, Mechanical brake, Hydraulic brake, Air brake, Disc and drum brake, Anti-lock Braking System (ABS)		

Unit 04	**Internal Combustion (IC) Engines in automotive**	**08 hrs**

Classification of IC engines, Two-stroke and four-stroke engines, Petrol engine and diesel engine, Engine components (cylinder, piston, crankshaft, valves etc.), Fuel supply systems, Carburetor, Fuel injection system, Engine cooling and lubrication systems		
Unit 05	**Vehicle Performance and Safety**	**08 hrs**
Vehicle performance parameters- Measuring devices for BP, IP & Air Fuel mixture, Morse Test & Heat balance Sheet. (Numerical Treatment), Vehicle safety systems- Active & Passive, automotive pollution and emission control		
Text Books:		
[T1]	Automobile Engineering – **by** R. K. Rajput, Publisher: Laxmi Publications	
[T2]	Automobile Engineering Vol. 1 & Vol. 2 – **by** Kirpal Singh, Publisher: Standard Publishers Distributors	
[T3]	Basic Automobile Engineering – **by** C. P. Nakra, Publisher: Dhanpat Rai Publications	
[T4]	Automobile Engineering – **by** K. P. Ramalingam, Publisher: Scitech Publications	
Reference Books:		
[R1]	The Motor Vehicle – **by** T. K. Garrett**,** K. Newton**, and** W. Steeds, Publisher: Butterworth-Heinemann	
[R2]	Automotive Handbook – **by** Robert Bosch GmbH	
[R3]	Internal Combustion Engines – **by** V. Ganeshan, Publisher: Tata McGraw-Hill	
[R4]	Internal Combustion Engine Fundamentals – **by** John B. Heywood, Publisher: Massachusetts Institute of Technology Press	
[R5]	Kirpal Singh – Automobile Engineering Vol. 1 & 2	

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-361B-MXA: Elective – II Digital Image Processing						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites Courses
Signals and System

Course Objectives:
This course aims to: 1. To become familiar with digital image fundamentals to learn Transform of Digital Images and its applications. 2. To get familiar with simple image enhancement techniques in both spatial and frequency domain. 3. To become familiar with image compression and recognition methods 4. To learn concepts of image restoration techniques and image segmentation and representation techniques. 5. To study Edge detection in Digital Image Processing. 6. To become familiar with basics of Security in Digital Image Processing .

Course Outcomes:	
On completion of the course, learner will be able to	
CO1	Understand the fundamentals of Digital Imaging and the importance of Digital Image Transform.
CO2	Explain the importance of Digital Image enhancement in spatial and frequency domains along with filtering techniques.
CO3	Explain the requirements, types, and standards of Image Compression.
CO4	Demonstrate the basic concepts of Digital Image Restoration and Segmentation.
CO5	Apply edge detection techniques and understand concepts of security in Digital Image Processing.

Unit 01	**Digital Imaging Basics and Transform Methods**	**08 hrs**
Digital Imaging Fundamentals: Basic idea of Digital image, Image formation in human eye, Pixel, Mathematical operation of Digital Image, Sampling, Quantization, application of digital Image Processing Transform of Digital Images: Importance of Digital Image Transform, Fourier Transform of Digital Image (DFT), Inverse Fourier Transform (IDFT), Fast Fourier Transform, Inverse Fast Fourier Transform, Application of Digital Image Transform in different area		

Unit 02	**Digital Image Enhancement**	**08 hrs**
Importance of Digital Image enhancement, enhancement in spatial and frequency domain, Bit plane slicing, Histogram, Histogram Equalization , Mean and Median filtering in Digital Images, Frequency domain filtering in Digital Images – LPF, HPF and BPF		

Unit 03	**Digital Image Compression**	**08 hrs**

Importance of Digital Image Compression, Types of Image Compression, example of lossless and lossy compression, Image compression standards, Compression in spatial domain, compression using Huffman coding, DCT and Wavelet based Digital image compression		
Unit 04	**Image Restoration and Segmentation Techniques**	**08 hrs**
Digital Image Restoration : Application and Importance of Digital Image Restoration, Reason for Image degradation, Inverse filtering Segmentation of Digital Images: Importance and applications of Digital Image Segmentation, Detection of discontinuities, Edge linking and Boundary detection, Thresholding, Segmentation based on Region Growing, Watershed algorithm.		
Unit 05	**Image Feature Extraction and Security Concepts**	**08 hrs**
Edge detection in Digital Image Processing: Importance of Edge detection in Digital Image Processing, Types of Edge Detection, Mathematical Equation of each operator. Security in Digital Image Processing : Importance of Digital Image Security, Watermarking, Image encryption in spatial and frequency domain, Steganography		
Text Books:		
[T1]	Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education, 2010	
[T2]	S. Annadurai,R. Shanmugalakshmi, "Fundamentals of Digital Image Processing", Pearson Education, 2006	
Reference Books:		
[R1]	Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata Mc Graw Hill Pvt. Ltd., 2011. Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2011.	
[R2]	Willliam K Pratt, "Digital Image Processing", John Willey, 2002.	
[R3]	Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI Learning Pvt. Ltd., 2011.	
MOOC Courses/e- Learning:		
[OE1]	NPTEL Course on Digital Image Processing, By Prof. Prabir Kumar Biswas, Indian Institute of Technology Kharagpur. https://onlinecourses.nptel.ac.in/noc25_ee126/preview	
[OE2]	Fundamentals of Digital Image and Video Processing (Coursera)	
[OE3]	Image and Video Processing – Duke University (Coursera)	
[OE4]	Introduction to Image Processing (Coursera – MathWorks)	
[OE5]	Image Processing for Engineering and Science Specialization (Coursera)	

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-362A-MXA: Elective – III Smart Manufacturing						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites Courses

Engineering Graphics, Solid Mechanics, Engineering Materials and Metallurgy, physics & mathematics

Course Objectives:

This course aims to:

1. Understand the fundamentals of various manufacturing processes including casting, joining, and forming.
2. Gain knowledge of conventional machining processes such as turning, milling, drilling, and grinding.
3. Learn the principles and working of advanced manufacturing processes like CNC, EDM, LBM, and additive manufacturing.
4. Develop an understanding of industrial automation, including sensors, actuators, PLC, SCADA, and robotics.
5. Explore modern manufacturing trends such as smart manufacturing and the concept of Industry 4.0.

Course Outcomes:

On completion of the course, learner will be able to

CO1	Explain various types of manufacturing processes and describe casting, metal joining, and metal forming processes with their applications
CO2	Describe the working principles, construction, and operations of conventional machining processes such as lathe, milling, drilling, and grinding.
CO3	Understand and compare advanced manufacturing processes including CNC machining, EDM, LBM, water jet machining, ultrasonic machining, and additive manufacturing
CO4	Apply knowledge of industrial automation systems including sensors, actuators, PLC, SCADA, and robotics in manufacturing environments.
CO5	Analyze the concept of smart manufacturing and explain key technologies involved in Industry 4.0.

Unit 01	**Introduction to Manufacturing Processes**	**08 hrs**

Introduction, Types of manufacturing Processes
Casting process - Classification, Sand Casting Process, Advantages, Disadvantages & Applications of casting Process
Metal Joining processes - Classification, Arc Welding Processes, Gas Welding-oxyacetylene
Metal Forming process- Forging: Open and closed die forging, Hot and Cold Forging,

Unit 02	**Machining Process**	**08 hrs**

Introduction to Metal Cutting Processes,
Lathe machine- Working Principle & Construction, Lathe Operations
Milling machine- Working Principle & Construction, Milling Operations
Drilling- Working Principle & Construction, Classification.
Grinding-Classification of Grinding Machines, Grinding Wheel Designation.

Unit 03	**Advanced Manufacturing Processes**	**08 hrs**

CNC Machining – Construction & working, Advantages, Disadvantages & Applications, , Laser Beam Machining (LBM), Electrical Discharge Machining (EDM), Water Jet Machining, Ultrasonic Machining, , Additive manufacturing and 3D printing, Advantages of Advanced Manufacturing Processes

Unit 04	**Industrial Automation and Control**	**08 hrs**

Basics of industrial automation, Sensors and actuators in manufacturing systems, PLC based automation, SCADA systems in manufacturing, CNC machines and automation, Industrial robotics in manufacturing, Flexible Manufacturing Systems (FMS)

Unit 05	**Introduction to Smart Manufacturing & Technologies**	**08 hrs**

Evolution of manufacturing systems, Traditional manufacturing vs smart manufacturing, Concept of Industry 4.0, Industry 4.0 Technologies, Smart production systems, Autonomous robots and collaborative robots, Future trends in smart manufacturing

Text Books:	
[T1]	Manufacturing Engineering and Technology – Serope Kalpakjian & Steven Schmid
[T2]	Manufacturing Technology (Vol. I & II) – P. N. Rao
[T3]	Production Technology – R. K. Jain
[T4]	Automation, Production Systems, and Computer-Integrated Manufacturing – Mikell P. Groover
Reference Books:	
[R1]	Manufacturing Processes for Engineering Materials – Serope Kalpakjian
[R2]	Principles of Modern Manufacturing – Mikell P. Groover
[R3]	Welding Engineering and Technology – R. S. Parmar
[R4]	CNC Machines – M. Adithan & B. S. Pabla
[R5]	Advanced Machining Processes – V. K. Jain
[R6]	Industrial Robotics: Technology, Programming, and Applications – Mikell P. Groover et al.

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-362B-MXA: Elective – III Internet of Things						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	CCE	30
					ESE	70

Prerequisites Courses
Basic knowledge of electronics, programming, microcontrollers, sensors, and computer networking.

Course Objectives:
This course aims to: 1. To understand the fundamentals and architecture of IoT systems. 2. To study sensors, actuators, and embedded platforms used in IoT. 3. To analyze communication technologies and wireless sensor networks. 4. To explore IoT system development with cloud integration. 5. To understand big data analytics for IoT applications

Course Outcomes:	
On completion of the course, learner will be able to	
CO1	Explain IoT fundamentals, architecture, and applications.
CO2	Apply knowledge of sensors, actuators, and IoT development boards.
CO3	Analyze communication protocols and wireless sensor networks.
CO4	Apply IoT frameworks with cloud computing and data management.
CO5	Analyze big data technologies and analytics in IoT applications.

Unit 01	**Fundamentals of IoT and Applications**	**08 hrs**
Introduction to Internet of Things (IoT), Functional Characteristics, IoT Architecture, Recent Trends in IoT Adoption, Role of Cloud in IoT, Main Design Principles and Required Capabilities, Standards Considerations, M2M vs IoT Technology, Societal Applications: Healthcare, Smart Cities, Smart Grid, Smart Transportation, Smart Living.		
Unit 02	**Sensors, Actuators and Embedded IoT Platforms**	**08 hrs**
Role of Sensors and Actuators in IoT, Sensors: Definition, Characteristics, Types and Working (Soil Moisture Sensor, DHT11, Ultrasonic Sensor, PIR Sensor, Sound Sensor, Colour Sensor, LDR, Accelerometer, Gyroscope, Magnetometer), Actuators: LED, Relay, DC Motor, LCD, Introduction to IoT Boards: Arduino, Raspberry Pi, Node MCU, Beagle Bone, Jetson Nano, GPIO Structure, Specifications, OS Requirements, Datasheet Reading, Interfacing Sensors and Actuators.		
Unit 03	**Communication Technologies and Wireless Sensor Networks**	**08 hrs**

Basics of Communication, Wired vs Wireless Communication, Introduction to Wireless Sensor Networks (WSN), WSN Node Architecture, Types of WSN, Standards: IEEE 802.15.4, Zigbee, BLE, LoRa, Protocol Stack of WSN, Communication with Mobile Devices using Bluetooth and Wi-Fi.		
Unit 04	**IoT System Development and Cloud Integration**	**08 hrs**
Framework for IoT Application Development, Device Integration, Data Acquisition, Data Storage on Cloud/Local Server, Authentication and Authorization of Devices, Introduction to Cloud Computing (Concept, Architecture, Working), Cloud Service Models (IaaS, PaaS, SaaS), Cloud Platforms: AWS, Microsoft Azure, Google Cloud, Distributed Computing vs Cloud Computing.		
Unit 05	**Big Data Analytics for IoT Applications**	**08 hrs**
Introduction to Big Data, Types and Characteristics of Data, Data Handling Technologies, Data Acquisition and Storage, Hadoop Ecosystem, Introduction to Data Analytics, Types of Analytics (Local and Cloud Analytics), Applications of Big Data in IoT.		
Text Books:		
[T1]	Arshdeep Bahga & Vijay Madisetti, Internet of Things: A Hands-on Approach.	
[T2]	Raj Kamal, Internet of Things: Architecture and Design Principles.	
Reference Books:		
[R1]	Cuno Pfister, *Getting Started with the Internet of Things*.	
[R2]	Michael Miller, *The Internet of Things: How Smart TVs, Smart Cars….*	
[R3]	Tom White, *Hadoop: The Definitive Guide*.	
MOOC Courses/e- Learning:		
[OE1]	**NPTEL Course on Internet of Things, By Prof. Sudip Misra, Indian Institute of Technology Kharagpur.** https://onlinecourses.nptel.ac.in/noc22_cs98/preview	
[OE2]	**NPTEL Course on Introduction to Internet of Things, By Prof. Dhananjay Singh, Indian Institute of Technology Roorkee.** https://onlinecourses.nptel.ac.in/noc21_cs60/preview	
[OE3]	**Introduction to Internet of Things, By University of California, Irvine (Coursera).** https://www.coursera.org/learn/internet-of-things	
[OE4]	**IoT (Internet of Things) Specialization, By University of California, Irvine (Coursera).** https://www.coursera.org/specializations/iot	
[OE5]	**An Introduction to Programming the Internet of Things (IOT), By University of California, Irvine (Coursera).** https://www.coursera.org/learn/iot-programming	
[OE6]	**Internet of Things Foundations, By LinkedIn Learning.** https://www.linkedin.com/learning/internet-of-things-foundations	
[OE7]	**Introduction to IoT, By Cisco Networking Academy.** https://www.netacad.com/courses/iot/introduction-iot	

Savitribai Phule Pune University
Third Year of Mechatronics Engineering (2024 Pattern)

PEC-363A-MXA: Elective – III Automotive Engineering Lab

Teaching Scheme			Credits		Examination Scheme	
Practical	02	Hrs/Week/Batch	Practical	01	Term Work	25
					Oral	25

Prerequisites Courses

Physics, Mathematics, Engineering Graphics, Solid Mechanics, Engineering Materials and Metallurgy

Course Objectives:

This course aims to:

1. To understand the basic construction and working of automotive systems.
2. To study the transmission, steering, suspension and braking systems used in vehicles.
3. To explain the construction and working of internal combustion engines used in automotive.
4. To understand modern automotive technologies including electric and hybrid vehicles.
5. To analyze vehicle performance parameters, safety and emission control techniques.

Course Outcomes:

On completion of the course, learner will be able to

CO1	Explain the construction, layout and classification of automotive.
CO2	Describe the working principles of automotive transmission systems.
CO3	Analyze steering, suspension and braking systems used in automotive.
CO4	Explain the construction and working of IC engines and their subsystems.
CO5	Understand vehicle components, vehicle performance and safety aspects.

List of Experiments

To conduct any eight experiment from the list given below as study, demonstration & performance type

1. To study different automotive layouts such as FR, FF, RR and 4WD.
2. To study chassis construction and frame types.
3. To study construction and working of clutch and gearbox.
4. To study differential mechanism and rear axle.
5. To study steering mechanism.
6. To study types of suspension systems.
7. To study automotive braking systems.
8. To study IC engine components .
9. Morse Test To calculate BP, IP & Mech Efficiency
10. To determine HBS of petrol engine.

Text Books:	
[T1]	Automobile Engineering – **by** R. K. Rajput, Publisher: Laxmi Publications
[T2]	Automobile Engineering Vol. 1 & Vol. 2 – **by** Kirpal Singh, Publisher: Standard Publishers Distributors
[T3]	Basic Automobile Engineering – **by** C. P. Nakra, Publisher: Dhanpat Rai Publications
[T4]	Automobile Engineering – **by** K. P. Ramalingam, Publisher: Scitech Publications
Reference Books:	
[R1]	The Motor Vehicle – **by** T. K. Garrett**,** K. Newton**, and** W. Steeds, Publisher: Butterworth-Heinemann
[R2]	Automotive Handbook – **by** Robert Bosch GmbH
[R3]	Internal Combustion Engines – **by** V. Ganeshan, Publisher: Tata McGraw-Hill
[R4]	Internal Combustion Engine Fundamentals – **by** John B. Heywood, Publisher: Massachusetts Institute of Technology Press
[R5]	Kirpal Singh – Automobile Engineering Vol. 1 & 2

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
PEC-363B-MXA: Elective – III Digital Image Processing Lab						
Teaching Scheme			**Credits**		**Examination Scheme**	
Practical	02	Hrs/Week/Batch	Practical	01	Term Work	25
					Oral	25

Prerequisites Courses

1. Basic knowledge of Signals and Systems
2. Fundamentals of Engineering Mathematics (Fourier Transform, matrices, probability)
3. Basic understanding of Digital Electronics and Programming (MATLAB/Python)
4. Introduction to Communication Systems

Course Objectives:

This course aims to:

1. To understand the fundamentals of digital imaging and mathematical representation of images.
2. To study image transforms and their applications in image analysis.
3. To analyze image enhancement techniques in spatial and frequency domains.
4. To explore image compression techniques and standards.
5. To apply image restoration and segmentation techniques for real-world problems.
6. To understand edge detection methods and security techniques in digital image processing.

Course Outcomes:

On completion of the course, learner will be able to

CO1	Explain digital imaging fundamentals including image formation, sampling, quantization, and applications of digital image processing.
CO2	Analyze digital image transforms such as DFT, IDFT, FFT, and their applications in various domains.
CO3	Apply image enhancement techniques in spatial and frequency domains including histogram processing and filtering methods.
CO4	Compare image compression techniques, standards, and methods such as Huffman coding, DCT, and Wavelet transform.
CO5	Apply image restoration and segmentation techniques including thresholding, region-based methods, and watershed algorithm.
CO6	Evaluate edge detection techniques and analyze security methods such as watermarking, encryption, and steganography in digital images.

List for Practical:

Software based:(Any 7)

1. Implementation of 2D Discrete Fourier Transform (DFT) and IDFT *Using:* MATLAB (fft2, ifft2 functions)
2. Implementation of Fast Fourier Transform (FFT) and frequency spectrum visualization *Using:* Python (NumPy FFT module + Matplotlib)
3. Image enhancement using histogram analysis and equalization *Using:* ImageJ / Fiji software

4. Apply frequency domain filtering (LPF, HPF, BPF) *Using:* MATLAB (frequency mask implementation)
6. Implementation of DCT-based image compression (JPEG concept) *Using:* MATLAB (dct2 function)
7. Implementation of image restoration using inverse filtering *Using:* MATLAB (deconvolution techniques)
8. Implementation of region growing segmentation algorithm *Using:* Python (custom algorithm)
9. Implementation of digital image watermarking *Using:* MATLAB (DWT/DCT-based watermarking)
10. Study and Demonstration of Time-Domain and Frequency-Domain Waveforms Using FFT Analyzer
11. Analysis of Different Signal Waveforms Using FFT Analyzer in Digital Signal Processing
12. Experimental Study of Waveform Characteristics Using FFT Analyzer
13. FFT-Based Analysis and Demonstration of Sinusoidal, Square, and Triangular Waveforms

Hardware based:(all 3)

1. Implementation of FFT on DSP processor using Code Composer Studio.
2. Real-time image filtering using DSP processor.
3. Implementation of edge detection using DSP processor.

Mini Project (Compulsory)

Image Processing based application such as image denoising, image enhancement, image segmentation for object detection, face detection system, or digital image security (watermarking/steganography).

Alternative :

Real-time image processing application using software/DSP such as noise removal, edge detection, object segmentation, or image encryption for secure communication.

Term Work:
Term work shall consist of 8 experiments mentioned above and should be set to have well predefined inference and conclusion. The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Distribution of marks for Term work shall be as follows:
Laboratory work (experiments/assignments): 20 marks
Attendance (Theory and practical's): 05 marks

Practical Examination:
Pair of Internal and External Examiners should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Text Books:	
[T1]	Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education, 2010
[T2]	S. Annadurai,R. Shanmugalakshmi, "Fundamentals of Digital Image Processing", Pearson Education, 2006

Reference Books:	
[R1]	Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata Mc Graw Hill Pvt. Ltd., 2011. Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2011.
[R2]	Willliam K Pratt, "Digital Image Processing", John Willey, 2002.
[R3]	Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI Learning Pvt. Ltd., 2011.
MOOC Courses/e- Learning:	
[OE1]	NPTEL Course on Digital Image Processing, By Prof. Prabir Kumar Biswas, Indian Institute of Technology Kharagpur. https://onlinecourses.nptel.ac.in/noc25_ee126/preview
[OE2]	Fundamentals of Digital Image and Video Processing (Coursera)
[OE3]	Image and Video Processing – Duke University (Coursera)
[OE4]	Introduction to Image Processing (Coursera – MathWorks)
[OE5]	Image Processing for Engineering and Science Specialization (Coursera)

Savitribai Phule Pune University
Third Year of Mechatronics Engineering (2024 Pattern)

MDM-371-MXE: Artificial Intelligence & Machine Learning

Teaching Scheme			Credits		Examination Scheme	
Tutorial	01	Hrs/Week/Batch	Tutorial	01	Term Work	25
Practical	02	Hrs/Week/Batch	Practical	01	Oral	25

Prerequisites

Knowledge of basic Mathematics (Linear Algebra, Probability & Statistics), Programming fundamentals, Data Structures, and Logic Building is essential for understanding AIML concepts

Course Objectives:

This course aims to:

1. To introduce fundamentals of Artificial Intelligence and Machine Learning.
2. To develop skills in data preprocessing, model building, and evaluation.
3. To understand modern AI techniques such as Deep Learning, NLP, and LLMs.
4. To explore AI deployment, ethics, and real-world constraints.
5. To apply AI/ML in mechatronics systems like robotics, automation, and smart manufacturing.

Course Outcomes:

On completion of the course, learner will be able to

CO1	Understand AI/ML concepts, terminology, and workflow.
CO2	Evaluate Apply ML algorithms for prediction and classification tasks.
CO3	Implement deep learning and modern AI techniques.
CO4	Evaluate AI models considering performance and ethical issues.
CO5	Design AI-enabled mechatronics systems for real-world applications

Unit 01	**Introduction to AI & Intelligent Systems**	

AI overview, history, and applications, Types of AI (Narrow, General, Generative AI), Machine Learning types:-Supervised, Unsupervised, Reinforcement Learning,Intelligent agents and systems, AI vs. ML vs. Robotics, Introduction to Generative AI & LLMs (ChatGPT, Gemini)

Unit 02	**Data Handling & Machine Learning**	

Python for AI (NumPy, Pandas), Data preprocessing & feature engineering, Supervised learning: Regression, Classification, Unsupervised learning: Clustering (K-means), Model evaluation metrics

Unit 03	**Deep Learning & Computer Vision**

Neural networks and back propagation, CNN for image processing, RNN & LSTM for time-series, Computer Vision: Image processing, object detection

Unit 04	Advanced AI Techniques	
Natural Language Processing (NLP),Large Language Models (LLMs),Generative AI (text, image), Reinforcement Learning basics, Explainable AI (XAI), AI ethics		
Unit 05	**AI Applications in Mechatronics**	
AI in Robotics (path planning, SLAM basics),Predictive maintenance in industries,Vision-based quality inspection,Autonomous systems (AGV, drones),Embedded AI (TinyML, Edge AI),Smart agriculture & Industry 4.0		

Text Books:	
[T1]	Artificial Intelligence: A Modern Approach – Stuart Russell & Peter Norvig
[T2]	Machine Learning with Python – Andreas Müller & Sarah Guido
[T3]	Deep Learning – Ian Goodfellow
Reference Books:	
[R1]	Neural Networks and Learning Machines – Simon Haykin
[R2]	Pattern Recognition and Machine Learning – Christopher Bishop
[R3]	Hands-On Machine Learning with Scikit-Learn & TensorFlow – Aurélien Géron
[R4]	Introduction to Autonomous Mobile Robots – Siegwart

List of Experiments:

Out of following experiment Any 8 Experiment need to conducted in Lab as part of Practical Examination. For Tutorial teachers must discuss AI models before implementation, also teacher can give small projects based on following experiments.

1. Introduction to Python Programming for AI Applications Data analysis using Pandas
2. NumPy and Pandas for Data Analysis
3. Data Visualization for Industrial Parameters
4. Linear Regression implementation
5. Linear Regression for Prediction (e.g. Machine Temperature)
6. Classification of Defective and Non-Defective Products using KNN
7. Decision Tree for Fault Diagnosis in Mechatronic Systems
8. Principal Component Analysis (PCA) for Sensor Data Reduction
9. CNN-Based Image Classification for Industrial Object Detection
10. Reinforcement Learning Concept using Maze Solver Robot Simulation
11. Edge AI model deployment (TensorFlow Lite)
12. Computer vision using OpenCV (defect detection)
13. Voice Command Controlled Mechatronic System
14. Implementation of Basic Logic Gates using Perceptron

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
MDM-372-MXE: Solar Technology and Maintenance						
Teaching Scheme			**Credits**		**Examination Scheme**	
Practical	02	Hrs/Week/Batch	Practical	01	Term Work	50

Prerequisites

Basic knowledge of Physics, Electrical Engineering, Basic Electronics, Semiconductor Devices, Energy Conversion, Electrical Measurements, and Renewable Energy concepts.

Course Objectives:

Students shall undertake and execute a Mini Project through a group of students to

1. To apply safe installation, wiring, testing, and commissioning practices for solar PV systems
2. To analyze the impact of environmental and operational conditions on solar PV system performance.
3. To evaluate maintenance and troubleshooting procedures for solar photovoltaic systems and associated equipment.
4. To develop practical solutions and technical documentation for improving solar energy system efficiency and reliability.

Course Outcomes:

On completion of the course, learner will be able to

CO1	Apply safe installation, wiring, commissioning, and performance measurement techniques for solar PV systems.
CO2	Analyze the effect of irradiance, temperature, shading, and environmental conditions on solar PV performance.
CO3	Evaluate maintenance procedures, inverter health, battery performance, and troubleshooting methods in solar systems.
CO4	Create simple practical solutions or documentation for improving solar system performance via mini projects.

List of Experiments

Note:- Perform 8 experiments, Experiment No 1, 2 and 10 are compulsory. Perform any 2 Experiments from 3 to 5. Perform any 3 Experiments from 6 to 9.

1. Measurement of solar irradiance using pyrometer/lux meter at different times and tilt angles. Real-World Assignment: Survey solar irradiance on the college rooftop and estimate daily energy generation for a 100 W solar panel.
2. Plot I-V and P-V characteristics of solar PV module under varying light & temperature. Real-World Assignment: Simulate cloudy/rainy day conditions. Calculate module efficiency and estimate annual energy loss in local area climate.
3. Survey and Comparative Analysis of Solar PV Installation Systems: Grid-Tied, Hybrid, and Off-Grid Configurations. Real-World Assignment: Survey 2–3 real solar installations (e.g., college rooftop, nearby home/business, or online/virtual)
4. Series and parallel connection of PV modules, observe mismatch issues. Real-World Assignment: Design a small array for 12V/24V system (e.g., for small electrical loads). Calculate total power and suggest suitable protection.

5. Installation and wiring of standalone solar PV system (PV ⇨ Charge controller ⇨ Battery ⇨ Load/Inverter) Real-World Assignment: Prepare a complete wiring diagram and BOM for a 100W standalone system.
6. Preventive maintenance: Cleaning, visual inspection, corrosion/loose connection check. Real-World Assignment: Inspect any existing rooftop solar panel instalation. Prepare a 6-month maintenance schedule with cost estimation (dust cleaning, tightening)
7. Grid-Related Maintenance Checks for Grid-Tied Solar PV Systems: Inverter Health, Performance Monitoring, and Fault Diagnosis. Real-World Assignment: Survey a real grid-tied installation, Prepare a maintenance schedule: Monthly inverter check, quarterly visual, annual professional inspection.
8. Mounting structure assembly: Rooftop/ground mount, tilt adjustment, stability check Real-World Assignment: Design a simple mounting frame for local area wind load conditions. Calculate wind load and suggest material/cost for a 5kW residential installation.
9. IoT-Based Real-Time Solar PV System Monitoring and Performance Dashboard. Real-World Assignment: Develop a simple dashboard for real-time monitoring of solar energy generation.
10. Industrial Visit to Solar power plant/ solar installation in local area: Real-World Assignment: Prepare a technical report on solar PV system operation, maintenance practices, and safety measures.

Text Books	
[T1]	S.P. Sukhatme, Solar Energy
[T2]	C.S. Solanki, Solar Photovoltaics
[T3]	D.P. Kothari et al., Renewable Energy Sources
[T4]	G.D. Rai, Non-Conventional Energy Sources
[T5]	H.P. Garg, Solar Energy Utilization
Reference Books	
[R1]	Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers Author: Chetan Singh Solanki.
[R2]	Solar PV System: Design, Installation, Operation and Maintenance, Authors: L. Ashok Kumar and K. Mohana Sundaram.
[R3]	Solar Engineering of Thermal Processes, Photovoltaics and Wind (5th Edition) Authors: John A. Duffie, William A. Beckman (updated with Nathan Blair).
[R4]	Principles of Solar Engineering (3rd Edition) Authors: D. Yogi Goswami, Frank Kreith, Jan F. Kreider
SWAYAM/NPTEL Courses	
[O1]	Solar Photovoltaics: Fundamentals, Technology and Applications: https://onlinecourses.nptel.ac.in/noc
[O2]	SkillCat or Other Free Solar Training (Installation Focus). https://www.skillcatapp.com/solarinstallation-training
[O3]	SWAYAM – Solar Energy and Solar PV Systems
[O4]	NPTEL – Power Electronics Applications in Renewable Energy Systems

Savitribai Phule Pune University Third Year of Mechatronics Engineering (2024 Pattern)						
ELC-381-MXE: Internship						
Teaching Scheme			**Credits**		**Examination Scheme**	
Practical	08	Hrs/Week/Batch	Practical	04	Oral	50

Prerequisites Courses

Internship is a short-term industrial working experience for the students. The internship aims at providing entry-level exposure to a particular industry. It is expected that students should spend time working on relevant projects or part of the project and acquire learning about the field, along with developing industry connections, and employability skills.

Course Objectives:

This course aims to:

1. Encourage and provide opportunities to the students to acquire professional learning experiences.
2. Empower students to relate and then apply the theoretical knowledge in real-life industrial situations.
3. Provide exposure for handing and using various tools, measuring instruments, meters, and technologies used in industries.
4. Enable students to develop professional and employability skills and expand their professional network.
5. Empower students to apply the internship learnings to the academic courses and project completions.
6. Impart professional and societal ethics in students through the internship.
7. Make students aware of social, economic, and administrative aspects influencing the working environment of the industry..

Course Outcomes:

On completion of the course, learner will be able to

CO1	Understand the working culture and environment of the Industry and get familiar with various departments and practices in the industry.
CO2	Operate various meters, measuring instruments, tools used in industry efficiently and develop technical competence.
CO3	Apply internship learning in other course completions and final year project management, i.e. topic finalization, project planning, hardware development, result interpretations, report writing, etc.
CO4	Create a professional network and learn about ethical, safety measures, and legal practices.
CO5	Appreciate the responsibility of a professional towards society and the environment.
CO6	Identify career goals and personal aspirations.

Guidelines: The guidelines related to the internship are given below.

Duration: Guidelines related to duration are as follows.

1. Students must have to opt for technical internship (minimum 100hrs) after V semester and before VI semester commencement preferably during winter break (December & January)
2. It should be assessed and evaluated in semester 6.

2. Internship Identification:

A student may choose to undergo an Internship at Industries, Government organizations, NGOs, Micro- Small-Medium enterprises, startups, Innovation and Incubation Centers, Institutes of National interests, organizations working for rural development, organizations promoting IPR and Entrepreneurship, etc. Approaching various industries for Internships and finalizing the same should be initiated in the 5th semester in consultation with Institute's Training and Placement Cell, Industry Institute Cell, or Internship Cell. This will help students to start their internship work on time. Also, it will allow students to work in a vacation

period after their 5th-semester examination and before the start of the 6th semester. Student can take internship work in the form of Online/Onsite work from any of the following but not limited to:

1. Working for consultancy or the funded research project of the institute/Department.
2. Contributing at Incubation, Innovation, Entrepreneurship Cell, Institutional Innovation Council, Start-up Cell of Institute where students will get learning opportunities on projects.
3. Learning at Departmental Lab leading to lab development and modernization, Tinkering Lab, Institutional workshop for prototyping and model development, etc.
4. Working at Industry or Government Organization on project or part of the project.
5. Internship through Internshala, AICTE, Government initiatives, etc.
6. In-house product or working model development, intercollegiate, inter-department research under research lab or research group, etc.
7. Working at micro-small-medium enterprises on solving their specific problems.
8. Research internship under professors at IISc, IIT's, NIT's, Research organizations, etc.
9. Working with NGOs or Social Internships, Rural Internship, etc

Further, other internship opportunities should be discussed and finalized in consultation with Department/Institute constituted committees for Internship.

3. Internship Record Book:

Students must maintain an Internship record book. The main purpose of maintaining a record book is to nurture the habit of documenting and keeping records by students. The students should maintain the record of daily activities completed which may include, field visits, important discussions, observations, project work completed, suggestions received, etc. The record book should be signed every day by the supervisor or in-charge where the student is undergoing an internship. The internship record book and well-drafted Internship Report should be submitted by the students to the department faculty coordinator within a week after the completion of the internship.

4. Internship Evaluation:

The evaluation of activities recorded in the Internship Record Book will be done by Program Head, Cell In-charge, Project Head, faculty mentor, or Industry Supervisor based on the overall compilation of internship activities, sub-activities, the level of achievement expected, and the duration for certain activities. Assessment and Evaluation are to be done in consultation with the internship supervisors (Internal from the institute and External from industry).

5. Evaluation and Assessment of Internship:

Internship Record Book – 25 Marks + Internship Report - 25 Marks + Post Internship Internal Evaluation-50 Marks = Total 100 Marks converted to again 50 Marks

5.1 Internship Record Book: The attendance record of the student along with the evaluation sheet, duly signed and stamped by the industry should be submitted by the industry Supervisor or Mentor tothe Institute/Department after the completion of the internship. The internship record book may be evaluated based on the following criteria:

- ✓ Proper and timely documented entries
- ✓ Adequacy and quality of information
- ✓ Data, observations, discussions recorded
- ✓ Thought process and recording techniques used
- ✓ Organization of the information

5.2 Internship Report: After completion of the Internship, the student should prepare a comprehensive report to indicate what he/she has observed and learned in the internship period. The report shall be presented covering the following recommended fields but not limited to:

- ➢ Title/Cover Page
- ➢ Internship certificate with details like company name, location, duration, supervisor, etc.
- ➢ Institute Certificate

- Declaration
- Abstract
- Index/Table of Contents
- List of Figures/Tables
- Chapter 1: Introduction: Brief about company, industry or organization, objectives, motivation, organization of the report
- Chapter 2: Problem Identification/Problem statement/objectives and scope/expected outcomes
- Chapter 3: Methodological details
- Chapter 4: Results / Analysis /inferences and conclusion
- Chapter 5: Suggestions/Recommendations for improvement to industry, if any
- Attendance Record
- Acknowledgement
- List of reference (Library books, magazines, and other sources)

5.3 Post Internship Internal Evaluation: The student will give a presentation based on his Internship report before an expert committee constituted by the concerned department as per norms of the institute. The evaluation will be based on the following criteria:

1. Internship Identification and Selection
2. Problem Studied with objectives and expected outcomes
3. Consideration of Environment/ Social /Ethics/ Safety measures/Legal aspects.
4. Methodology/System/Procedure Q&A
5. Block-diagram, flow-chart, algorithm, system description Q&A
6. Final results, discussions, suggestions, comments, etc. Q&A
7. Presentation and Communication

6. Feedback from internship supervisor (External and Internal)

Post internship, the faculty Internship coordinator should collect feedback about the student on the following suggested parameters from Industry Supervisor.

- Technical knowledge,
- Discipline and Punctuality,
- Work Commitment,
- Willingness to do the work,
- Communication skills, etc.

Savitribai Phule Pune University, Pune

Maharashtra, India

Task Force for Curriculum Design and Development

Programme Coordinator

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Chairman

Dr. Vaibhav Dixit - Board of Studies Mechatronics Engineering

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Dean

Dr. Raosaheb Latpate - Dean – Science and Technology

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