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)

in

Automobile Engineering

(With effect from Academic Year 2026-27)

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Nomenclature:-

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

Preface by Board of Studies: -

Dear Students and Teachers,

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

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

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

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

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

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

Dr. Pradeep A. Patil
Chairman
Board of Studies – Automobile & Mechanical Engineering

Program Specific Outcomes:-

PSO1 : SPECIFY, DESIGN and **EVALUATE** Automobile components and systems using modelling and analysis software.

PSO2 : APPLY knowledge of machines, tools, automation, properties of advanced materials and modern management methods for manufacturing of Automobile components and systems.

PSO3 : **APPLY** core aspects of thermal and fluid engineering to determine the performance of Automobile systems including power absorbing and power generating systems.

Program Educational Objectives: -

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

PEO1 : The graduate will have a successful career in Automobile engineering with strong technical, research & professional skills.

PEO2 : The graduate will possess an ability to work in diversified fields along with team work and leadership qualities.

PEO3 : The graduate will continue to learn and to adapt in a society of constantly evolving technological environment

Program Outcomes:-

Program Outcomes (POs) are statements that articulate what students are expected to know, understand, and be able to do by the time they graduate from the program. These outcomes are aligned with the overall educational objectives of the program and reflect the skills, knowledge, attitudes, and behaviors acquired by students throughout their academic journey. On successful completion of B.E. in Automobile Engineering, graduating students/graduates will be able to:

PO No.	Title	Program Outcome Description
PO1	Engineering Knowledge	Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop the solution of complex engineering problems.
PO2	Problem Analysis	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
PO3	Design / Development of Solutions	Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for public health and safety, whole-life cost, net zero carbon, culture, society and environment. (WK5)
PO4	Conduct Investigations of Complex Problems	Conduct investigations of complex engineering problems using research- based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)
PO5	Engineering Tool Usage	Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling, recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
PO6	The Engineer and The World	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7)
PO7	Environment & Sustainability	Understand environmental impact and apply sustainable engineering practices.
PO8	Ethics	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO9	Individual and Collaborative Team Work	Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO10	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.
PO11	Project Management and Finance	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one’s own work, as a member and leader in a team, and to manage projects in multidisciplinary environments.
PO12	Life-Long Learning	Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Knowledge and Attitude Profile (WK):-

WK No.	Focus Area	Description
WK1	Natural Sciences and Social Sciences	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
WK2	Mathematics and Data Analysis	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	Engineering Fundamentals	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering Specialist Knowledge	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	Engineering Design and Environmental Considerations	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	Engineering Practice (Technology)	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Role of Engineering in Society	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	Research and Critical Thinking	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 and Inclusive Behavior	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 respect.

#Reference: Self-Assessment Report (SAR) Format Undergraduate Engineering Programs Graduate Attributes and Professional Competencies Version 4.0 (GAPC V4.0) - (August 2024) Page 55-56

General Rules and Guidelines:-

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

Assessment and Evaluation:

Assessment and Evaluation shall be conducted in two parts: 1. Comprehensive Continuous Evaluation (CCE) 2. End-Semester Examination (ESE)		
Component	**Description**	**Marks**
Comprehensive Continuous Evaluation (CCE)	Conducted at institute level, covering all Units of the syllabus. The design and mark allocation follow the Continuous Assessment Sheet structure.	30
End-Semester Examination (ESE)	Conducted at university level, typically covering the entire syllabus through summative examination.	70
	Total Marks per Subject	**100**

A) **<u>Comprehensive Continuous Evaluation (CCE) : It can be conducted via Mode 1 or Mode 2</u>**

<u>Mode 1:</u>

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

Savitribai Phule Pune University																					
Board of Studies (Mechanical and Automobile Engineering)																					
Comprehensive Continous Evaluation (CCE)																					
Class: TE A													Subject: Heat & Mass Transfer								
Exam Seat No.	Roll No.	Name of Student	Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Cumulative Sum				30 Marks Distribution				Marks obtained out
			Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Internal Test	Attendance	Field Activity	Quiz	Internal Test	Attendance	
			A	B	C	D	E	F	G	H	I	J	SUM(A+C+E+G+I)	SUM(B+D+F+H+J)							
			10	10	10	10	10	10	10	10	10	10	50	50	100	100	15	5	5	5	30
T242520252	2026	R A PANCAL	9	8	9	8	9	8	9	9	9	8	45	41	60	75	14	4.1	3	3.8	24.35
T242520253	2027																				
T242520254	2028																				
T242520255	2029																				

Figure 1 Template Comprehensive Continuous Evaluation (CCE)

Field Activities / Home Assignments

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

1. ***Course Projects***

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

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

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

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

2. ***Industrial Visit***

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

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

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

3. ***Guest Lectures***

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

Assessment methods for guest lectures may include:

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

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

4. ***Quiz***

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

- Simple Multiple-Choice Questions (MCQs)
- Numerical MCQs
- Image-based Questions
- Match the Following
- Fill in the Blanks
- Drag and Drop (using images or words)

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

5. ***Internal Tests***

Two major internal tests should be conducted as follows:

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

Mode 2:

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

1. CCE of 30 marks based on all the Units of course syllabus to be scheduled and conducted at institute level.

2. Case studies included under each unit are intended to support applied learning and are part of Comprehensive Continuous Evaluation

3. These case studies will be assessed through internal assessment components such as presentations, assignments, or group discussions. They shall not be included in the End-Semester Theory Examination.

4. To design a Comprehensive Continuous Evaluation scheme for a theory subject of 30 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr. No.	Parameters	Marks	Coverage of Units
1	Unit Test	12 Marks	Unit 1 & Unit 2 (6 Marks/Unit)
2	Assignments/Case Study	12 Marks	Unit 3 & Unit 4 (6 Marks/Unit)
3	Seminar Presentation/ Open Book Test/ Quiz	06 Marks	Unit 5

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

Sr. No.	Parameters	Marks	Coverage of Units
1	Unit Test	10 Marks	Unit 1 & Unit 2 (5 Marks/Unit)
2	Seminar Presentation/ Open Book Test/ Assignments/ Case Studies	05 Marks	Unit 3 & Unit 4

- ***Unit Test*–**

Format: Questions designed as per Bloom's Taxonomy guidelines to assess various cognitive levels (Remember, Understand, Apply, Analyze, Evaluate, and 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*–**

1. Remembering (2 Marks): Define key terms related to [Topic from Units 1 and 2].
2. Understanding (2 Marks): Explain the principle of [Concept] in [Context].
3. Applying (2 Marks): Demonstrate how [Concept] can be used in [Scenario]
4. Analyzing (3 Marks): Compare & contrast [Two related concepts] from Units 1 and 2
5. Evaluating (3 Marks): Evaluate the effectiveness of [Theory/Model] in [Situation].

- **Assignments / Case Study:** Students should submit one assignment or one Case Study Report based on Unit 3 and one assignment or one Case Study Report based on Unit 4.

– ***Format*:** Problem-solving tasks, theoretical questions, practical exercises, or case studies that require in-depth analysis and application of concepts.

– ***Implementation:*** Distribute the assignments or case study after covering Units 3 and 4. Provide clear guidelines and a rubric for evaluation.

- ***Seminar Presentation:* –**

Format: Oral presentation on a topic from Unit 5, followed by a Q&A session. –
Deliverables: Presentation slides, a summary report in 2 to 3 pages, and performance during the presentation
Implementation: Schedule the seminar presentations towards the end of the course. Provide students with ample time to prepare and offer guidance on presentation skills.

- ***Open Book Test:* –**

Format: Analytical and application-based questions to assess depth of understanding. – **Implementation**: Schedule the open book test towards the end of the course, ensuring it covers critical aspects of Unit 5

- ***Quiz:* –**

Format: Quizzes can help your students practice existing knowledge while stimulating in tersest 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: –***
    1. Weeks 1-4 : Cover Units 1 and 2
    2. Week 5 : Conduct Unit Test (12 marks)
    3. Weeks 6-8 : Cover Units 3 and 4
    4. Week 9 : Distribute and collect Assignments / Case Study (12 marks)
    5. Weeks 10-12 : Cover Unit 5
    6. Week 13 : Conduct Seminar Presentations or Open Book Test or Quiz (6 marks)

- ***Evaluation and Feedback: –***
    1. Unit Test: Evaluate promptly and provide constructive feedback on strengths and areas for improvement.
    2. Assignments / Case Study: Assess the quality of submissions based on the provided rubric. Offer feedback to help students understand their performance.
    3. Seminar Presentation: Evaluate based on content, delivery, and engagement during the Q&A session. Provide feedback on presentation skills and comprehension of the topic.
    4. Open Book Test: Evaluate based on the depth of analysis and application of concepts. Provide feedback on critical thinking and problem-solving skills.

B) <u>**End-Semester Examination (ESE)**</u>

Detailed Scheme for 70 Marks: Unit-Wise Allocation (14 Marks per Unit): Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students' understanding and application of the course material, adhering to Bloom's Taxonomy guidelines for cognitive skills evaluation.

Detailed Scheme for 35 Marks: Unit-Wise Allocation (08 Marks for Unit 1 , 09 Marks for Unit 2, Unit 3 and Unit 4) : Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students' understanding and application of the course material, adhering to Bloom's Taxonomy guidelines for cognitive skills evaluation

Question Paper Design

The following structure is to be followed for designing an ESE for a **theory subject of 70 marks** covering **all 5 units** of the syllabus, with **questions set as per Bloom's Taxonomy** guidelines and **14 marks allocated per unit**.

2. ***Balanced Coverage***

Ensure balanced coverage of all units with questions that assess different **cognitive levels of Bloom's**

Taxonomy:

a) **Remembering**: Basic recall of facts and concepts.

b) **Understanding**: Explanation of ideas or concepts.

c) **Applying**: Use of information in new situations.

d) **Analyzing**: Drawing connections among ideas.

e) **Evaluating**: Justifying a decision or course of action.

f) **Creating**: Producing new or original work (if applicable).

3. *Detailed Scheme*

- **Unit-Wise Allocation**: **14 Marks per Unit**

  Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students' understanding and application of the course material, adhering to **Bloom's Taxonomy guidelines** for cognitive skills evaluation.

Curriculum Structure - Semester V: -

NEP 2020 Compliant Curriculum Structure

Course Code		Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credit			
			L	T	P	CCE	ESE	TW	OR	PR	TOTAL	L	T	P	TOTAL
Semester-V															
PCC301-ABE	Major Course-7	Automotive Design - I	**4**			**30**	**70**	**-**	**-**	**-**	**100**	**3**			**3**
PCC302-ABE	Major Course-8	Kinematics and Dynamics of Machines	**3**			**30**	**70**				**100**	**3**			**3**
PCC303-ABE	Major Course-9	Automotive HVAC	**3**			**30**	**70**				**100**	**3**			**3**
PCC304-ABE	Major Course-10	Automotive Electrical and Electronics Systems	**3**			**30**	**70**				**100**	**3**			**3**
PCC305-ABE	Major Course -11	Advance Manufacturing Technology	**3**			**30**	**70**				**100**	**3**			**3**
PCC306-ABE	Major Course-7A	Automotive Design Lab-I			**2**			**25**			**25**			**1**	**1**
PCC307-ABE	Major Course-9A	HVAC Lab			**2**					**25**	**25**			**1**	**1**
MDM321-ABE	Multidisciplinary Course-3	Autotronics Lab			**2**			**25**			**25**			**1**	**1**
MDM322-ABE	Multidisciplinary Course-4	Integrated Mechanisms Lab			**2**					**25**	**25**			**1**	**1**
MDM323-ABE	Multidisciplinary Course-5	Advance Manufacturing Lab			**2**					**50**	**50**			**1**	**1**
OLE324	Open Elective	OE is to be chosen compulsorily from faculty other than that of the Engineering	**2**				**50**				**50**	**2**			**2**
			18	**0**	**10**	**150**	**400**	**50**	**0**	**100**	**700**	**17**	**0**	**5**	**22**

***CCE: Comprehensive Continuous Evaluation**

Important Note: Min.1 to Max.2 hrs. per batch of (20-25 students) to be assigned for *CCE and to be considered in teaching load of concerned faculty. (Only applicable for Mode -1)

Curriculum Structure - Semester VI: -

NEP 2020 Compliant Curriculum Structure

Semester-VI

Course Code		Course Name	Teaching Scheme (Hrs./week)		
			L	T	P
PCC351-ABE	Major Course-12	Automotive Design - II	4		
PCC352-ABE	Major Course-13	Automotive Chassis and Transmission Systems	3		
PCC353-ABE	Major Course-14	Vehicle Aerodynamics and Body Engineering	3		
PCC354-ABE	Major Course-12A	Automotive Design II Lab			2
PCC355-ABE	Major Course-13A	Power Transmission Systems Lab			2
PEC361-ABE	Program Elective-I	Students can pick the elective from basket	3		
PEC362-ABE	Program Elective-II	Students can pick the elective from basket	3		
MDM371-ABE	Multidisciplinary Course-6	Metrology and Quality Engineering	2		
MDM372-ABE	Multidisciplinary Course-7	Measurement and Quality Lab			2
MDM373-ABE	Multidisciplinary Course-8	Industrial Hydraulics & Pneumatics Lab			2
VSE381	Vocational Skill Course	Simulation and Analysis Lab			2
			18	0	10

Course Code	Examination Scheme and Marks						Credit			
	CCE	ESE	TW	OR	PR	TOTAL	L	T	P	TOTAL
PCC351-ABE	30	70				100	3			3
PCC352-ABE	30	70				100	3			3
PCC353-ABE	30	70				100	3			3
PCC354-ABE			25			25			1	1
PCC355-ABE					25	25			1	1
PEC361-ABE	30	70				100	3			3
PEC362-ABE	30	70				100	3			3
MDM371-ABE	50					50	2			2
MDM372-ABE					25	25			1	1
MDM373-ABE			25			25			1	1
VSE381					50	50			1	1
	200	350	50	0	100	700	17	0	5	22

Program Elective -I		Program Elective -II	
PEC361A-ABE	Finite Element Analysis	PEC362A-ABE	Vehicle Product Design and Development
PEC361B-ABE	Computational Fluid Dynamics	PEC362B-ABE	Automotive Driver Assistance Systems
PEC361C-ABE	Automotive Control Systems	PEC362C-ABE	Alternative Fuels and Emission Control

CCE: Comprehensive Continuous Evaluation

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

Elective I & II: Courses like *Project Management*, *Business Analytics*, or *Financial Management* can be opted from Inter-Disciplinary Studies, Commerce, and Management faculties, respectively.

Savitribai Phule Pune University, Pune
Third Year of Automobile Engineering (2024 Course)
PCC301-ABE : Automotive Design -I

Teaching Scheme: TH: 04 hrs./week	Credits: TH: 03	Examination Scheme: CCE:30 End-Sem: 70

Prerequisite 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. The preferred sizes, tolerances and types of fits. Construction of SMD and BMD. Roots of equations.

Prerequisites: -

1. Engineering Mathematics,
2. Engineering Graphics,
3. Solid Mechanics,
4. Engineering Materials.

Course Objectives: -

This course "Automotive Design-I" is designed with the following objectives:

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: -

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

CO. 1 **IDENTIFY** types of levers and components subjected to eccentric loading design problems
CO. 2 **DESIGN** shafts, keys and couplings under different loading conditions.
CO.3 **ANALYZE** different stresses developed in power screws and **APPLY** those in the design of screw jack.
CO. 4 **EVALUATE** dimensions of machine components under fluctuating loads.
CO. 5 **APPLY** basic design knowledge for spur and helical gear strength design.

Course Contents

Unit - I	Fundamentals of Machine Design	10 hours

Introduction of Machine Design, Design procedure, Design Process, Design considerations, Static and fluctuating loads, Simple stresses in Machine components, Selection of materials & Factor of safety. Design of Cotter Joint, Design of Knuckle Joint, Levers - hand / foot lever, Principal Planes and Principal stresses, Theories of failures, Design of components subjected to eccentric loading.

Real World Assignment

1 Determine whether an elevator cable is safe under the maximum passenger load.
2 Determine the factor of safety of motorcycle side stand and verify whether design is safe.
3 Identification of different engineering materials used in various parts of two-wheeler with reasoning
4 Ergonomic Lever Design for Hand Lever or Foot Lever for bore-well pump
5 The Material selection and analysis of failed mechanical component such as snapped bolt, fan blade etc. Stress Concentration for plate with a central hole.
6 Design a cotter joint for bicycle so as to transmit power from pedal to axle of bicycle.

7 Design a knuckle joint for tractor and trailer so that tractor can pull the trailer of 3 ton. (Empty weight 0.5 ton + material weight 2.5 ton).

Exemplar / Practical Applications

Material Selection in Industry, Bell Crank Lever for Bicycle Braking Systems, Lever for Safety Valve for Industrial Boilers, Eccentric Loading in C-Clamps, Fluctuating Loads in Automobile Leaf Springs, Service Factor for different mechanical systems.

Unit - II	Design of Keys, Couplings and Shafts	10 hours

Keys and Splines: Design of square and rectangular parallel taper keys, Kennedy key, Design of splines.
Couplings: Rigid muff coupling, Rigid flange coupling, Bush pin type flexible coupling.
Shafts: 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 propeller shafts.

Real World Assignment

1 Design of shaft for real world applications like gear box of automobile, lathe , pump etc.
2 Design, and analyze keys used in real mechanical systems (i.e. shaft-gear, shaft-pulley) for torque transmission.
3 Identify different types of couplings used in the transmission system and justify their use.

Unit-III	Design of Power Screws, Bolted Joints, Riveted joints and Welded joints	10 hours

Power Screw:
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 jack and C-Clamp.
Bolted Joints: Basic types of fastenings, Design of bolted joints under tension, eccentrically loaded bolted joint in shear and parallel to axis of bolt, torque requirement for tightening.
Welded Joints: Welding symbols, types of welds, stresses in butt and fillet welds, strength of butt, parallel and transverse fillet welds, eccentric load in plane of weld, welded joints subjected to bending and torsion.
Riveted Joints: Types of rivets, rivet materials, analysis of riveted joints, joint efficiency, failures of riveted joints.

Real World Assignment

1 Torque Requirement and Efficiency Estimation of a Bench Vice Screw Mechanism
2 Analysis of C-Clamp Screw and Collar Friction Effects
3 Design a Power screw for a Hydraulic Press
4 Design of a toggle jack for 2-Ton capacity
5 Industrial Visit to workshop/automobile service station

Exemplar / Practical Applications

The car Jack, machine vise, Large mechanical Press.

Unit - IV	Design for Fluctuating Loads	8 hours

Fatigue Failure, Stress-Life (S–N) Curve and Endurance Limit, Factors Affecting Endurance Strength (Modifying Factors and Notch Sensitivity), Reversed Stress Concept, Fatigue Failure Theories: Soderberg, Goodman, and Gerber Criteria, Modified Goodman Diagram for Design Applications, Design for Finite and Infinite Life.

Real World Assignment

1 Fatigue Design of an Automotive Drive Shaft
2 Fatigue Analysis of a Connecting Rod

Exemplar / Practical Applications

Fatigue Design of Rotating Shaft Under Variable Loading.

Unit - V	Design of Spur, Helical, Bevel and Worm Gears	10 hours

Spur Gears: Force analysis, Number of teeth, Face width & Beam strength of gear tooth, Incremental dynamic tooth load, Effective load on gear tooth, Estimation of module based on beam strength and wear strength.

Helical Gears: Virtual number of teeth, Tooth proportions, Force analysis, Beam strength and Wear strength of helical gears, Effective load on gear tooth, Herringbone gears.

Bevel Gears: Types, Terminology of bevel gears, Force analysis, Beam strength and Wear strength of bevel gears, Effective load on gear tooth.

Worm Gears: Terminology, Force analysis, Friction in worm gears, Strength rating and wear rating of worm gears, Thermal considerations.

	Real World Assignment	

1. Design of Helical Gears for High-Speed Rotary Equipment.
2. Design Parameters of Spur Gears for Industrial Conveyor Systems.
3. Comparison of Spur and Helical Gears in Industrial Power Transmission.
4. Analysis of Spur Gears in a Car Transmission System.

Exemplar / Practical Applications

Automobile Gearbox, Machine tool gearbox.

Books:

Text Book:

1. V. B. Bhandari, “Design of Machine Elements”, Tata McGraw Hill Publications, New Delhi.
2. Textbook of “Machine Design” By R.S.Khurmi and J.K.Gupta S. Chand Publication, New Delhi.

Reference Books:

1. J. E. Shigley and C. R. Mischke, “Mechanical Engineering Design”, McGraw Hill Inc. New York.
2. M. F. Spotts and T. E. Shoup, “Design of Machine Elements”, Prentice Hall International.
3. W. C. Orthwein, “Machine Component Design”, West-Pub. Co. and Jaico Pub. House.
4. R. C. Juvinal, “Fundamentals of Machine Components Design”, John Wiley and Sons.
5. A. S. Hall, A. R. Holowenko and H. G. Laughlin, “Theory and Problems of Machine Design”, Schaum‟s Outline Series.

Design Data Books:

1. P.S. G. College of Technology, Coimbatore, “Design Data Handbook”
2. K. Mahadevan, K. Balveera Reddy, “Design Data Handbook”

MOOC / NPTEL/YouTube Links: -

https://www.youtube.com/watch?v=ofmbhbVCU qI&list=PL3D4EECEFAA99D9BE&index=3
https://www.youtube.com/watch?v=SL21aDqgs8Q https://www.youtube.com/watch?v=TPURJnlekeo

Savitribai Phule Pune University, Pune
Third Year of Automobile Engineering (2024 Course)
PCC302-ABE: Kinematics & Dynamics of Machines

Teaching Scheme: TH: 03 hrs./week	Credits: TH: 03	Examination Scheme: CCE: 30 End-Sem: 70

Prerequisite Courses:

To bridge the gap between basic engineering sciences and core automotive design, this course requires a foundational understanding of mathematical formulation, graphical representation, and physical mechanics. Students must be comfortable with vector algebra, kinematic properties of rigid bodies, and the laws of dry friction to successfully analyze how mechanical assemblies move and react under operational loads. The mapped prerequisite courses for Kinematics and Dynamics of Machines are:

Prerequisites: -

1. Engineering Mathematics
2. Engineering Graphics
3. Solid Mechanics
4. Engineering Materials

Course Objectives: -

This course “Kinematics & Dynamics of Machines” is designed with the following objectives:

UNDERSTAND various kinematic components, link mobility criteria, configurations, and correct steering inversions in vehicle assemblies.

SELECT or evaluate geometric properties of spur gears, epicyclic gear train ratios, and mechanical cam layouts.

EVALUATE the velocity and acceleration profiles of planar mechanisms using graphical approaches.

DESIGN or size essential elements for friction transmission, automotive clutch plates, and vehicular shoe/band braking layouts.

ANALYZE rotary components and vehicle assemblies subjected to fluctuating forces, rotating mass unbalance, and gyroscopic precession loops.

Course Outcomes: -

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

CO. 1 **UNDERSTAND** linkages and automotive components subjected to spatial constraints, correct steering geometry, and universal joint velocity variations.

CO. 2 **DESIGN** or map velocity and acceleration profiles of complex planar link configurations using both analytical equations and graphical vector polygons.

CO. 3 **ANALYZE** gear mesh geometry, compute speed ratios or holding torques in epicyclic gear setups, and construct precise cam displacement profiles.

CO. 4 **EVALUATE** dimensions and torque capacities of single/multi-plate clutch assemblies, short-shoe/band brake configurations, and vehicle front-to-rear axle load distributions.

CO. 5 **APPLY** basic kinematic and dynamic force knowledge to solve single-plane or multi-plane dynamic mass balancing problems and evaluate gyroscopic vehicular stability during cornering.

Course Contents

Unit - I	Automotive Linkages and Mechanisms	7 hours

Mechanisms: Links, kinematic pairs, degrees of freedom (Mobility), inversions, Kutzbach’s criterion for planar mechanisms (Four-bar and slider-crank chains).

Steering Gear Mechanisms: Condition for correct steering. Comparative study and kinematic analysis of Davis and Ackermann steering gear mechanisms.

Universal Joints: Hooke’s Joint (Single and Double) – polar velocity diagrams, angular velocity ratio, maximum and minimum speed of the driven shaft.

Real World Assignment

Exemplar / Practical Applications

Vehicle windshield wipers and bonnet hinges, to prevent tyre skidding during cornering, Ackermann steering gear layouts, Davis steering mechanism, single Hooke's joint, Double Hook joint (propeller Shaft).

Unit - II	Velocity and Acceleration Analysis	7 hours

Velocity Analysis: Instantaneous Center (I-Center) method, Kennedy's theorem of three centers. Relative velocity method for four-bar and slider-crank mechanisms.
Acceleration Analysis: Relative acceleration method for core automotive mechanisms (four-bar and slider-crank). Rubbing velocity at pin joints.
Coriolis Component: Coriolis component of acceleration: acceleration analysis of mechanisms involving slider amplification (e.g., crank and slotted lever mechanism).

Real World Assignment

Determine the virtual Pivots (I-Centers) of a car's double-wishbone front suspension linkage.

Determine the velocities and accelerations of different moving components of a Single Cylinder IC Engine at a particular speed.

Perform Kinematic analysis of a practical machine having mechanism a slider block inside an automated tracking slot moves outward at a constant velocity.

Exemplar / Practical Applications

Double-Wishbone Suspension Roll Centers, Engine Piston Velocity Calculations, Piston Inertia and Structural Balancing, Connecting Rod Journal Design, Variable-Transmission Slotted Drives & Quick-Return Industrial Actuators, Predicting Side-Thrust Guide Wear.

Unit-III	Transmission Kinematics: Gears and Cams	8 hours

Spur Gears: Involute tooth profile properties, terminology, law of gearing. Path of contact, arc of contact, contact ratio. Interference and undercutting (concept and prevention).

Gear Trains: Simple, compound, and epicyclic gear trains. Torque and holding torque analysis in epicyclic gear trains.

Cams & Followers: Classification. Construction of cam using displacement diagrams for Simple Harmonic Motion (SHM) and Uniform Acceleration and Retardation (UARM) only.

Real World Assignment

Perform design parameter verification and interference check of a spur gear pair mesh used in a light commercial vehicle auxiliary drive.

Analyze an automotive differential gear assembly or a planetary gear hub cluster during a turning maneuver.

Design a valve train cam profile responsible for operating an overhead intake valve of an IC Engine.

Exemplar / Practical Applications

Manual transmission system, Differential, Contact Ratio optimization (Noise, Vibration, and Harshness - NVH Reduction), Automatic transmission system, Undercutting Prevention (High-Torque Starter Motor Pinions), Overhead Camshafts (IC Engine Valve trains).

Perform a Kinematic Verification & Mobility Analysis of a mechanism used in vehicle.

Identify for a vehicle transmission assembly, the different types of links and pairs in the mechanisms.

Evaluate whether a commercial vehicle meets the mathematical criteria for perfect steering during cornering.

Perform a Velocity Fluctuation Profile Analysis of a RWD Propeller Shaft.

Unit - IV	Automotive Clutches and Braking Dynamics	7 hours

Friction Clutches: Friction considerations in torque transmission. Uniform pressure and uniform wear theories. Torque capacity derivations for single-plate, multi-plate, and cone clutches.
Braking Systems: Kinematic and force analysis of shoe, band and shoe-band brakes.

Real World Assignment

Apply uniform wear and uniform pressure theories to evaluate an in-service automotive clutch for torque capacity & service Margin.

Apply kinematic force balances to calculate the mechanical leverage required to stop a rotating drum.

Exemplar / Practical Applications

Brand-new clutches, in-service clutches, Single-Plate Dry Clutches (Passenger Vehicles), Multi-Plate Wet Clutches (Motorcycles), Short-Shoe Braking Systems (Industrial Hoists and Elevators), Band Brakes (Automatic Gearbox Controls & Heavy Winches), Planetary Gear Controls.

Unit - V	Vehicle Balancing and Gyroscopic Stabilization	7 hours

Balancing of Reciprocating Masses: Concept of static and dynamic unbalance. Single Cylinder partial balancing, Graphical method for balancing of multi-cylinder engine.

Gyroscopic Effects in Vehicles: Concept of gyroscopic couple and precession. **Vehicle Stability Analysis**: Gyroscopic and centrifugal couples acting on a four-wheeler taking a turn and a two-wheeler (motorcycle) negotiating a curve.

Real World Assignment

Determine the required rotating counterweight mass needed to minimize vibrations of single cylinder engine.

Calculate the slope a motorcycle must maintain to prevent low-side skidding.

Exemplar / Practical Applications

Wheel Balancing Service Stations, Single-Cylinder Partial Balancing (Motorcycles and Lawnmowers), Multi-Cylinder Inline (Automotive Engine Blocks), Aircraft Propeller Pitching Maneuvers, EV and Hybrid Powertrain Layouts, Four-Wheeler Stability & Anti-Roll Limits (SUVs vs. Sports Cars), Motorcycle Cornering.

Books:

Text Book:

S. S. Rattan, "Theory of Machines", Tata McGraw Hill Publications, New Delhi.

Textbook of "Theory of Machines" By R.S.Khurmi and J.K.Gupta S. Chand Publication, New Delhi.

Reference Books:

Theory of Machines and Mechanisms – John J. Uicker, Gordon R. Pennock, and Joseph E. Shigley (Oxford University Press) M. F. Spotts and T. E. Shoup, "Design of Machine Elements", Prentice Hall International.

Mechanical Engineering Design – J. E. Shigley and C. R. Mischke (McGraw-Hill International) R. C. Juvinal, "Fundamentals of Machine Components Design", John Wiley and Sons.

Theory of Mechanisms and Machines – Amitabha Ghosh and Asok Kumar Mallik (East-West Press).

MOOC / NPTEL/YouTube Links: -

https://youtu.be/FeXZq_w9mZo?si=hpjlOjIgokymFko6.
https://youtu.be/5f3wBlRY8dQ?si=lGEEI6HS3l-OCar1.
https://youtu.be/O1xeoRTIAkU?si=AP4wYqauOpOif8tz.

Savitribai Phule Pune University Third Year of Engineering (2024 Pattern)		
PCC303-ABE: Automotive HVAC		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week **Tutorial: - NA**	**03**	**CCE : 30 Marks** **End-Semester :70 Marks**

Prerequisite Courses:

- Thermodynamics
- Heat Transfer
- Fluid Mechanics
- Automobile Engineering Fundamentals

Course Objectives:

1. Understand refrigeration and air-conditioning principles used in automobiles.
2. Analyze psychrometric properties and thermal comfort requirements in vehicles.
3. Study automotive HVAC components, controls, and refrigerants.
4. Perform cooling load calculations for passenger and commercial vehicles.
5. Diagnose, service, and optimize automotive HVAC systems with focus on sustainability and EV applications.

Course Outcomes:

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

CO1	Explain refrigeration cycles and HVAC fundamentals used in automobiles
CO2	Analyze psychrometric processes and passenger comfort conditions
CO3	Evaluate performance of HVAC components and thermal control systems
CO4	Calculate vehicle cooling loads and HVAC energy requirements
CO5	Diagnose faults and perform servicing of automotive HVAC systems
CO6	Apply modern HVAC technologies in EVs and intelligent vehicles

Course Contents

Unit I	Fundamentals of Refrigeration and Automotive HVAC	(08 Hours)

Vapour Compression Refrigeration System (VCRS): working principle, components such as compressor, condenser, expansion valve and evaporator, p-h and T-s diagrams, advantages and limitations.
Refrigerants: properties of refrigerants, primary and secondary refrigerants, refrigerants R12, R134a, R1234yf, eco-friendly refrigerants and their applications.
Environmental Impacts: ozone depletion potential (ODP), global warming potential (GWP), Montreal Protocol and environmental regulations.
Need of HVAC in Automobiles: thermal comfort, cabin cooling and heating requirements, defogging and demisting, air quality control.
Passenger Comfort Requirements: temperature control, humidity control, air circulation, noise reduction, thermal sensation and comfort parameters.

Automotive HVAC Applications: HVAC systems in passenger vehicles, buses, trucks and electric vehicles (EVs), challenges in EV HVAC systems, energy-efficient HVAC systems, automatic climate control systems.

Real World Assignment

1. Study energy consumption and cooling capacity of a passenger car air-conditioning system and estimate COP using vehicle specifications.
2. Develop a P-h diagram simulation tool using Excel/MATLAB for automotive refrigeration cycle analysis.
3. Compare refrigerants used in modern vehicles based on environmental and performance parameters.

Exemplar / Practical Applications

1. Passenger car air-conditioning systems
2. Bus and coach HVAC systems
3. Electric vehicle cabin cooling systems
4. Automotive heat pump systems1hl'

Unit II	Psychrometry and Human Comfort	(07 Hours)

Psychrometric Properties of Air: properties of moist air, psychrometric terms and definitions.
Dry Bulb, Wet Bulb and Dew Point Temperature: measurement and significance in HVAC systems.
Relative Humidity and Specific Humidity: humidity ratio, degree of saturation and HVAC applications.
Psychrometric Chart and Processes: sensible heating and cooling, humidification, dehumidification and air mixing processes, sensible heat factor and cooling load concepts.
Human Thermal Comfort: comfort parameters, thermal sensation and comfort zone.
Effective Temperature: concept and application in automotive cabin comfort.
Cabin Ventilation Requirements: fresh air circulation, airflow distribution and ventilation standards.
Air Quality Standards in Vehicles: indoor air quality, cabin air filtration, CO_2 control and pollutant reduction.

Real World Assignments

1. Study thermal management system used in an electric vehicle.
2. Analyze performance of dual-zone automotive air-conditioning systems.
3. Compare conventional compressor systems with electric compressors used in EVs.

Exemplar / Practical Applications

1. Multi-zone luxury vehicle HVAC systems
2. Electric vehicle thermal management systems
3. Battery cooling systems in EVs
4. Heat pump-based EV climate control systems

Unit III	Automotive HVAC Components and System Layout	(08 Hours)

Automotive HVAC Systems and Components: classification of automotive air conditioning systems, manual and automatic HVAC systems, single zone and multi-zone AC systems.
Air Distribution and Control in Vehicle Cabins: airflow distribution methods, ducting system, vents, blower operation and cabin temperature control.
ASHRAE Standards for Automotive AC Systems: thermal comfort standards, ventilation requirements and automotive HVAC performance standards.
HVAC Components: Compressor: types, working principle and drive mechanisms**.**
Condenser: construction, heat rejection process and condenser cooling methods**. Receiver-Drier / Accumulator:** moisture removal, refrigerant storage and filtration. **Expansion Valve / Fixed Orifice Valve:** refrigerant flow control and pressure reduction. **Evaporator:** cooling and dehumidification process inside vehicle cabin**. Anti-Frosting Devices:** frost prevention methods and temperature sensors. Basic Control Switches: thermostat switch, pressure switch, blower control and safety switches.

Real World Assignments

1. Select suitable compressor type for passenger vehicle application based on cooling requirements.
2. Study HVAC control architecture used in modern vehicles.
3. Design basic automotive air-conditioning system layout for a passenger car.

Exemplar / Practical Applications

1. Passenger vehicle HVAC systems
2. Luxury car climate control systems
3. Smart automotive HVAC controls
4. Automotive cabin filtration systems

Unit IV	Cooling Load and Thermal Analysis	(08 Hours)

Sources of Heat Load in Vehicles: external and internal heat loads, conductive, convective and radiant heat transfer in vehicle cabins.
Solar Radiation Effects: solar heat gain through windshield and windows, greenhouse effect in cabins, solar load reduction methods.
Occupancy Load: heat generated by passengers and its effect on cabin cooling requirements.
Engine and Exhaust Heat Transfer: engine compartment heat, exhaust heat influence and insulation methods.
Ventilation Load: fresh air load, infiltration load and air circulation requirements.
Pull-Down Load Calculations: initial cabin cooling load estimation and pull-down time concepts.
Cooling Load Estimation for Passenger Vehicles: sensible and latent heat load calculations, cooling capacity determination.
HVAC Impact on Fuel Economy: compressor power consumption, fuel efficiency reduction and energy optimization techniques.
Thermal Management in Electric Vehicles: EV cabin thermal management, battery cooling and energy-efficient HVAC operation. HVAC Systems in Hybrid and Electric Vehicles: electric compressors, high-voltage HVAC systems and regenerative energy utilization.
Battery Thermal Management Systems: battery cooling and heating methods, thermal runaway prevention and battery performance optimization. Heat Pump HVAC Systems**:** working principle, components, heating and cooling operation and applications in EVs

Real World Assignments

1. Calculate cooling load of a passenger vehicle cabin under summer conditions.
2. Plot and analyze automotive air-conditioning processes on psychrometric chart.
3. Study effect of solar radiation on cabin temperature rise.

Exemplar / Practical Applications

1. Passenger vehicle cabin cooling
2. Automotive thermal comfort analysis
3. Vehicle cabin air quality systems

Unit V	HVAC Controls & Diagnostics	(08 Hours)

Electrical and Electronic Control: Electrical Principles, Sensors and Actuators, Testing Sensors and Actuators, Oscilloscope Waveform Sampling, Multiplex Wiring Systems, OBD and EOBD, Reading Wiring Diagrams, Automotive A/C Manual Control System (Case Study 1), Automotive A/C Auto Temperature Control System (Case Study 2), Automotive Climate Control System (Case Study 3)

Diagnostics, Troubleshooting, and Service: Vehicle Inspection, Temperature & Pressure Testing, Leak Detection, Sight Glass Check, Servicing Precautions, Refrigerant Recovery & Charging, System Oil & Flushing, Odour Removal, Retrofitting, Compressor Component Replacement, Fixed Orifice Valve Service

Real World Assignments

- Design air distribution layout for a passenger car cabin.
- Study and compare automatic climate control systems used in modern vehicles.
- Analyze impact of HVAC system on EV driving range.

Exemplar / Practical Applications

- Luxury vehicle climate control systems
- EV thermal comfort systems

- Smart connected vehicle HVAC systems
- Automotive defogging and demisting systems

Learning Resources

Text Books:

1. Automotive Air Conditioning and Climate Control Systems — Steven Daly
2. Refrigeration and Air Conditioning — C.P. Arora
3. Automotive Heating and Air Conditioning — Tom Birch
4. Automobile Engineering — Kirpal Singh
5. Vehicle Thermal Management Systems — Meisner

Reference Books:

1. Principles of Heating, Ventilation and Air Conditioning in Buildings — John W. Mitchell
2. Thermal Management for Electric Vehicles — Ibrahim Dincer
3. Automotive HVAC System Design and Applications — Routledge Publications

MOOC / NPTEL/YouTube Links: -

1. NPTEL RAC: https://nptel.ac.in/courses/112105128 |
2. NPTEL Online: https://onlinecourses.nptel.ac.in/noc24_me77/preview |
3. Engineering Mindset: https://www.youtube.com/@EngineeringMindset
4. HVAC School: https://www.youtube.com/@HVACS
5. AC Service Tech: https://www.youtube.com/@acservicetechchannel
6. ASHRAE: https://www.ashrae.org |
7. SAE International: https://www.sae.org |
8. Denso HVAC: https://www.denso.com/global/en/products-and-services/automotive-service-parts-and-accessories/air-conditioning/
9. Bosch Training: https://www.boschaftermarket.com/global/en/services-and-training/training/

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

PCC304-ABE: Automotive Electrical & Electronics Systems

Teaching Scheme		Credits	Examination Scheme	
Theory	**03 Hr./Week**	**03**	**CCE**	**30 Marks**
Practical	**NA**		**End-Semester**	**70 Marks**

Prerequisite Courses: Basic Electronics Engineering, Basic Electrical Engineering, Electrical and Electronics Engineering, Applied Thermodynamics & Heat Transfer.

Course Objectives

1. To develop understanding of modern automotive electrical architectures, wiring, protection, communication networks and EMC requirements.
2. To select, test and evaluate automotive batteries, energy storage devices, charging systems and basic power electronics used in conventional, hybrid and electric vehicles.
3. To explain construction, working, performance and diagnostics of starting and ignition systems.
4. To classify and test automotive sensors and actuators used in powertrain, chassis, body and safety systems.
5. To analyze electronic engine management, ADAS and safety systems from the viewpoint of layout, working, diagnostics and vehicle-level integration.

Course Outcomes

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

1 ANALYZE automotive electrical architecture, wiring, communication network and EMC requirements for vehicle applications.

2 SELECT and EVALUATE suitable battery, power supply and electrical protection systems for IC engine vehicle applications.

3 EXPLAIN and DIAGNOSE starting and ignition systems with respect to performance, faults and design requirements.

4 CLASSIFY, TEST and INTERPRET signals from automotive sensors and actuators using suitable diagnostic tools.

5 ANALYZE engine management, ADAS and safety systems and RECOMMEND suitable diagnostic / improvement actions.

Course Contents

Unit I	**Automotive Electrical Architecture, Wiring, Communication and EMC**	**[07 Hr.]**

Introduction to automotive electricity generation, storage and distribution systems; vehicle electrical loads; 12 V, 24 V and 48 V electrical systems; high-voltage awareness in EV/HEV; wiring harness design considerations, fuses, relays, protection devices, connectors and terminals; earthing concepts and return paths; instrument cluster and driver information system; introduction to vehicle communication networks - CAN, LIN, Flex Ray, automotive Ethernet; OBD-II and UDS overview; electromagnetic interference, susceptibility and compatibility - need, coupling methods, sources of EMI, testing methods, related ISO / CISPR / SAE / AIS standards and automotive case studies.

Real World Assignment

1. Vehicle Wiring Harness Mapping:

Select a two-wheeler or four-wheeler and prepare a wiring layout map for lighting, horn, dashboard and charging circuits. Objective: Identify power distribution, protection, connectors and earthing points. Deliverable: Annotated wiring map with photographs and component list.

2. CAN/LIN Network Case Study:

Study CAN/LIN communication used in body, powertrain or comfort systems from service literature or simulator data. Objective: Explain nodes, messages, diagnostic interface and fault symptoms. Deliverable: Network block diagram and short diagnostic report.

3. EMI/EMC Problem Investigation:
Identify one EMI related vehicle issue such as radio noise, sensor disturbance or alternator whine. Objective: Analyze source, coupling path and possible mitigation. Deliverable: Case-study report with mitigation checklist.
4. Instrument Cluster and Warning Lamp Audit:
Observe dashboard indications during ignition ON, engine start and fault simulation. Objective: Relate warning lamps to sensors, ECU inputs and driver information system. Deliverable: Table of indications, probable inputs and safety relevance.

Unit II	Battery, Power Supply and Electrical Protection Systems	[07 Hr.]

Lead-acid batteries in IC engine vehicles: construction, working principle, electrolyte, cell voltage and battery voltage; battery ratings such as Ah rating, reserve capacity and cold cranking amperes; battery charging/discharging characteristics, capacity, efficiency, self-discharge, sulphation and common failures; battery testing by hydrometer, open-circuit voltage, load test and conductance test.
Automotive power supply system: 12 V and 24 V systems, dual-battery arrangement in commercial vehicles, battery selection for two-wheelers, passenger cars, tractors and commercial vehicles; jump-starting precautions, battery terminals, cables, earthing/grounding, voltage drop and loose connection diagnosis.
Electrical protection and distribution: fuses, fusible links, relays, circuit breakers, ignition switch, fuse/relay box layout and power distribution to starter, alternator, ignition, lighting and accessories; basic diagnosis of battery drain, overcharging, undercharging and no-crank/no-start faults; safe handling, maintenance and recycling of lead-acid batteries.

Real World Assignment
1. Battery Health Testing of an IC Engine Vehicle
Test a vehicle battery using open-circuit voltage, specific gravity and load test. Prepare a battery health report with conclusion: healthy, weak, discharged or faulty. Deliverable**:** Battery health report including test readings, observations, battery condition conclusion and recommended corrective action.
2. Battery Selection for Different IC Vehicles
Compare battery requirements for a two-wheeler, passenger car, tractor and heavy commercial vehicle based on Ah rating, CCA, voltage system and operating conditions. Deliverable: Comparative table showing vehicle type, required battery voltage, Ah rating, CCA rating, application conditions and final battery selection justification.
3. Voltage Drop Diagnosis in Starting Circuit
Measure voltage drop across battery terminals, starter cable, ground connection and starter motor during cranking. Identify possible causes of slow cranking. Deliverable: Voltage drop test report with circuit diagram, measured values, permissible limits, fault identification and corrective measures.
4. Parasitic Battery Drain Investigation
Study battery discharge in a parked vehicle due to accessories, lamps, ECU memory supply or wiring leakage. Prepare a diagnostic flowchart. Deliverable: Diagnostic flowchart showing step-by-step parasitic drain testing procedure, possible causes, current limits and suggested remedies.
5. Fuse and Relay Box Mapping of a Vehicle
Identify major fuses and relays in a vehicle fuse box. Prepare a labelled chart showing power supply path for starter, ignition, lighting, horn and accessories. Deliverable: Labelled fuse/relay box chart showing fuse rating, relay function and power supply path for starter, ignition, lighting, horn and accessories.

Unit III	Starting, Charging and Ignition System	[07 Hr.]

Starting system: requirements; construction, working and characteristics of starter motor; starter drives, solenoid switches, starter relays, protection and control circuits; starter motor testing, no-crank and slow-crank fault diagnosis; design considerations and start-stop system overview.
Charging system: requirements; construction and working of alternator; rectification, voltage regulators, charging indicator circuit and charging characteristics; charging circuit layout, alternator testing, overcharging and undercharging diagnosis, charging system faults and maintenance.
Ignition system: requirements; battery ignition system components and working; electronic ignition, distributor-less ignition, coil-on-plug ignition and CDI overview; spark plugs - construction, heat range, types and characteristics; ignition timing control, misfire detection and diagnostic approach.

Real World Assignments

1. Starter Motor Performance Testing

Study and test a starter motor using a practical setup or service-station data. Measure/observe current draw, cranking speed, voltage drop and starter engagement. Deliverable: Testing report with circuit diagram, observations, probable faults and corrective actions.

2.No-Crank / Slow-Crank Fault Diagnosis

Prepare a diagnostic flowchart for common starting system faults such as weak battery, loose terminal, faulty solenoid switch, starter relay failure, worn brushes or poor earthing. Deliverable: Fault diagnosis chart with symptoms, causes, testing method and solution.

3. Alternator Charging System Analysis

Inspect the charging system of an IC engine vehicle and study alternator output, rectifier, voltage regulator and charging indicator circuit. Deliverable: Report showing alternator circuit layout, expected voltage range, common faults like undercharging/overcharging and maintenance steps.

4. Vehicle Charging Fault Case Study

Take a real or simulated case such as "battery warning lamp ON," "battery not charging," or "battery overcharging." Diagnose the fault step-by-step using voltage test, belt inspection, wiring inspection and alternator output test. Deliverable: Case study report with fault tree, test results and final diagnosis.

5. Comparison of Ignition Systems

Compare battery ignition, electronic ignition, distributor-less ignition, coil-on-plug ignition and CDI system based on construction, working, advantages, limitations and applications. Deliverable: Comparative table with block diagrams and suitable vehicle applications.

6. Ignition Timing and Misfire Diagnosis

Study the effect of incorrect ignition timing or misfire on engine performance, fuel consumption and emissions using scan-tool data, case study or simulation. Deliverable: Short technical report with symptoms, probable causes, diagnostic steps and remedies.

7. Start-Stop System Study in Modern IC Vehicles

Study the working of start-stop system used in modern IC engine vehicles, including starter motor requirements, battery support, sensors and control logic. Deliverable: Block diagram, working explanation, advantages, limitations and service precautions.

Unit IV	Automotive Sensors, Actuators, ECU and Diagnostics	[07 Hr.]

Engine sensors - manifold absolute pressure sensor, mass air flow sensor, knock sensor, coolant and intake air temperature sensors, exhaust oxygen sensor, throttle position sensor, accelerator pedal position sensor, crankshaft and camshaft position sensors; chassis/body/safety sensors - steering angle, wheel speed/RPM, torque, load cell, proximity, rain, crash, vibration and acceleration sensors; actuators - solenoids, relays, stepper motors, DC motors, PWM-controlled actuators and piezo actuators; ECU signal conditioning, sensor power supply and grounding; scan tools, diagnostic trouble codes, freeze-frame data, live data, oscilloscope/multimeter testing and basic calibration/fault diagnosis.

Real World Assignment

1. Sensor Live Data Interpretation:

Use OBD scanner/simulator to record MAP/MAF/TPS/O2/coolant temperature data. Objective: Interpret live data and identify normal/abnormal values. Deliverable: Live-data table with diagnosis.

2. Wheel Speed / ABS Sensor Testing:

Test wheel speed sensor output using scanner, multimeter or oscilloscope/simulation. Objective: Relate sensor signal to ABS/traction control operation. Deliverable: Signal waveform or reading with explanation.

3. Actuator Control Demonstration:

Demonstrate relay, injector, idle actuator, solenoid or stepper motor control using ECU trainer/Arduino/PWM setup. Objective: Understand actuator command, duty cycle and response. Deliverable: Circuit diagram, observations and safety precautions.

4. DTC-Based Fault Finding:

Create or study a diagnostic trouble code case from a vehicle or scanner simulator. Objective: Follow a structured troubleshooting path using symptom, DTC, live data and inspection. Deliverable: Fault tree and final repair recommendation.

Unit V	Engine Management, ADAS, Safety and Connected Vehicle Systems	[08 Hr.]

Engine management system layout; open-loop and closed-loop control; SI engine management - TBI, MPFI, GDI, group and sequential injection strategies, fuel system components, cold/warm start, idle speed control, acceleration/deceleration enrichment, full-load enrichment, fuel cut-off and spark timing control; CI engine management - CRDI, fuel quantity control, injection timing control, idle speed control, fuel maps and advancements;

ABS layout and working; supplementary restraint system - airbags, seat belts, retractor, pretensioner and load limiter; ADAS - driver state monitoring, adaptive cruise control, automatic emergency braking, collision avoidance, lane departure warning, tire pressure monitoring, smart parking assist, adaptive front lighting and head-up display; ADAS sensors - camera, radar, lidar and ultrasonic overview; connected vehicle, GPS, keyless entry, cybersecurity awareness and functional safety overview.

Real World Assignment

1. Fuel Injection Strategy Comparison:

Compare TBI, MPFI, GDI and CRDI systems using layout diagrams and service data. Objective: Relate injection strategy to performance, emissions and diagnostics. Deliverable: Comparative matrix and practical application notes.

2. Engine Management Live Data Case Study:

Analyze OBD live data during idle, acceleration and deceleration. Objective: Identify closed-loop control, fuel trim, O2 sensor response and possible faults. Deliverable: Data screenshots/plots with interpretation.

3. ABS and Airbag Safety System Study:

Study ABS/SRS layout of a vehicle and identify sensors, ECU, actuators and warning strategies. Objective: Explain safety logic and diagnostic precautions. Deliverable: System block diagram and safety handling checklist.

4. ADAS Feature Evaluation Report:

Select one ADAS feature such as AEB, ACC, LDWS or smart parking and study its sensor suite and operating limitations. Objective: Evaluate benefits, limitations and Indian road challenges. Deliverable: Technical report with use-case and failure-mode analysis.

Learning Resources

Text Books

1. P. L. Kohli, “Automotive Electrical Equipment’s”, Tata McGraw Hill Pub. Co. Ltd.
2. Tom Denton, “Automobile Electrical & Electronic Systems”, 3rd Edition, Elsevier Butterworth-Heinemann
3. William B. Ribbens, “Understanding Automotive Electronics”, 6th Edition, Newnes an imprint of Elsevier Science.

Reference Books

1. Allan W. M. Bonnick, “Automotive Computer Controlled Systems”, Butterworth-Heinemann.
2. V. A. W. Hilliers, “Fundamentals of Automotive Electronics”, Hatchin, London.
3. Tomwather J. R., Cland Hunter, “Automotive Computer & Control System”, Prentice Inc. NJ
4. Robert N. Brandy, “Automotive Computers& Digital Instrumentation”, Prentice Hall Eaglewood, Cliffs, NJ
5. Young, Griffithe, “Automobile Electrical & Electronic Equipments”, The English Language Book Co., London.
6. Henry W. Ott, “Electromagnetic Compatibility Engineering”, John Wiley & Sons Inc., Publication
7. Clayton R. Paul “Introduction to Electromagnetic Compatibility”, John Wiley & Sons Inc., Publication

MOOC / NPTEL/ YouTube Links: -

1. https://nptel.ac.in/courses/112106913

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

PCC305-ABE: Advance Manufacturing Technology

Teaching Scheme		Credits	Examination Scheme	
Theory	**03 Hr./Week**	**03**	**CCE**	**30 Marks**
Practical	**NA**		**End-Semester**	**70 Marks**

Prerequisite Courses: Workshop Practices, Manufacturing Technology.

Course Objectives

1. To develop understanding of mechanics of machining, cutting forces, tool wear, tool life and machinability for selecting suitable machining conditions.
2. To explain the construction, selection and applications of multipoint cutting tools and analyze common gear and thread manufacturing processes.
3. To compare modern machining processes and select an appropriate process for difficult-to-machine materials, intricate geometries and precision applications.
4. To understand the complete additive manufacturing workflow, process selection, quality considerations and automotive applications.
5. To apply locating, clamping and fixture-design principles for safe, accurate and economical production.

Course Outcomes

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

1. ANALYZE machining mechanics, cutting forces, tool life, tool wear and machinability to recommend suitable cutting conditions.
2. SELECT suitable multipoint cutting tools and COMPARE gear and thread manufacturing processes for specific component requirements.
3. CLASSIFY and EVALUATE modern machining processes based on material, geometry, accuracy, surface finish and productivity requirements.
4. EXPLAIN additive manufacturing workflows and SELECT suitable AM processes, materials and post-processing methods for engineering applications.
5. APPLY locating, clamping and 3-2-1 principles to DEVELOP conceptual jig and fixture solutions for production applications.

Course Contents

Unit I	Mechanics of Metal Cutting	[07 Hr.]

Introduction to metal cutting, Elements of machining process, Geometry of single-point cutting tool, Orthogonal and Oblique cutting processes, Chip formation, Types of chips, Chip thickness ratio, Process parameters and their effect on machining, chip breakers, Merchant's Circle of forces analysis – forces and energy calculations, power consumed – MRR- Effect of Cutting variables on forces, Concept of Machinability Factors affecting machinability, Machinability Index, Tool Life, Tool life equation of Taylor, Tool wear and its types, Factors affecting on tool life. tool materials/coatings, surface-finish influence, cutting fluids, Minimum Quantity Lubrication (MQL) and sustainable machining practices.
Introduction of multi point cutting tools, Nomenclature of multipoint cutting tools like milling, drilling, reaming and taps, Selection criteria for multipoint cutters.

Real World Assignment

1. Machining Parameter Selection for an Automotive Component: Select a component such as a shaft, brake disc or wheel hub and recommend cutting speed, feed, depth of cut and tool material using a machining handbook or manufacturer catalogue. Deliverable: One-page process sheet with justification.
2. Chip Type and Machining Fault Identification: Use workshop photographs, videos or available chip samples to identify chip types, built-up edge and possible reasons. Deliverable: Annotated chart linking chip condition with corrective action.
3. Tool Wear Case Study: Study worn cutting-tool images from a workshop or online industrial source and

identify flank wear, crater wear or chipping. Deliverable: Fault-analysis table with likely causes and remedies.

4. Sustainable Machining Comparison: Compare dry machining, flood cooling and MQL for one machining operation. Deliverable: Comparison table covering quality, cost, safety and environmental aspects.

5. Merchant Circle Application: Use given cutting-force data for a simple turning operation to estimate cutting power and discuss motor suitability. Deliverable: Calculation sheet with assumptions and conclusion.

Unit II	**Gear Manufacturing and CNC Programming**	**[07 Hr.]**

Introduction and classification of gear manufacturing, Gear milling, standard cutters and limitations, Indexing and numerical on indexing, Gear Hobbing, Gear Shaping, Gear Shaving and Gear Grinding processes, process-selection focus for automotive gears, gear finishing.

Thread Manufacturing: Various methods of thread manufacturing, thread rolling, die threading & tapping, Thread milling, Thread grinding etc., Rolled-thread applications and basic quality considerations.

CNC Programming-CNC part programming adaptable to suitable controller. Steps in developing CNC part program. CNC part programming for Lathe Machine – Threading & Grooving cycle (Canned cycle). CNC part programming for Milling Machine - Linear & circular interpolation, milling cutter, tool length compensation & cutter radius compensation. Pocketing, contouring & drilling, subroutine and Do loop using canned cycle

Real World Assignment

1. Automotive Gear Manufacturing Route: Select one gear from a gearbox or differential and prepare its manufacturing route from blank to finishing. Deliverable: Process flowchart with reasons for each operation.

2. Cut Thread vs. Rolled Thread Comparison: Compare the suitability of cut and rolled threads for a wheel stud, bolt or fastener. Deliverable: Short comparison table with final recommendation.

3. Tool Selection for Drilling and Tapping: Select drill size and tap type for a given threaded hole using standard tables. Deliverable: Calculation sheet and tool-selection note.

4. Gear Defect Identification: Study images or workshop samples of gear defects such as burrs, poor finish, pitting or profile error and relate them to manufacturing stages. Deliverable: Defect-cause-remedy chart.

5. Indexing Exercise for Gear Milling: Calculate indexing arrangement for a specified number of gear teeth using a dividing head. Deliverable: Stepwise calculation sheet.

Unit III	**Jigs & Fixtures**	**[07 Hr.]**

Importance of jigs and fixtures in mass production, Concept of Interchangeability, degree of freedom, six-point principle or 3-2-1 location method, Fundamental principles for the design of jigs and fixtures. Jigs Definition, locating methods and devices, Clamping principles, Drill bushes, Types of jigs- Template jig, Leaf jig, Box Jig or Tumble Jig, Indexing Jig, Angular post jig. Fixtures: Definition. Design principles of fixture, Types of fixtures- Turning fixture, grinding fixture, welding fixture, Indexing fixtures, Inspection fixtures. Numerical on simple jig or fixture design. Modular fixtures, CNC work-holding, quick-change fixtures, flexible fixtures and poka-yoke.

Real World Assignment

1. 3-2-1 Location Analysis: Choose a prismatic automotive component and identify the locating points required to restrict its degrees of freedom. Deliverable: Labelled sketch showing locators and clamps.

2. Drilling Jig Concept for a Bracket: Prepare a conceptual jig design for drilling holes in a simple mounting bracket. Deliverable: Hand sketch showing locators, clamp and drill bush.

3. Fixture Improvement Audit: Observe an available vice, clamp or fixture and suggest changes for safer and faster loading. Deliverable: Before-after sketch and improvement note.

4. Poka-Yoke in Work-holding: Develop a fool-proofing idea to prevent incorrect component orientation during machining. Deliverable: Short illustrated concept note.

5. Conventional vs. Modular Fixture Comparison: Compare conventional dedicated fixture and modular fixture for low-volume automotive parts. Deliverable: Comparison table with recommendation.

Unit IV	**Modern Machining Processes**	**[07 Hr.]**

Introduction to modern manufacturing processes, Need and classification of modern manufacturing methods. Introduction, Working Principle, equipment, process parameters, process-selection criteria material removal rates of Mechanical Energy Process machining processes : Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Ultra Sonic Machining (USM), Energy Assisted Modern Fabrication Process : Laser beam machining (LBM), Focused Ion beam (FIB) Electro-chemical Machining Process : Electro chemical machining (ECM), Photochemical machining (PCM) Electro-thermal Machining Process : Electric discharge machining (EDM), Wire Electric Discharge Machining (W-EDM). Introduction to micromachining and hybrid machining processes.

Real World Assignment

1. Process Selection for Difficult-to-Machine Component: Select a suitable modern machining process for a fuel-injector nozzle, turbine blade, die cavity or hardened gear profile. Deliverable: Decision matrix considering material, geometry, accuracy and cost.

2. EDM vs. W-EDM Application Study: Compare EDM and W-EDM for die cavity and profile-cutting applications. Deliverable: Illustrated comparison chart with suitable examples.

3. AWJM Application Audit: Identify three industrial components suitable for AWJM and explain why conventional machining may be difficult. Deliverable: Application table with limitations and safety points.

4. Laser Machining Safety Checklist: Study basic LBM hazards and prepare a laboratory or shop-floor safety checklist. Deliverable: One-page safety checklist.

5. Modern Machining Process Map: Prepare a selection chart linking AJM, USM, ECM, EDM, W-EDM and LBM with suitable work materials and applications. Deliverable: Visual process-selection map.

Unit V	**Additive Manufacturing**	**[08 Hr.]**

Introduction to AM, Classification of AM Processes (Process-based, material form based, application-based- direct and indirect processes and Micro- and Nano-additive processes), Light-Based Photo-curing: Stereolithography (SLA), Digital Light Processing (DLP), Laser-Based Melting: Selective Laser Sintering (SLS), Direct Metal Laser Sintering (DMLS), Selective Laser Melting (SLM). Extrusion-Based Deposition: Fused Deposition Modeling (FDM). Inkjet(droplet)-Based Deposition and Fusion: Multi-jet Modeling (MJM), Polyjet Printing, Nanoparticle Jet, Quality considerations and post-processing techniques: Requirements and Techniques, Support Removal, Sanding, Acetone treatment, Polishing. End-to-end CAD-to-print workflow, STL/3MF, slicing, build orientation, DfAM, defects, quality and automotive applications.

Real World Assignment

1. AM Process Selection for Automotive Part: Select a suitable AM process for a dashboard prototype, air duct, jig insert or lightweight bracket. Deliverable: Process-selection sheet with material and post-processing recommendation.

2. Build Orientation Study: Use a simple CAD model or sketch and compare two build orientations based on support requirement, surface finish and build time. Deliverable: Annotated sketches with recommendation.

3. DfAM Redesign Exercise: Redesign a simple conventional bracket for reduced weight while maintaining mounting points. Deliverable: Before-after sketch with design rationale.

4. AM Defect Identification: Study images of warping, porosity, delamination, support marks or poor surface finish and suggest corrective actions. Deliverable: Defect-cause-remedy table.

5. Automotive AM Case Study: Study one real automotive application of polymer or metal AM such as prototype tooling, customized fixture or lightweight part. Deliverable: One-page case study describing benefits and limitations.

Learning Resources

Text Books:

1. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley.
2. P. N. Rao, Manufacturing Technology, Vol. II: Metal Cutting and Machine Tools, McGraw Hill.
3. V. K. Jain, Advanced Machining Processes, Allied Publishers.
4. Ian Gibson, David Rosen, Brent Stucker and Mahyar Khorasani, Additive Manufacturing Technologies, Springer.
5. P. C. Sharma, A Textbook of Production Engineering, S. Chand.

Reference Books:

1. Amitabha Ghosh and Asok Kumar Mallik, Manufacturing Science, East-West Press.
2. H. M. T. Production Technology, Tata McGraw Hill.

3. J. A. McGeough, Advanced Methods of Machining, Springer.
4. ASTM International / ISO 52900 terminology and general principles for additive manufacturing (latest available edition).

Web References:

1. **https://nptel.ac.in/courses/112105127 - Introduction to Manufacturing and Machining**
2. **https://nptel.ac.in/courses/112105126 - Manufacturing Processes II**
3. **https://nptel.ac.in/courses/112103202 - Advanced Machining Processes**
4. **https://nptel.ac.in/courses/112103306 - Fundamentals of Additive Manufacturing Technologies**
5. **https://nptel.ac.in/courses/112104312 - Metal Additive Manufacturing**

Savitribai Phule Pune University, Pune Third Year of Automobile Engineering (2024 Course) PCC306-ABE: Automotive Design -I- LAB		
Teaching Scheme: **TH: NA** **PR:02 hrs./week**	**Credits:** **PR: 01**	**Examination Scheme:** **TW: 25** **CCE: NA**

Prerequisite 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. The preferred sizes, tolerances and types of fits. Construction of SMD and BMD. Roots of equations.

Prerequisites: -

1. Engineering Mathematics,
2. Engineering Graphics,
3. Solid Mechanics,
4. Engineering Materials.

Course Objectives: -

This course "Automotive Design-I-LAB" is designed with the following objectives:

1. **STUDY t**he basic design principles, design considerations & design procedures,
2. **SELECT** materials for a specific application by the use of design data book,
3. **EVALUATE** the stresses in machine components due to various types of loads and failure.
4. **WRITE** basic design equations for automotive components.
5. **DESIGN** various machine components such as shafts, couplings, keys, screws, joints, springs.
6. **PREPARE** working drawings based on designs

Course Outcomes: -

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

CO. 1 Use design data book to select material properties of parts to be designed such as Cotter Joint, Knuckle Joint, Rigid Muff Coupling, Flexible Bush Pin type coupling, Screw Jack and Toggle Jack,

CO.2 Write basic design equations based on different modes of failure of different parts to be designed such as Cotter Joint, Knuckle Joint, Rigid Muff Coupling, Flexible Bush Pin type coupling, Screw Jack and Toggle Jack,

CO.3 Design various machine parts of Cotter Joint, Knuckle Joint, Rigid Muff Coupling, Flexible Bush Pin type coupling, Screw Jack and Toggle Jack,

CO.4 Convert design dimensions into working/manufacturing drawing for Cotter Joint, Knuckle Joint, Rigid Muff Coupling, Flexible Bush Pin type coupling, Screw Jack and Toggle Jack,

CO.5 Apply CAD knowledge to convert manual drafting into computer aided drafting of Cotter Joint, Knuckle Joint, Rigid Muff Coupling, Flexible Bush Pin type coupling and Screw Jack.

Course Contents		
	Design Sheets	
Sheet - I		**06 Hrs.**

Design various parts of Cotter Joint/ Knuckle Joint, Also, draw part and assembly drawing with designed dimensions.

It will consist of design report and sheet based on Design of Cotter Joint/ Knuckle Joint. It will be done on one half imperial size (A2) sheets. Half part of the sheet is to be used for assembly drawing with part list and other half part of sheet is to be used for drawings of individual components.

Sheet - II		**06 Hrs.**

Design various parts of for Rigid Muff Coupling, Flexible Bush Pin type coupling. Also, draw part and assembly drawing with designed dimensions.

It will consist of design report and CAD sheet based on Rigid Muff Coupling, Flexible Bush Pin type coupling.

Prepare solid model of each part and assemble them by using any solid modeling software package. Extract three views of assembly on one sheet. Also, extract at least two views of every part on other sheet.

Sheet-III		**06 hours**

Design various parts of Screw Jack,/Toggle Jack, Also, draw part and assembly drawing with designed dimensions.

It will consist of design report and sheet based on Design of Power Screw. It will consist of two half imperial size (A2) sheets. One sheet is based assembly drawing with part list and other sheet is based on drawings of individual components.

Also, prepare solid model of each part and assemble them by using any solid modeling software package. Extract three views of assembly on one sheet. Also, extract at least two views of every part on other sheet.

	Assignments:	**06 hours**

Assignments: -

Four assignments based on syllabus units (Any Two).

A. Design of Levers, Design of components subjected to Combined Loading
B. Design of power transmission shafts such as gear box shaft, propeller shaft.
C. Design of power screw.
D. Numerical on design of m/c components subjected to variable stress

Books:

Text Book:

1. V. B. Bhandari, “Design of Machine Elements”, Tata McGraw Hill Publications, New Delhi.
2. Textbook of “Machine Design” By R.S.Khurmi and J.K.Gupta S. Chand Publication, New Delhi.

Reference Books:

A. J. E. Shigley and C. R. Mischke, “Mechanical Engineering Design”, McGraw Hill Inc. New York.
B. M. F. Spotts and T. E. Shoup, “Design of Machine Elements”, Prentice Hall International.
C. S. Hall, A. R. Holowenko and H. G. Laughlin, “Theory and Problems of Machine Design”, Schaum’s Outline Series.

Design Data Books:

1. P.S. G. College of Technology, Coimbatore, “Design Data Handbook”
2. K. Mahadevan, K. Balveera Reddy, “Design Data Handbook”

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

PCC307-ABE: Automotive HVAC Laboratory

Teaching Scheme		Credit	Examination Scheme	
Theory	**NA**	**1**	**PR**	**25 Marks**
Practical	**2 Hours/Week**		**CCE**	**NA**

Prerequisite Courses, if any:

Thermodynamics, Heat Transfer, Fluid Mechanics, Refrigeration & Air Conditioning, Psychrometry Automobile Engineering Basics, CFD & Simulation Tools (optional but valuable)

Course Objectives:

1. **Remember & understand** the fundamentals of automotive HVAC systems and heat load estimation.
2. **Apply** psychrometric principles to evaluate cabin comfort conditions.
3. **Analyze & Evaluate** refrigeration cycles and HVAC component performance.
4. **Use & evaluate** modern computational tools (CFD) to analyze cabin airflow and thermal comfort.
5. **Design & create** innovative HVAC solutions including automatic climate control, EV heat pumps, and cabin air quality systems with sustainability focus.

Course Outcomes:

1. CO1 – Explain fundamentals of automotive HVAC systems and perform heat load estimation. *(Remember, Understand)*
2. CO2 – Apply psychrometric principles to analyze comfort conditions in vehicle cabins. *(Understand, Apply)*
3. CO3 – Evaluate refrigeration cycles and HVAC components for performance. *(Apply, Analyze)*
4. CO4 – Use CFD and modern tools to analyze cabin airflow and thermal comfort. *(Analyze, Evaluate)*
5. CO5 – Design and assess modern HVAC technologies (automatic climate control, EV heat pumps, cabin air quality). *(Evaluate, Create)*

Course Contents

Practical's

Practical 1: Heat Load Estimation for Vehicle Cabin

Aim: To perform a detailed heat load estimation for a vehicle cabin under specified climatic conditions and determine the contribution of solar radiation, occupants, engine heat, and ventilation loads.

Deliverables

- Heat load calculation sheet.
- Breakdown of individual heat sources.
- Total cabin cooling load estimation.
- Analysis report with assumptions and conclusions.

Practical 2: Psychrometric Analysis of Cabin Air

Aim: To plot the cooling and dehumidification process of cabin air on a psychrometric chart and evaluate passenger comfort conditions based on ASHRAE standards.

Deliverables

- Psychrometric chart with process path.
- Calculated temperature, humidity ratio, and relative humidity values.
- Comfort zone analysis according to ASHRAE standards.
- Summary report of findings.

Practical 3: Simulation of Automotive Refrigeration Cycle

Aim: To simulate the vapor compression refrigeration cycle using R134a and R1234yf refrigerants and compare their thermodynamic performance.

Deliverables

- Refrigeration cycle diagrams.
- Thermodynamic property calculations.
- COP comparison table for R134a and R1234yf.
- Comparative performance report.

Practical 4: Performance Testing of HVAC Components

Aim: To evaluate the performance of compressor, condenser, and evaporator components on an HVAC test rig under varying operating conditions.

Deliverables

- Experimental data sheets.
- Performance curves for each component.
- Efficiency calculations under different loads.
- Test and evaluation report.

Practical 5: CFD Simulation of Cabin Airflow

Aim: To perform CFD analysis of airflow distribution inside a vehicle cabin and assess passenger thermal comfort using PMV and PPD indices.

Deliverables

- CFD model and simulation setup.
- Airflow velocity and temperature contour plots.
- PMV and PPD assessment results.
- Comfort analysis report.

Practical 6: Automatic Climate Control System Study

Aim: To study the working of an automatic climate control system and evaluate sensor-based regulation of cabin temperature and humidity

Deliverables

- Functional block diagram of climate control system.
- Sensor operation and control strategy analysis.
- Temperature and humidity regulation observations.
- Technical report.

Practical 7: HVAC Systems in Electric Vehicles

Aim: To investigate HVAC systems used in electric vehicles with emphasis on heat pump technology and compare their efficiency with conventional systems.

Deliverables

- Study of EV HVAC architecture.
- Heat pump system analysis.
- Efficiency comparison charts.

- Comparative technical report.

Practical 8: Cabin Air Quality Assessment

Aim: To evaluate cabin air quality using filters and sensors and recommend improvements for maintaining healthy indoor air conditions.

Deliverables

- Air quality measurement data.
- Filter performance evaluation.
- Pollutant analysis results.
- Design improvement recommendations report.

Practical 9: Comparative Study of Automotive Refrigerants

Aim: To compare refrigerants used in automotive HVAC systems and assess eco-friendly alternatives based on performance and environmental impact.

Deliverables

- Refrigerant property comparison table.
- Environmental impact assessment (GWP, ODP).
- Advantages and limitations of alternative refrigerants.
- Comparative study report.

Practical 10: Mini Project – HVAC Layout Design

Aim: To design an HVAC system layout for a bus or electric vehicle considering passenger capacity, climatic conditions, energy efficiency, and safety requirements.

Deliverables

- HVAC system layout drawing.
- Cooling load calculations.
- Component selection and justification.
- Project presentation and final report.

Practical 11: Industrial Visit and HVAC System Study

Aim: To gain practical exposure to automotive HVAC manufacturing, assembly, testing, and servicing practices through an industrial visit.

Deliverables

- Industrial visit report.
- Documentation of observed HVAC components and systems.
- Photographs and observations (if permitted).
- Summary of industrial practices and learning outcomes.

Textbooks

- Automotive Heating and Air Conditioning – James D. Halderman, Pearson Education.
- Automotive Air Conditioning and Climate Control Systems – Butterworth-Heinemann.
- Refrigeration and Air Conditioning – McGraw Hill Education.
- A Course in Refrigeration and Air Conditioning – Dhanpat Rai Publications.
- Fundamentals of HVAC Systems – Elsevier.
- Heating, Ventilating, and Air Conditioning: Analysis and Design – Wiley.
- Thermodynamics: An Engineering Approach – McGraw Hill.
- Fundamentals of Heat and Mass Transfer – Wiley.
- Computational Fluid Dynamics: The Basics with Applications – McGraw Hill.
- Vehicle Thermal Management Systems – SAE International.

Note: Any eight practical shall be performed from the given list

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

MDM321-ABE: Autotronics Laboratory

Teaching Scheme		Credits	Examination Scheme	
Theory	**NA**	**01**	**CCE**	**NA**
Practical	**02 Hours/Week**		**Term-work**	**25 Marks**

Prerequisite Courses: Basic Electronics Engineering, Basic Electrical Engineering, Electrical and Electronics Engineering, Applied Thermodynamics & Heat Transfer.

Course Objectives

1. To develop practical understanding of automotive electrical architecture, wiring harness, protection devices, earthing systems, instrument cluster and vehicle electrical circuits.
2. To perform testing and diagnosis of IC vehicle battery, power supply system, fuses, relays, voltage drop and common electrical faults using suitable instruments.
3. To demonstrate and evaluate the working, performance and faults of starting, charging and ignition systems used in IC engine vehicles.
4. To test and interpret signals from automotive sensors and actuators using mustimeter, oscilloscope, OBD scanner, diagnostic tool or suitable trainer kit.
5. To apply diagnostic procedures for engine management, safety and basic vehicle electronic systems through fault-code reading, live-data analysis and system-level troubleshooting.

Course Outcomes

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

1. ANALYZE vehicle electrical architecture, wiring harness, protection devices, instrument cluster indications, communication network basics and EMC-related issues.
2. SELECT, TEST and EVALUATE lead-acid battery condition, IC vehicle power supply, electrical protection and distribution systems.
3. TEST and DIAGNOSE starting, charging and ignition systems with respect to performance, faults and service requirements.
4. CLASSIFY, TEST and INTERPRET signals from automotive sensors and actuators using suitable diagnostic tools.
5. ANALYZE engine management, OBD, ABS/SRS/ADAS and safety systems and RECOMMEND suitable diagnostic or improvement actions

Laboratory Practical (Perform Any 8 Experiments)

Experiment 1: Vehicle Electrical Architecture, Wiring Harness and Instrument Cluster Study

Aim: To study the vehicle electrical architecture, wiring harness, fuse/relay protection, connectors, earthing points and instrument cluster indications.

Apparatus / Instruments: Vehicle or wiring harness trainer, wiring diagram/service manual, multimeter, test lamp, fuse/relay box, connector samples and PPE.

Procedure:

- Identify battery, fuse box, relay box, major wiring harness branches and earth/ground points.
- Trace circuits for lighting, horn, wiper, dashboard and charging indicator.
- Observe instrument cluster warning lamps during ignition ON and engine start.
- Prepare a wiring map showing power source, fuse/relay, switch, load and ground path.
- Note common faults such as open fuse, loose ground, corroded connector and wrong fuse rating.

Deliverable: Annotated wiring layout with photographs/sketches, fuse/relay identification table, instrument cluster warning-lamp observation table and fault-prevention checklist.

Experiment 2: Lead-Acid Battery Health Testing and Battery Selection

Aim: To evaluate the health of an IC vehicle lead-acid battery and select suitable batteries for different IC vehicle applications.

Apparatus / Instruments: 12 V battery, hydrometer, digital multimeter, battery load tester or conductance tester, battery charger, thermometer and PPE.

Procedure:

- Measure open-circuit voltage after suitable rest period.
- Measure specific gravity of each cell using hydrometer where applicable.
- Perform load test or conductance test as per equipment rating and safety instructions.
- Record battery Ah rating, reserve capacity and CCA rating from label/catalogue.
- Compare battery requirements for two-wheeler, passenger car, tractor and commercial vehicle.

Deliverable: Battery health report with test readings, condition conclusion, corrective action and comparative battery selection table for different IC vehicles.

Experiment 3: Voltage Drop, Parasitic Drain and Fuse/Relay Box Diagnosis

Aim: To diagnose IC vehicle power distribution problems using voltage-drop testing, parasitic drain measurement and fuse/relay box mapping.

Apparatus / Instruments: Vehicle or electrical trainer, digital multimeter, DC clamp meter or ammeter, fuse puller, test lamp, wiring diagram and PPE.

Procedure:

- Measure voltage drop across battery positive cable, ground cable and main supply path during cranking or load operation.
- Identify high-resistance points such as loose terminals, corroded clamps and poor earthing.
- Measure key-off parasitic current using safe series or clamp method.
- Remove fuses one by one to identify suspected drain circuit, if applicable.
- Map fuse/relay box circuits for starter, ignition, lights, horn and accessories.

Deliverable: Voltage-drop report, parasitic-drain diagnostic flowchart, labelled fuse/relay box chart and corrective-action list.

Experiment 4: Starter Motor Testing and No-Crank / Slow-Crank Diagnosis

Aim: To test starter motor operation and diagnose no-crank or slow-crank faults in IC engine vehicles.

Apparatus / Instruments: Starter motor with solenoid, starter test bench or vehicle, 12 V battery, DC clamp meter, multimeter, tachometer where available, wiring diagram and PPE.

Procedure:

- Study starter motor construction, solenoid terminals and starter drive mechanism.
- Measure battery voltage before and during cranking.
- Measure starter current draw and observe starter engagement.
- Check solenoid operation, starter relay command, terminal tightness and ground path.
- Prepare diagnostic chart for no-crank and slow-crank symptoms.

Deliverable: Starter motor testing report with circuit diagram, measured values, symptom-cause-remedy chart and safety precautions.

Experiment 5: Alternator Charging System Testing and Fault Diagnosis

Aim: To test alternator output, rectifier/regulator performance and diagnose overcharging/undercharging faults.

Apparatus / Instruments: Vehicle or alternator test bench, multimeter, DC clamp meter, oscilloscope if available, belt-tension inspection tools, wiring diagram and PPE.

Procedure:

- Identify alternator terminals, charging indicator circuit and battery connection.
- Measure battery voltage at engine OFF, idle and increased RPM.
- Measure charging current under electrical load, where equipment permits.
- Inspect drive belt condition, terminal tightness and ground path.

- Check AC ripple voltage or waveform to identify possible diode/rectifier fault, if oscilloscope is available.

Deliverable: Charging system test sheet with voltage/current readings, alternator circuit layout, possible fault diagnosis and maintenance recommendations.

Experiment 6: Ignition System and Spark Plug Testing

Aim: To study and test battery ignition, electronic ignition, CDI/COP systems and spark plug condition.

Apparatus / Instruments: Ignition trainer or vehicle, spark plug tester, ignition coil/HT coil tester, timing light, multimeter, spark plug gap gauge and PPE.

Procedure:

- Identify ignition system components and circuit connections.
- Inspect spark plug electrode, insulator, carbon fouling, oil fouling, overheating and gap.
- Test spark intensity using spark plug tester or ignition trainer.
- Measure primary/secondary resistance of ignition coil where applicable.

Study ignition timing or misfire symptoms using timing light/scanner/simulator data.

Deliverable: Spark plug condition chart, ignition component test readings, ignition system comparison table and misfire diagnostic notes.

Experiment 7: OBD-II Scan Tool, DTC Reading and Live Data Interpretation

Aim: To use OBD-II scan tool for reading diagnostic trouble codes, freeze-frame data and live parameters.

Apparatus / Instruments: OBD-II compliant vehicle or simulator, scan tool/ELM327 interface, mobile/laptop software, DTC reference sheet and PPE.

Procedure:

- Connect scanner to OBD-II port and identify ECU communication.
- Read stored/pending DTCs and freeze-frame data.
- Record live data such as RPM, coolant temperature, MAP/MAF, TPS, O2 sensor and fuel trim where available.
- Clear code only on simulator/trainer or after approval, and observe code reappearance if fault is present.
- Prepare a structured diagnostic path from symptom to final recommendation.

Deliverable: OBD diagnostic report with screenshots/data table, DTC meaning, live-data interpretation and repair recommendation.

Experiment 8: Automotive Sensor Testing using Multimeter / Oscilloscope / Scanner

Aim: To test and interpret signals from commonly used automotive sensors.

Apparatus / Instruments: Sensor trainer or vehicle, multimeter, oscilloscope/DSO if available, OBD scanner, regulated DC supply and sensor datasheets.

Procedure:

- Identify sensor type: resistive, voltage-generating, Hall-effect, inductive or digital.
- Test any three sensors from TPS, MAP, MAF, ECT, IAT, O2, CKP/CMP and wheel-speed sensor.
- Measure supply voltage, ground, signal voltage/frequency/resistance as applicable.
- Observe waveform using oscilloscope or live data using scanner.
- Compare measured values with expected ranges and identify normal/abnormal behavior.

Deliverable: Sensor test table, signal graphs/waveforms or live-data screenshots, interpretation and fault-diagnosis summary.

Experiment 9: Automotive Actuator Testing: Relay, Solenoid, Injector and PWM Actuator

Aim: To demonstrate and test automotive actuator operation and control signals.

Apparatus / Instruments: Relay board, solenoid/injector/stepper/PWM actuator trainer, injector pulse tester, multimeter, oscilloscope if available, low-voltage DC supply and PPE.

Procedure:

- Identify actuator type and control method: ON/OFF, duty-cycle/PWM, stepper or ECU-controlled.
- Test relay and solenoid operation using correct supply and protection fuse.
- Demonstrate injector pulse or idle actuator control using trainer/pulse tester.
- Measure coil resistance/current and observe duty cycle/waveform where possible.
- Discuss faults such as open coil, short circuit, stuck actuator and poor connector contact.

Deliverable: Circuit diagram, actuator test readings, waveform/duty-cycle observation, fault table and safety precautions.

Experiment 10: Engine Management and Vehicle Safety Systems Diagnostic Case Study

Aim: To analyze engine management and vehicle safety systems using available vehicle, trainer, scanner or case-study data.

Apparatus / Instruments: MPFI/CRDI vehicle or engine management trainer, OBD scanner, ABS/SRS/TPMS demo module or simulator, service literature and PPE.

Procedure:

- Study engine management layout: sensors, ECU, injectors, ignition/CRDI control and feedback signals.
- Record live data during idle, acceleration and deceleration where practical.
- Study ABS/SRS/TPMS/ADAS feature layout using scanner, trainer or service literature.
- Identify safety precautions for ABS/SRS handling and battery disconnection.
- Analyze one fault case such as high fuel trim, misfire, ABS warning lamp, SRS warning lamp or TPMS fault.

Deliverable: System block diagram, live-data/case-study interpretation, safety checklist and final diagnostic/improvement recommendation.

Experiment No. 11: Demonstration of ADAS Sensors and Study of Sensor Limitations

Aim: To demonstrate the working of basic ADAS sensors and study the effect of object distance, angle, lighting, surface condition and obstruction on sensor performance.

Apparatus / Instruments Required: ADAS sensor demonstration kit / trainer kit, ultrasonic sensor module, camera-based lane/object detection module, radar demonstration module if available, display unit / laptop, measuring tape, obstacle boards, reflective and non-reflective objects, white/black chart paper, cardboard targets, power supply and connecting wires.

Procedure:

- Identify the sensors available in the ADAS demonstration kit.
- Connect the kit as per manufacturer instructions and switch ON the system.
- Place obstacle targets at different distances and observe detection response.
- Change target position, angle and surface condition and note the change in sensor output.
- For camera-based demo, observe effect of lighting, lane markings or obstruction.
- Study calibration points, mounting position and alignment requirements.
- Record limitations and possible fault conditions.

Deliverables:

Sensor demonstration report including sensor block diagram, observation table, limitations, calibration awareness points and safety precautions.

Learning Resources

Text Books

1. P. L. Kohli, “Automotive Electrical Equipments”, Tata McGraw Hill Pub. Co. Ltd.
2. Tom Denton, “Automobile Electrical & Electronic Systems”, 3rd Edition, Elsevier Butterworth-Heinemann
3. William B. Ribbens, “Understanding Automotive Electronics”, 6th Edition, Newnes an imprint of Elsevier Science.

Reference Books

1. Allan W. M. Bonnick, “Automotive Computer Controlled Systems”, Butterworth-Heinemann.
2. V. A. W. Hilliers, “Fundamentals of Automotive Electronics”, Hatchin, London.
3. Tomwather J. R., Cland Hunter, “Automotive Computer & Control System”, Prentice Inc. NJ
4. Robert N. Brandy, “Automotive Computers& Digital Instrumentation”, Prentice Hall Eaglewood, Cliffs, NJ
5. Young, Griffithe, “Automobile Electrical & Electronic Equipments”, The English Language Book Co., London.

6. Henry W. Ott, "Electromagnetic Compatibility Engineering", John Wiley & Sons Inc., Publication
7. Clayton R. Paul "Introduction to Electromagnetic Compatibility", John Wiley & Sons Inc., Publication

MOOC / NPTEL/ YouTube Links: -

1. https://nptel.ac.in/courses/112106913

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

MDM322-ABE: Integrated Mechanism Lab.

Teaching Scheme		Credit	Examination Scheme	
Theory	NA	1	PR	25 Marks
Practical	2 Hours/Week		CCE	NA

Prerequisite Courses, if any:

Students should have a baseline understanding of:

1. **Engineering Mechanics:** Force systems, equilibrium equations, and structural friction boundaries.
2. **Kinematics and Dynamics of Machinery (KDOM):** Kinematic pairs, links, degrees of freedom, velocity and acceleration analysis, and turning moment profiles.
3. **Automotive Systems:** Foundational configurations of steering systems, multi-speed gearboxes, and suspension/drivetrain components.

Course Objectives:

1. To **FORMULATE** complete kinematic mobility constraints and calculate degree of freedom across 1D automotive linkage chains.
2. To **ANALYZE** complex velocity and acceleration profiles within operational high-speed reciprocating engine elements using both graphical vector polygons.
3. To **SYNTHESIZE** structural configurations of vehicle transmission systems, assessing profile interference thresholds in spur gears and torque capacities in epicyclic gear assembly.
4. To **EVALUATE** uniform wear and pressure boundaries across vehicular friction systems (clutches, drum/band brakes).
5. To **COMPUTE** multi-plane dynamic unbalance masses and 3D gyroscopic precession couples to optimize the cornering stability of two-wheeler and four-wheeler vehicle configurations.

Course Outcomes:

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

CO1: CALCULATE spatial mobility, degrees of freedom, and velocity variation curves for automotive mechanisms including steering gear systems and universal joint assemblies.

CO2: CONSTRUCT precise velocity and acceleration vector polygons to map kinematic rubbing limits and Coriolis forces inside slider-crank and suspension links.

CO3: SYNTHESIZE design metrics for vehicle transmission trains, confirming non-interfering gear profiles and evaluating holding torque requirements for epicyclic differentials.

CO4: FORMULATE mechanical load equations for single/multi-plate dry clutches and short-shoe/band braking linkages based on uniform pressure and wear parameters.

CO5: DETERMINE balancing arrays for multi-mass rotating hubs and calculate vehicle overturning margins caused by simultaneous gyroscopic and centrifugal couples.

Course Contents

Experiment-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**	**(02 Hours)**

Description: Perform structural tracing and kinematic mobility mapping on a physical motorcycle side-stand linkage mechanism. Students will isolate distinct kinematic pairs, measure link boundaries, and calculate the system's exact Degrees of Freedom (DoF) utilizing Kutzbach's criterion for planar mechanisms.

Exemplars / Practical Applications

Automotive Windshield Wiper Linkage, Boot Space Gas Strut Hinge, Scissor Jack, Bicycle Rear Derailleur Gear Shifting Linkage

Experiment-2	**Comparative Kinematic Analysis of Ackerman and Davis Steering Gear Layouts**	**(02 Hours)**

Description: Conduct a rigorous spatial study on functional bench-top models of Davis and Ackermann steering gear mechanisms. Measure track-arm lengths, tie-rod dimensions, and swivel-pin offsets to track slip angles across a full range of inner and outer wheel turning sweeps.

Exemplars / Practical Applications:

Modern Passenger Cars and SUVs, Heavy Industrial Forklifts and Material Handling Equipment, Understanding Why the Davis Mechanism is Obsolete, High-Performance Race Car Tuning (Parallel and Anti-Ackermann Geometry).

Experiment-3	**To design a simple Planer Mechanism by using any software (Geogebra, SAM, Working Model, any 3D Modelling Software, etc.)**	**(02 Hours)**

Description: Software like SAM or Working Model to profile complex four-bar or six-bar pick-and-place links, ensuring the output claws lift and drop components along exact, repeatable paths without colliding with factory enclosures.

Exemplars / Practical Applications:

Synthesizing Automated Machinery, Optimizing Vehicle Suspension Geometry, Developing Biomechanical Prosthetics & Exoskeletons, Sizing Aerospace Landing Gear Links.

Experiment-4	**To solve two problems on graphical method for kinematic analysis of mechanism.**	**(02 Hours)**

Description: Method uses a vector polygon where the known linear velocity of one point on a mechanism (like a crankpin) is drawn to scale. By drawing lines perpendicular to the remaining links from the vector origins, engineers can graphically isolate the exact intersection points to measure the linear velocities of other links and the angular velocities of connecting rods.

Exemplars / Practical Applications:

Determination of velocity, acceleration and displacement, inertial forces, Designing, Synthesis of components.

Experiment-5	**To study manufacturing of gear using gear generation with rack as a cutter and to generate an involute profile.**	**(02 Hours)**

Description: This method models the mechanical engagement between a gear blank and a moving rack cutter to generate a highly precise **involute tooth profile**. The rack cutter possesses straight-sided teeth (representing an infinite radius gear), while the gear blank rotates at a synchronized, proportional linear speed.

Exemplars / Practical Applications

Mass Production of Industrial Spur and Helical Gears, Pinion Sizing and Checking for Geometric Interference.

Experiment-6	**Speed and torque analysis of epicyclic gear train to determine holding torque.**	**(02 Hours)**

Description: Speed and torque analysis of an epicyclic (planetary) gear train involves tracking relative angular velocities and calculating internal power distributions across coaxial links (the sun gear, planet gears, carrier, and ring gear).

Exemplars / Practical Applications

Automobile Differential Assemblies, Automatic Transmissions and Torque Converters, Heavy Industrial Winches and Crane Hoists.

Experiment-7	**To draw cam profile for any two problems with combination of various follower motion with radial and off-set cam.**	**(02 Hours)**

Description: This process involves constructing a 2D geometric profile of a cam rotatory disk to deliver a precisely timed, custom lift trajectory to a radial or offset follower.

Exemplars / Practical Applications

Internal Combustion Engine Valve trains, Automotive Mechanical Fuel Injection Pumps, Automated Product Assembly and Packaging Machinery.

Experiment-8	**To verify cam, jump phenomenon for an eccentric cam**	**(02 Hours)**

Description: The cam jump phenomenon is a dynamic failure mode that occurs in high-speed cam-follower systems when the follower loses physical contact with the cam profile.

Exemplars / Practical Applications

High-RPM Engine Valve train Sizing, Valve Bounce and Noise (NVH) Suppression, Validating High-Speed Industrial Automation Cams.

Experiment-9	**To verify gyroscopic effect on a gyroscope setup**	**(02 Hours)**

Description: Verifying the gyroscopic effect using a motorized gyroscope setup involves analyzing the relationship between three orthogonal vector axes: the **axis of spin**, the **axis of precision**, and the **axis of gyroscopic couple**.

Exemplars / Practical Applications

Stabilizing Two-Wheeled and Four-Wheeled Vehicles During Cornering**,** Marine Ship Gyro-Stabilizers, Aerospace Attitude Control and Inertial Guidance Systems.

Experiment-10	**To verify dynamic balancing of rotating masses.**	**(02 Hours)**

Description: Verifying the dynamic balancing of rotating masses involves identifying and neutralizing both the **unbalanced centrifugal forces** and the **unbalanced centrifugal couples** acting across a high-speed rotating shaft.

Exemplars / Practical Applications

Automotive Engine Crankshaft and Flywheel Calibration, Industrial Gas Turbine and Turbocharger Rotor Sizing, Vehicle Wheel and Tyre Balancing.

Learning Resources

Text Books:

1. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune, 1st Edition, 2008.
2. S. S. Bhavikatti, Finite Element Analysis, New Age International Publishers, Third Edition, 2015.
3. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
4. G Lakshmi Narasaiah, Finite Element Analysis, BS Publications / BSP Books, 2nd edition, 2020.
5. J. N. Reddy, An Introduction to the Finite Element Method, Mcgraw Hill Series in Mechanical, 2005.

6. P. Seshu, Text book of Finite Element Analysis, PHI Learning Private Limited, New Delhi, 10th Printing, 2012.

Reference Books:

1. Bathe K. J., Finite Element Procedures Prentice, Hall of India (P) Ltd., New Delhi.
2. R. D. Cook, et al., Concepts and Applications of Finite Element Analysis. Wiley, India
3. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill
4. S. Moaveni, Finite element analysis, theory and application with Ansys, Prentice Hall
5. O.C. Zienkiewicz, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, Elsevier Butterworth-Heinemann, 2005.

MOOC / NPTEL/ YouTube Links: -

1. NPTEL – FEM Course by Prof. C.S. Upadhyay, IIT Kanpur
2. ANSYS Learning Hub — ansys.com/training (free student access)
3. SimScale Community — cloud-based FEA practice (free tier available)

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

MDM323-ABE: Advanced Manufacturing Laboratory

Teaching Scheme		Credit	Examination Scheme	
Theory	**NA**	**1**	**PR**	**50 Marks**
Practical	**2 Hours/Week**		**CCE**	**NA**

Prerequisite Courses, if any:

- Basic knowledge of Manufacturing Technology, Machining Processes, CAD/CAM, CNC Technology, Automation & Robotics.

Course Objectives:

After completing this course, students will be able to:

1) To understand the principles and operational concepts of advanced manufacturing systems including robotics, CNC machining, additive manufacturing, and flexible manufacturing systems.
2) To develop practical skills in CNC programming, robotic operations, machining processes, and digital manufacturing tools used in modern industries.
3) To analyze advanced manufacturing technologies such as IoT-enabled predictive maintenance, digital twin technology, non-traditional machining, and process simulation techniques.
4) To evaluate manufacturing systems and industrial practices related to lean manufacturing, Industry 4.0, group technology, and advanced surface engineering techniques.
5) To integrate digital and intelligent manufacturing approaches for improving productivity, flexibility, quality, and sustainability in industrial applications

Course Outcomes:

On completion of the course, Student will be able to

CO1: Demonstrate the operation and applications of robotics, CNC systems, additive manufacturing, and flexible manufacturing systems in industrial environments.

CO2: Prepare CNC part programs using G-codes and M-codes and perform machining operations using CNC machines.

CO3: Analyze modern manufacturing technologies including IoT-based monitoring, digital twin applications, non-traditional machining, and process simulation tools.)

CO4: Evaluate advanced manufacturing strategies such as lean manufacturing, Industry 4.0, group technology, and surface treatment techniques for industrial applications.

CO5: Apply digital manufacturing concepts and simulation tools to improve manufacturing efficiency, automation, and process optimization.

Course Contents

The list of practical’s is given below. Students are required to perform any eight practical’s from the given list.

1. Robotics in Manufacturing.
   - Programming a robotic arm for pick-and-place operations.
   - Application in assembly line automation.
2. CNC Machine Programming.
3. Prepare the manual CNC part programs using G-codes and M-codes for CNC lathe/milling machines.
4. Demonstration of additive manufacturing technology.
5. Machining of a mechanical component using CNC machines.
6. Manufacturing of any one assembly consisting of minimum two components and involving all the lathe operations.
7. Welding Automation.
   - Demonstration of robotic welding systems.
8. Smart Manufacturing & IoT Integration.
   - Demonstration of sensors and IoT devices in a manufacturing setup.
   - Data collection and monitoring for predictive maintenance.
9. Simulation of casting, forging, sheet metal, and plastic processing using free/open-source software.
10. Flexible Manufacturing Systems (FMS)
    - To study components, working principles, and industrial applications of Flexible Manufacturing Systems.
11. Industry Visit
    - Visit to an advanced manufacturing facility.
    - Report preparation and oral presentation.

Savitribai Phule Pune University, Pune

Maharashtra, India

TE - Automobile Engineering (2024 Pattern)

Semester - VI Courses

Savitribai Phule Pune University, Pune
Third Year of Automobile Engineering (2024 Course)
PCC351-ABE : Automotive Design II

Teaching Scheme:	Credits:	Examination Scheme:
TH: 04 hrs/week	TH: 03	CCE: 30 End-Sem: 70

Prerequisite Courses:

Students must possess a strong foundational grasp of core automotive engineering disciplines that govern materials, stress analysis, fluid film lubrication, and high-speed multi-link mechanism dynamics. This background is essential for transforming theoretical equations into durable automotive components—such as designing pistons to handle intense static stresses, sizing connecting rods to withstand sudden column buckling, tracking hydrodynamic oil film profiles inside sliding contact bearings, and computing flywheel masses to smooth out structural crankshaft torque fluctuations.:

Prerequisites: -

1. Engineering Mathematics
2. Engineering Graphics
3. Solid Mechanics
4. Engineering Metallurgy and Materials Science
5. Kinematics & Dynamics of Machines
6. Automotive Design I

Course Objectives: -

This course "**Automotive Design II**" is designed with the following objectives:

1. **UNDERSTAND** the fundamental principles of designing major internal combustion engine parts.
2. **ANALYZE** the mechanics behind energy-storing flywheels and valve-timing mechanisms.
3. **DESIGN** critical vehicle components like suspension springs, braking systems, and mechanical bearings.
4. **BRIDGE** the gap between textbook theory and real-world engineering through teardowns and practical design assignments.

Course Outcomes:-

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

CO 1: DESIGN Core Engine Components.

CO 2: DEVELOP Crankshafts and Valve Trains

CO 3: OPTIMIZE Kinetic Energy Storage Systems for engines & motors.

CO 4: FORMULATE Tribological and Bearing Selection Criteria.

CO 5: ANALYZE Springs & Brakes for vehicle systems.

Course Contents

Unit - I	Engine Design- Cylinder, Piston and Connecting rod	10 hours

Materials of different engine components,

Cylinder: Introduction, Stresses in cylinder wall of IC engine, Design of cylinder liner, cylinder head design.

Piston: Introduction, Empirical relationship for design of piston head, piston ribs, piston cup, piston ring & piston barrel. Design of piston skirt and piston pin.

Connecting rod: Introduction, Buckling of connecting rod, Design of big and small end bearings, Design of big end cap and bolts, Whipping stress in connecting rod.

Real World Assignment

1. Prepare a technical specification sheet (e.g., from a standard passenger hatchback or a multi-cylinder diesel truck) to justify engineering material selections based on real-world.
2. Determine structural wall safety of a heavy-duty diesel engine operating with a maximum internal gas combustion pressure by considering a real life single cylinder engine.

3 Apply column buckling theories to select and validate the optimal structural cross-section for a connecting rod shank.

Exemplar / Practical Applications

Materials Selection, Cylinder Component Design, Engine block, Piston Sub-Assembly Kinematics, Connecting Rod: Dynamic Links and Stress Management.

Unit - II	Engine Design- Crankshaft & Valve Mechanism	10 hours

Crankshaft: Introduction, Types of crankshaft and their construction, Design of center crankshaft at Top-Dead Centre position.

Valve-gear mechanism: Introduction, Design of valves, Ports, Rocker arm, Valve spring, Tappet, Push rod, Follower, Cam, Cam shaft & Pulley belt drive.

Real World Assignment

1 Design a center crankshaft layout subjected to pure maximum bending moments during peak firing pressure.

2 Design a valve train cam profile responsible for operating an exhaust valve of an IC Engine.

Exemplar / Practical Applications

Crankshaft: Dynamic Force Conversion and Geometry, Overhead Camshafts (OHC), Spring, Rocker arm, cam shaft, pulley, belt drive, valve timing.

Unit-III	Flywheels	8 hours

Introduction to flywheel, Flywheel and Governor, Torque analysis of flywheel, Coefficient of fluctuation of energy of flywheel. Torque-angle (T-Ө) Diagram for flywheel. Numerical treatment on applications of flywheel for electric motor, single cylinder & multi cylinder engine.

Design of solid disk and rimmed flywheel, Stresses in rimmed flywheel.

Real World Assignment

1 Perform Energy Fluctuation Analysis of a Punching Press Workshop.

2 Analyze the Turning Moment Diagram Integration for a Multi-Cylinder Powertrain and find out the mean torque.

3 Apply centrifugal force mechanics to validate structural safety margins against sudden rim fracturing.

Exemplar / Practical Applications

Flywheel Application (Cyclic Mitigation), Governor Application (Load-Demand Mitigation), Torque-Angle (T-Ө) Diagrams & Energy Fluctuation, Industrial Punching Presses and Shearing Machines, Regenerative Braking in Hybrid Transit Buses, Rimmed Flywheels (Low-Speed, High-Inertia Machinery), Solid Disk Flywheels (High-RPM Machinery).

Unit - IV	Design of Bearings	10 hours

Sliding Contact Bearing: Basic modes of lubrication, Application of Petroff's equation, Sommerfeld number & effect of temperature for Bearing design of the crankshaft of an engine.

Rolling Contact Bearing: Types of Rolling-contact Bearings, Static and dynamic load carrying capacities, equivalent bearing load, load life relationship, selection of bearing life, selection of rolling contact bearings.

Real World Assignment

1 Design a hydrodynamic sliding contact journal bearing for a centrifugal water pump profile.

2 Determine the combined radial and axial force vectors to establish a true representative dynamic engineering load.

Exemplar / Practical Applications

Engine Crankshaft and Main Journal Bearings, Turboid Machinery and Supercharger Shafts, Marine Propeller Shaft Sleeves, Deep Groove Ball Bearings (Automotive Alternators and Electric 2-Wheelers), Tapered Roller Bearings (Heavy-Duty Truck Axles and Wheel Hubs), Thrust Ball Bearings (Automotive Clutch Release Mechanisms).

Unit - V	Design of Springs & Brakes	10 hours

Springs: Types and applications of springs, Stress and deflection equations for helical compression Design of helical springs for suspension system of a vehicle, Springs in series and parallel, Spring Design for Fluctuating Stresses, Design of Multi-leaf springs for vehicles, Nipping of Leaf springs.

Brakes: Introduction, Types of brakes, Material, Design of band brake, Design of Internal expanding shoe brakes & disc brakes for vehicle braking system.

Real World Assignment

1 Design a leaf spring for new mid-sized urban delivery truck under sustained payloads.
2 Design a disc brake for bicycle.

Exemplar / Practical Applications

Suspension system, NVH, vehicle braking system, Drum brake, Disc Brake.

Books:

Text Books:

3. Bhandari V.B., Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.
4. R. S. Khurmi, J.K. Gupta, "A Text Book of Machine Design" Edition 11, Eurasia Publishing House.
5. S. P. Patil, "Mechanical System Design", Jaico Publications.

References Books:

1 V. L. Maleev, "I. C. Engine", McGraw Hill Book Co. Ltd., New Delhi, Second Edition
2 J.B. Heywood, "I. C. Engine Fundamentals", McGraw Hill Book Co., New Delhi.
3 Joseph E. Shigley & Larry D. Mitchell, "Mechanical Engineering Design", Sixth Edition, McGraw-Hill International Book Company
4 George E. Dieter, "Engineering Design- A Material and Processing Approach", Second Edition, McGraw-Hill International Edition
5 Paul H. Black & O. Eugene Adams Jr., "Machine Design", Third Edition, McGraw-Hill International Edition.
6 Juvinal R.C., Fundamentals of Machine Components Design, John Wiley and Sons.
7 Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.
8 C. S. Sharma and KamleshPurohit, Design of Machine Elements, PHI Learing Pvt. Ltd.
9 Design Data - P.S.G. College of Technology, Coimbatore.
10 Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd.
11 K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers.

MOOC / NPTEL/YouTube Links: -

1 https://www.youtube.com/watch?v=yI6bGBiL9Fw&list=PLyqSpQzTE6M9G2SNxKfsVEjcM9MlJau4F&index=4
2 https://www.youtube.com/watch?v=2XIdT7G3UGo&list=PLyqSpQzTE6M9G2SNxKfsVEjcM9MlJau4F&index=5
3 https://www.youtube.com/watch?v=OlZXxPVpmBs
4 https://www.youtube.com/watch?v=oZhR1HPdvR4&list=RDCMUC640y4UvDAlya_WOj5U4pfA&start_radio=1&rv=oZhR1HPdvR4&t=2844
5 https://www.youtube.com/watch?v=swgvKwyOnYk.

Savitribai Phule Pune University Third Year of Automobile Engineering (2024 Pattern)				
PCC352-ABE: Automotive Chassis and Transmission Systems				
Teaching Scheme		**Credits**	**Examination Scheme**	
Theory	**03 Hr./Week**	**03**	**CCE**	**30 Marks**
Practical	**NA**		**End-Semester**	**70 Marks**

Prerequisite Courses: Engineering Mechanics, Strength of Materials, Theory of Machines, Automobile Engineering Fundamentals.

Course Objectives

1. To understand vehicle layouts, chassis types, front axle construction, steering geometry and steering system requirements.
2. To explain the construction, working and application of suspension systems used in passenger and commercial vehicles.
3. To select suitable wheels, Tyres and braking systems for different vehicle operating conditions.
4. To analyze clutch, manual gearbox, driveline, final drive and differential systems used in automobiles.
5. To develop awareness of automatic, semi-automatic and continuously variable transmission systems with respect to layout, working and performance.

Course Outcomes

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

1. CLASSIFY vehicle layouts and ANALYZE chassis, front axle and steering system parameters for automobile applications.
2. EXPLAIN and COMPARE suspension systems, springs, dampers and ride-control elements used in vehicles.
3. SELECT suitable wheels, Tyres and braking systems and EVALUATE their performance and service requirements.
4. ANALYZE the construction, working and faults of clutches and manual gearboxes used in automobiles.
5. EXPLAIN and EVALUATE driveline, final drive, differential, rear axle and automatic transmission systems.

Course Contents

Unit I	**Vehicle Layouts, Chassis, Front Axle and Steering Systems**	**[07 Hr.]**

Classification of automobiles; types of vehicle layouts with reference to engine location and type of drive; chassis layouts for two-wheelers, three-wheelers, passenger cars, buses and trucks; functions and types of chassis frames; basic frame materials and cross-members; front axle functions and types; stub axle and wheel bearing; steering system requirements and layout; steering geometry - caster, camber, king pin inclination, toe-in, toe-out, included angle, scrub radius and self-centering action; Ackermann and Davis steering mechanisms; steering gear boxes; power steering and electric power steering overview; wheel alignment checking and common steering faults.

Real World Assignment

1. Vehicle Layout Comparison: Compare FF, FR, RR, 4WD/AWD and two-wheeler/three-wheeler layouts with respect to space utilization, traction, stability and serviceability.
Deliverable: Comparative chart with neat layout sketches and application examples.
2. Wheel Alignment Case Study: Study symptoms of incorrect caster, camber, toe and KPI using service data or vehicle observation.
Deliverable: Alignment parameter table with symptom-cause-remedy chart.
3. Steering Gearbox Selection: Compare rack and pinion, recirculating ball and worm-type steering gearboxes for passenger and commercial vehicles.
Deliverable: Selection matrix with advantages, limitations and applications.

4. Chassis Layout Audit: Observe a vehicle chassis or service manual and identify frame members, suspension mountings and steering layout.
Deliverable: Annotated chassis layout with photographs/sketches and component list.

Unit II	Vehicle Suspension Systems and Ride Control	[07 Hr.]

Road irregularities and need of suspension system; sprung and unsprung mass; ride comfort and road holding; suspension requirements; suspension springs - leaf spring, coil spring, torsion bar, rubber spring and air spring; characteristics of springs; independent front and rear suspension systems; MacPherson strut, double wishbone, trailing arm and multi-link suspension overview; shock absorbers - need, construction, working and types; anti-roll bar and stabilizer bar; roll centre and body roll; hydro-elastic suspension, air suspension, active and semi-active suspension overview; suspension inspection, noise, vibration and ride-related fault diagnosis.

Real World Assignment

1. Suspension Type Identification: Identify suspension layout of two selected vehicles and compare spring, damper and linkage arrangement.
Deliverable: Labelled sketches/photographs with comparison table.
2. Ride Comfort Observation: Study vehicle ride behaviour over speed breakers, potholes or uneven road conditions through controlled observation.
Deliverable: Observation sheet linking ride symptoms to suspension elements.
3. Shock Absorber Fault Case Study: Analyze symptoms of worn shock absorbers such as bouncing, nose dive, uneven tyre wear and poor road holding.
Deliverable: Diagnostic chart with causes, inspection method and corrective action.
4. Sprung and Unsprung Mass Study: Compare suspension components contributing to sprung and unsprung mass and their effect on ride and handling.
Deliverable: Short report with diagram and practical implications.

Unit III	Wheels, Tyres and Braking Systems	[07 Hr.]

Requirements of wheels and Tyres; types of road wheels and wheel assembly; wheel balancing; tyre construction, materials, tube and tubeless Tyres, cross-ply and radial Tyres; tyre size designation, aspect ratio, tread pattern, valve, inflation pressure, tyre rotation, tyre matching, tyre wear patterns and causes, tyre retreading and tyre selection for different applications. Braking system requirements; types of brakes; elementary theory of shoe brake; drum brake and disc brake arrangements; self-energizing action; brake friction materials; hydraulic brake system and components; brake fluids; air brakes, vacuum servo assistance, parking brake, dual-circuit brake, fail-safe braking, engine exhaust brake; braking ratio, weight transfer, brake efficiency and testing; ABS and anti-skid braking overview.

Real World Assignment

1. Tyre Selection for Indian Road Conditions: Select Tyres for two-wheeler, passenger car, tractor and light commercial vehicle considering load, speed rating, road condition and inflation pressure.
Deliverable: Tyre selection table with justification.
2. Tyre Wear Pattern Diagnosis: Study tyre wear patterns such as centre wear, edge wear, cupping and feathering and relate them to faults.
Deliverable: Tyre wear chart with probable causes and remedies.
3. Hydraulic Brake System Mapping: Prepare a hydraulic brake circuit map including master cylinder, wheel cylinder/caliper, lines, brake fluid and bleeding points.
Deliverable: Labelled brake circuit diagram with component functions.
4. Brake Performance Case Study: Analyze a case such as brake fade, spongy pedal, brake pull or poor braking efficiency.
Deliverable: Fault tree with inspection points and corrective measures.

Unit IV	Clutches and Manual Gearboxes	[07 Hr.]
Need, principle and functions of clutch; clutch requirements and torque capacity; cone clutch, single-plate clutch, diaphragm spring clutch, multi-plate clutch, centrifugal clutch, electromagnetic clutch and overrunning clutch; clutch lining materials; clutch control systems - mechanical, hydraulic and cable-operated; clutch faults and adjustments. Necessity and functions of gearbox; resistance to vehicle motion; gear ratio and tractive effort; requirements and types of gearboxes; sliding mesh, constant mesh and synchromesh gearboxes; synchronizing unit construction and working; helical gears; gear selector mechanism; two-wheeler gearbox; lubrication of gearbox; overdrive gears; common gearbox faults and service considerations.		
Real World Assignment **1. Clutch System Comparison:** Compare single-plate, multi-plate, centrifugal and diaphragm spring clutches used in two-wheelers and four-wheelers. **Deliverable:** Comparative table with sketches and application notes. **2. Clutch Fault Diagnosis:** Study clutch slipping, dragging, judder, noise and hard pedal cases using service literature or workshop observation. **Deliverable:** Symptom-cause-remedy chart. **3. Manual Gearbox Ratio Study:** Calculate gear ratios of a selected gearbox from tooth numbers or service data and relate them to vehicle performance. **Deliverable:** Gear ratio calculation sheet and performance interpretation. **4. Synchromesh Mechanism Study:** Study construction and working of synchronizer unit and explain gear shifting without gear clash. **Deliverable:** Neat sketch with working explanation and limitations.		
Unit V	**Driveline, Final Drive, Differential and Automatic Transmissions**	**[08 Hr.]**
Driving thrust and torque reaction; propeller shaft, slip joint, universal joint and constant velocity joint; Hotchkiss drive and torque tube drive; final drive purpose, final drive ratio and types; differential need, construction and working; differential lock, limited-slip differential overview and differential housing; rear axle functions, loads on rear axle, semi-floating, full-floating and three-quarter floating axles; final drive and axle lubrication. Fluid flywheel and torque converter - principle, construction, working, characteristics, advantages and limitations; epicyclic gear train and gear ratios; clutches and brakes in epicyclic gearboxes; hydraulic control system overview; semi-automatic and automatic transmission; CVT, AMT and DCT overview; transmission performance characteristics and service precautions.		
Real World Assignment **1. Driveline Layout Mapping:** Identify driveline components in front-wheel-drive, rear-wheel-drive and four-wheel-drive layouts. **Deliverable:** Driveline block diagrams with component functions. **2. Differential Working Case Study:** Explain vehicle turning with differential action and analyze need of differential lock/LSD in low-traction conditions. **Deliverable:** Working diagram with use-case explanation. **3. Final Drive Ratio Analysis:** Compare final drive ratios of passenger car, tractor and commercial vehicle and relate them to speed and tractive effort. **Deliverable:** Calculation table and interpretation. **4. Automatic Transmission Technology Comparison:** Compare torque converter AT, CVT, AMT and DCT based on working principle, efficiency, comfort, cost and applications. **Deliverable:** Comparative matrix with suitable vehicle applications.		
Learning Resources		
Text Books: 1. Kripal Singh, “Automobile Engineering-Vol. 1”, 13th Edition, Standard Publishers Distributors. 2. N. K. Giri, “Automotive Mechanics”, Khanna Publishers, Delhi, Eighth Edition		

3. C. P. Nakra, "Basic Automobile Engineering", Dhanpat Rai Publishing Company (Pvt) Ltd.

Reference Books:

1. Bosch "Automotive Handbook", Robert Bosch GmbH, Germany.
2. W. H. Crouse and D. L. Anglin, "Motor Vehicle Inspection",
3. Ramlingam , "Automobile Engineering" (Anna University)
4. Josepf Heitner , "Automotive Mechanics".
5. J.G .Giles "Vehicle Operation and Performance".
6. George Pieters, Barbara Pieters, "Automotive Vehicle Safety".
7. Jousha H. M, "Engine performance Diagnosis and Tune up Shop Manual".
8. Newton, Steed & Garrot, "Motor Vehicles", 13th Edition, Butterworth London
9. W. Judge, "Modern Transmission", Chapman & Hall Std., 1989,
10. Chek Chart, "Automatic Transmission", A Harper & Raw Publications,
11. Heisler, "Vehicle and Engine Technology", Second Edition, SAE International Publication

Web References:

1. https://nptel.ac.in/courses/107/106/107106088/
2. https://nptel.ac.in/courses/107/103/107103084/

Savitribai Phule Pune University Third Year of Automobile Engineering (2024 Pattern)				
PCC353-ABE : Vehicle Aerodynamics & Body Engineering				
Teaching Scheme		**Credit**	**Examination Scheme**	
Theory	**3 Hours/Week**	**3**	**CCE**	**30 Marks**
Practical	**–**		**End Sem**	**70 Marks**

Prerequisite Courses, if any:

- Prerequisites: Automobile Engineering, Fluid Mechanics, Heat Transfer.

Course Objectives:

After completing this course, students will be able to:

- **Remember & understand** the fundamentals of vehicle aerodynamics, forces, and moments.
- **Apply** fluid flow physics to vehicle body design and optimization.
- **Analyze** aerodynamic performance using experimental and computational techniques (CFD, wind tunnels).
- **Evaluate** ergonomics, safety, and structural aspects in body design.
- **Create** optimized vehicle body designs with aesthetic, functional, and sustainable considerations.

Course Outcomes:

On completion of the course, Student will be able to

- CO1: Identify aerodynamic forces and moments acting on vehicles.
- CO2: Understand fluid flow physics over vehicle bodies and optimization techniques.
- CO3: Apply experimental and computational methods (CFD, wind tunnels) for aerodynamic analysis.
- CO4: Demonstrate understanding of different vehicle body types and layouts.
- CO5: Illustrate ergonomics and safety applications in vehicle body design.
- CO6: Design vehicle bodies with aesthetic appeal and structural integrity.

Course Contents		
Unit I	**Fundamentals of Vehicle Aerodynamics (Remember, Understand)**	**(08 Hours)**

- **Scope and History of Vehicle Aerodynamics:** introduction, evolution of aerodynamic design, importance in vehicle performance, fuel economy and stability, present and future aerodynamic trends.
- **Flow Phenomena:** external flow around vehicle body, boundary layer, flow separation, wake formation, internal airflow in cabins, ventilation ducts and HVAC systems.
- **Drag and Lift on Aerofoils:** aerodynamic forces, lift and drag generation, pressure distribution, pressure drag, skin friction drag and induced drag.
- **Resistance to Vehicle Motion:** rolling resistance, aerodynamic resistance and gradient resistance

affecting vehicle performance and fuel consumption.

- **Passenger Car as Bluff Body:** bluff body characteristics, stagnation regions, wake regions and vortex formation around passenger cars.
- **EV Aerodynamics:** smooth underbody design, aerodynamic wheels, flush door handles, active grille shutters and drag reduction techniques in EVs.

CCE Activities:

- **CCE Assignment:** Prepare a report calculating drag and lift forces on a hatchback car using given dimensions and wind speed. Compare with published Cd values of popular Indian cars.
- **Real-Life Example:** Maruti Suzuki Swift (Cd ~0.32) vs Tesla Model S (Cd ~0.208) — showing how aerodynamics impacts fuel efficiency and EV range.

Unit II	Shape Optimization & Drag Reduction (Apply)	(07 Hours)

- **Drag Fractions and Low Drag Optimization:** contribution of front end, rear end, underbody, wheels and cooling airflow to aerodynamic drag, drag source analysis, streamlined body design, flow separation reduction and drag coefficient improvement techniques.
- **Aerodynamic Performance Improvement:** front and rear end modifications, bumper and diffuser design, windshield and A-pillar optimization, roof contour design, spoilers, air dams and wheel housing airflow management.
- **Body Shape Development Strategies:** aerodynamic design objectives, detail optimization, vehicle facelift considerations and aerodynamic adaptation of external attachments.
- **Water and Dirt Accumulation:** airflow effects on water and dust deposition, windshield contamination and aerodynamic cleaning strategies.
- **Active Aerodynamics:** adaptive spoilers, active grille shutters, deployable diffusers and variable aerodynamic devices for drag reduction, cooling control and vehicle stability.

Real World Assignment CCE Activities:

- CCE Assignment: Redesign the front fascia of a sedan in CAD to reduce drag. Justify modifications with reference to drag fractions (roof, windshield, rear end).
- Real-Life Example: Hyundai Ioniq and Mercedes EQS use smooth rooflines and flush door handles to minimize drag.

Unit III	Wind Tunnels, CFD & Wind Noise (Analyze)	(07 Hours)

Wind Tunnel Testing: principles of wind tunnel testing, airflow simulation, drag and lift measurement, flow visualization techniques, open and closed-circuit wind tunnels, climatic wind tunnel applications.

Simulation and Scale Models: limitations of aerodynamic simulations, reduced scale model testing, similarity parameters and scaling effects.

CFD Methodology: basics of CFD, meshing, boundary conditions, post-processing and turbulence models such as k-ε and k-ω models.

Wind Noise: virtual aerodynamic testing, wind noise generation around mirrors, pillars and gaps, cabin noise reduction techniques, digital twin simulations.

AI/ML Driven Aerodynamic Optimization: AI-based CFD optimization, machine learning assisted aerodynamic analysis and hybrid wind tunnel-CFD validation techniques.

Real World Assignment

CCE Activities:

- **CCE Assignment:** *Perform a CFD simulation of airflow around an Ahmed body. Compare results with wind tunnel data available in literature.*
- **Real-Life Example:** Mahindra Racing Formula E team uses CFD + wind tunnel validation

Unit IV	Car & Bus Body Details	(07 Hours)

- **Car Body Details:** car body types such as saloon, convertible, limousine, estate van, racing and sports cars; front assembly, roof structure, underfloor construction, bonnet and body panel integration.
- **Bus Body Details:** mini bus, single decker, double decker and articulated bus; floor height, engine location, entrance/exit arrangement, seating layout, passenger comfort, frame construction, double skin and integral construction, ergonomic layouts for EV buses and autonomous shuttles.
- **Regulations and Safety Design:** driver visibility requirements, visibility tests, mirror and glazing standards, passenger space management, crash safety and structural reinforcement**.**
- **Commercial Vehicle Body Details:** flat platform, tipper and tanker bodies, driver cabin design, chassis frame integration, load distribution, lightweight composite cabins and modular body structures.

CCE Activities:

- **CCE Assignment:** Prepare a comparative study of visibility and ergonomics in a sedan vs a city bus. Suggest design improvements for driver comfort and passenger safety.
- Design a tipper body layout for a commercial truck considering load distribution, driver cabin ergonomics, and safety standards.
- **Real-Life Example:** Volvo buses with ergonomic layouts and panoramic driver visibility vs compact hatchbacks with limited rear visibility.

Unit V	Body Loads & Ergonomics (Evaluate, Create)	(07 Hours)

- **Idealized Structures and Structural Surfaces:** load carrying structures, stressed skin construction and shear panel method.
- **Vehicle Load Distribution:** symmetric and asymmetric vertical loads, longitudinal load distribution and dynamic load transfer.
- **Ergonomics and Anthropometry:** driver workstation layout, human body dimensions, seat comfort and safety considerations.
- **Seats and Safety Systems:** types of seats, safety belts, energy absorbing systems and steering impact protection.
- **Automobile Bumpers:** bumper construction, impact absorption and pedestrian safety.
- **Crashworthy BIW and Smart Safety Systems:** composite BIW structures, airbags, ADAS safety systems and adaptive seating for autonomous vehicles.

CCE Activities:

- **CCE Assignment:** Conduct an ergonomic analysis of driver seating posture using anthropometric data. Suggest improvements in seat design and safety belt placement.

- **Real-Life Example:** Euro NCAP crash tests emphasize seat ergonomics, safety belts, and energy-absorbing steering systems in modern cars.

Learning Resources

Text Books:

1. J. Powloski, "Vehicle Body Engineering", Business Books Ltd., London.
2. W.H. Hucho, "Automotive aerodynamics"

References Books:

1. John Fenton, "Vehicle Body Layout & Analysis", Hutchinson, London.
2. Sydney F. Page, "Body Engineering", Chapman & Hill Ltd., London, 3rd Edition
3. J.G. Giles, "Body Construction and Design", Vol. 6, life Books/Butterworth & Co. London
4. P. L. Kohli, "Automotive Chassis & Body", Papyrus Publishing House, New Delhi.
5. Dr. V. Sumantran and Dr. Gino Sovram, Vehicle Aerodynamics Published by SAE International, USA
6. John Fenton, "Handbook of Automotive Body Construction and Design Analysis" Professional Engineering Publishing.

MOOC / NPTEL/ YouTube Links: -

- NPTEL: Vehicle Dynamics – IIT Madras
- NPTEL: Automobile Engineering – IIT Roorkee
- NPTEL: Introduction to CFD – IIT Kharagpur
- NPTEL: Applied Computational Fluid Dynamics – IIT Bombay
- NPTEL: Ergonomics in Automotive Design – IIT Guwahati
- SAE International – Vehicle Aerodynamics technical papers: SAE Vehicle Aerodynamics (sae.org in Bing)
- ANSYS Learning Hub – Automotive CFD tutorials: ANSYS Automotive CFD
- Skill-Lync – Automotive BIW Design & Development course: Skill-Lync BIW (skill-lync.com in Bing)
- Tata Motors Commercial Vehicle Body Builders Guide: Tata Motors CV
- UMTRI – Vehicle Ergonomics Research (University of Michigan): UMTRI Ergonomics (mreed.umtri.umich.edu in Bing)

Savitribai Phule Pune University, Pune
Third Year of Automobile Engineering (2024 Course)
PCC354-ABE: Automotive Design II- LAB

Teaching Scheme:	Credits:	Examination Scheme:
PR:02 hrs./week	PR: 02	TW: 25

Prerequisite Courses:

The basic understanding of material elastic behavior, failure modes, and the various theories of failure is necessary to evaluate the stresses in machine components due to various types of loads. Students require to have a strong foundational grasp of core automotive engineering disciplines that govern **materials, stress analysis, fluid film lubrication**, and **high-speed multi-link mechanism dynamics**.

Prerequisites: -

1. Engineering Mathematics,
2. Engineering Graphics,
3. Solid Mechanics,
4. Engineering Materials,
5. Kinematics & Dynamics of Machines,
6. Automotive Design I.

Course Objectives: -

This course “Automotive Design-II-LAB” is designed with the following objectives:

1. **ANALYZE** Material Selection and Engine Component Design requirements.
2. **EVALUATE** stresses in reciprocating parts, valve train, brakes and springs.
3. **DESIGN** engine components such as cylinders, pistons, and connecting rods using design data books.
4. **SYNTHESIZE** energy storage systems (Flywheels) and bearing selection criteria.
5. **PREPARE** working drawings and CAD models of internal combustion engine assemblies.

Course Outcomes: -

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

CO.1 USE design data book to select material properties and design parameters for IC engine components.
CO.2 WRITE design equations for parts like pistons, cylinders, connecting rods, springs, brakes and flywheels based on failure modes.
CO.3 DESIGN various parts of an IC engine including the cylinder assembly and valve mechanism.
CO.4 CONVERT design dimensions into manufacturing drawings for engine sub-assemblies.
CO.5 APPLY CAD software to generate 3D models and assembly drawings of engine components.

Course Contents

Tasks

Task - I	Design of Single Cylinder Engine Part Drawing (hand drawing)	06 Hrs.

Design various parts of Cylinder, Piston, Connecting Rod & Center Crankshaft. This includes Cylinder liner, Cylinder head, Studs, Piston head, Piston rings, Piston pin, Shank, Big end, small end of connecting rod and part of crankshaft. Draw part drawing with designed dimensions. It will consist of a design report and drawing on full size (A1) sheet.

Task - II	Design of Single Cylinder Engine Part Drawing (CAD drafting)	06 Hrs.

Design various parts for a valve mechanism. This includes valves, valve spring, valve guide, tappet, rocker arm, pushrod, cam lobes, cam shaft & belt drive connecting camshaft to crankshaft. Prepare solid models of valve mechanism parts using solid modeling software. Extract at least two views of each part drawing on CAD sheet.

Task-III	**Design of Single Cylinder Engine Assembly Drawing (CAD drafting & hand drawing)**	**06 hours**

Draw assembly drawing of Cylinder, Piston, Connecting Rod & Center Crankshaft on full size (A1) drawing sheet. Also, draft an assembly drawing of valve mechanism parts using any solid modeling software.

	Assignments:	**06 hours**

Assignments: -

Four assignments based on syllabus units (Any three with Assignment no. 4 compulsory).

1. Write the various Geometric dimensioning & Tolerancing symbol used in the industrial drawing.
2. Design of Flywheel for multi-cylinder engine.
3. Numerical on selection of bearings (both ball bearing & Sliding bearing) and brake design.
4. Design a suspension spring and its analysis using any analysis software. Also, verify analysis results (Maximum shear stress and maximum deflection) by using analytical method.

Books:

Text Book:

1. V. B. Bhandari, “Design of Machine Elements”, Tata McGraw Hill Publications, New Delhi.
2. Textbook of “Machine Design” By R.S.Khurmi and J.K.Gupta S. Chand Publication, New Delhi.

Reference Books:

1. J. E. Shigley and C. R. Mischke, “Mechanical Engineering Design”, McGraw Hill Inc. New York.
2. M. F. Spotts and T. E. Shoup, “Design of Machine Elements”, Prentice Hall International.
3. S. Hall, A. R. Holowenko and H. G. Laughlin, “Theory and Problems of Machine Design”, Schaum’s Outline Series.

Design Data Books:

2. P.S. G. College of Technology, Coimbatore, “Design Data Handbook”
2. K. Mahadevan, K. Balveera Reddy, “Design Data Handbook”

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

PCC355-ABE: Power Transmission Systems Lab

Teaching Scheme		Credits	Examination Scheme	
Theory	**NA**	**01**	**CCE**	**NA**
Practical	**02 Hours/Week**		**Practical**	**25 Marks**

Prerequisite Courses: Basic Electronics Engineering, Basic Electrical Engineering, Electrical and Electronics Engineering, Applied Thermodynamics & Heat Transfer.

Course Objectives

- To provide hands-on understanding of clutch, gearbox, driveline, final drive and differential systems used in automobiles.
- To perform dismantling, inspection, adjustment and assembly of power transmission components using standard tools and safety practices.
- To measure important parameters such as clutch free play, gear ratio, backlash, end play and component wear where applicable.
- To diagnose common transmission faults related to clutch slip, hard gear shifting, gear noise, vibration, backlash and leakage.
- To develop practical awareness of automatic transmission, CVT, torque converter and modern driveline systems using models, cut-sections or service data.

Course Outcomes

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

1. IDENTIFY and EXPLAIN the construction and working of clutch, gearbox, driveline, final drive and differential systems.
2. DISMANTLE, INSPECT, ASSEMBLE and ADJUST clutch and manual gearbox components using suitable tools and procedures.
3. MEASURE and INTERPRET gear ratio, backlash, free play, alignment and wear-related parameters in transmission systems.
4. DIAGNOSE common faults in clutch, gearbox, propeller shaft, universal joint, final drive and differential assemblies.
5. ANALYZE automatic transmission, CVT, torque converter and modern power transmission layouts using models, trainers or service literature.

Laboratory Practical (Perform Any 8 Experiments)

Experiment 1: Study of Vehicle Layouts and Power Transmission Path

Aim: To study different vehicle layouts and trace the power transmission path from engine to wheels.

Apparatus / Instruments: Vehicle/rolling chassis/cut-section model, service manual, measuring tape, marker tags, PPE.

Procedure:

• Identify engine location and drive type: FWD, RWD, 4WD/AWD, two-wheeler or three-wheeler layout.
• Trace power flow through clutch, gearbox, propeller shaft/drive shaft, final drive, differential and axle.
• Compare the layout with respect to space utilization, traction and service access.
• Prepare a labelled layout sketch showing all major transmission components.

Deliverable: Vehicle layout chart with power-flow diagram, component list and short comparison table.

Experiment 2: Two-Wheeler Clutch Dismantling, Inspection and Assembly

Aim: To dismantle, inspect, assemble and adjust a two-wheeler multi-plate clutch assembly.

Apparatus / Instruments: Two-wheeler clutch assembly/cut-section, spanner set, clutch holding tool, vernier caliper, feeler gauge, cleaning tray, PPE.

Procedure:

• Dismantle the clutch assembly as per safety procedure.
• Identify clutch plates, pressure plate, springs, hub, basket and release mechanism.
• Inspect friction plate wear, spring condition, warpage and oil contamination.
• Assemble the clutch and check free play/adjustment as per given data.

Deliverable: Clutch assembly sketch, inspection table, adjustment readings and fault-remedy notes.

Experiment 3: Four-Wheeler Clutch Inspection and Adjustment

Aim: To study construction, inspection and adjustment of a single-plate/diaphragm spring clutch used in four-wheelers.

Apparatus / Instruments: Clutch assembly, flywheel model, release bearing, pressure plate, clutch alignment tool, vernier caliper, feeler gauge, PPE.

Procedure:

• Identify clutch disc, pressure plate, diaphragm spring, release bearing and pilot bearing.
• Inspect lining thickness, rivet depth, uneven wear, spring damage and release bearing condition.
• Study clutch pedal free play or hydraulic clutch actuation on a vehicle/model.
• Prepare a fault chart for slipping, dragging, judder and noise.

Deliverable: Inspection report with labelled diagram, free-play/clearance data and symptom-cause-remedy chart.

Experiment 4: Manual Gearbox Gear Ratio Calculation and Gear Train Study

Aim: To study gear train arrangement and calculate gear ratios of sliding mesh/constant mesh/synchromesh gearbox.

Apparatus / Instruments: Manual gearbox model/cut-section, gear tooth counter, vernier caliper, service manual, calculator, PPE.

Procedure:

• Identify input shaft, output shaft, countershaft, gears, selector fork and synchronizer unit.
• Count gear teeth or use service data for each selected gear pair.
• Calculate gear ratios for available forward gears and reverse gear.
• Relate gear ratio to torque multiplication and vehicle speed.

Deliverable: Gearbox layout sketch, tooth-count table, gear-ratio calculations and interpretation.

Experiment 5: Synchromesh Gearbox Dismantling, Inspection and Assembly

Aim: To dismantle, inspect and assemble a synchromesh gearbox and study synchronizer operation.

Course Outcome Mapped: CO2, CO3, CO4

Apparatus / Instruments: Synchromesh gearbox, puller if available, circlip plier, spanner set, feeler gauge, dial gauge if available, cleaning tray, PPE.

Procedure:

• Dismantle gearbox sub-assemblies under supervision.
• Identify synchronizer hub, sleeve, blocker ring, dog teeth, selector mechanism and bearings.
• Inspect gear teeth, bearing condition, synchronizer wear and selector fork condition.
• Assemble the gearbox and check smooth gear shifting on bench.

Deliverable: Dismantling/assembly report with component identification chart, inspection observations and fault notes.

Experiment 6: Propeller Shaft, Universal Joint and Slip Joint Study

Aim: To study construction, alignment, wear and fault diagnosis of propeller shaft, universal joint and slip joint.
Apparatus / Instruments: Propeller shaft assembly, universal joint, slip joint, vernier caliper, dial gauge if available, grease gun, PPE.
Procedure:
• Identify yoke, cross, needle bearing, circlips, slip joint and balancing weights.
• Check universal joint play, lubrication condition and slip joint movement.
• Discuss vibration due to imbalance, worn UJ, incorrect phasing and misalignment.
• Prepare maintenance checklist for driveline inspection.
Deliverable: Propeller shaft component chart, inspection checklist and vibration fault-diagnosis table.

Experiment 7: Final Drive and Differential Dismantling, Inspection and Backlash Study

Aim: To study final drive and differential construction and inspect gear backlash and component condition.
Apparatus / Instruments: Differential/final drive assembly, spanner set, dial indicator with magnetic stand if available, marking compound, vernier caliper, PPE.
Procedure:
• Identify crown wheel, pinion, differential case, side gears, planet gears and bearings.
• Demonstrate differential action during straight running and turning.
• Measure or demonstrate backlash using dial indicator/model method.
• Inspect gear tooth contact pattern, wear, bearing play and lubrication condition.
Deliverable: Differential working sketch, backlash/inspection table, tooth-contact observations and fault-remedy chart.

Experiment 8: Rear Axle and Drive Shaft / CV Joint Study

Aim: To study rear axle types and inspect drive shaft/CV joint arrangement used in automobiles.
Apparatus / Instruments: Rear axle model, semi-floating/full-floating axle samples if available, FWD drive shaft/CV joint, tools, grease sample, PPE.
Procedure:
• Identify semi-floating, full-floating and three-quarter floating axle features using models/charts.
• Identify inner/outer CV joints, boots, splines and clamps in FWD drive shaft.
• Inspect CV boot damage, grease leakage, joint play and noise symptoms.
• Compare rear axle and FWD drive shaft applications.
Deliverable: Axle/CV joint comparison table, labelled sketches and fault-inspection checklist.

Experiment 9: Fluid Coupling, Torque Converter and Automatic Transmission Demonstration

Aim: To demonstrate working of fluid coupling, torque converter and automatic transmission components using model/cut-section/service data.
Apparatus / Instruments: Fluid coupling/torque converter cut-section, automatic transmission model, epicyclic gear train model, charts/videos/service manual, PPE.
Procedure:
• Identify pump, turbine, stator, one-way clutch and converter housing.
• Explain torque multiplication and coupling phase using model or chart.
• Study epicyclic gear train, clutches and brakes used in automatic transmission.
• Compare torque converter AT with manual gearbox.
Deliverable: Torque converter labelled diagram, epicyclic gear train observation sheet and comparison table.

Experiment 10: CV Joint and FWD Drive Shaft Demonstration Kit

Aim: To study the construction, working and application of constant velocity joints and front-wheel-drive shaft assembly used in modern passenger vehicles.
Apparatus / Instruments Required: CV joint and FWD drive shaft demonstration kit, tripod joint / Rzeppa joint model, half shaft assembly, boot clamp, grease sample, service manual, hand tools and PPE.
Procedure:

- Identify the main parts of the FWD drive shaft assembly: inner CV joint, outer CV joint, shaft, splines, boots, clamps and grease packing.
- Observe the working of CV joint at different steering angles.
- Demonstrate plunge movement of the inner joint due to suspension travel.
- Compare CV joint with universal joint in terms of torque transmission and angular movement.
- Inspect common faults such as torn boot, grease leakage, excessive play, clicking noise and worn splines.
- Discuss applications of CV joints in modern passenger cars.

Deliverables: Labelled diagram/sketch of FWD drive shaft assembly, component identification table, comparison of CV joint and universal joint, common fault diagnosis chart and safety precautions.

Experiment 11: CVT / AMT / DCT Transmission Study and Service Precautions

Aim: To study construction, working, applications and service precautions of CVT, AMT and DCT systems.
Apparatus / Instruments: CVT/AMT/DCT cut-section or demonstration model, service literature, scanner data/case study if available, PPE.
Procedure:
- Study basic layout of CVT belt-pulley mechanism, AMT actuator system and DCT clutch arrangement.
- Compare gear shifting method, driver comfort, efficiency and maintenance requirements.
- Identify common service precautions related to transmission fluid, actuator calibration and towing.
- Prepare application suitability for two-wheelers, passenger cars and commercial vehicles.

Deliverable: Technology comparison matrix, labelled layout sketches and service precaution checklist.

Learning Resources

Text Books:

1. Kripal Singh, “Automobile Engineering-Vol. 1”, 13th Edition, Standard Publishers Distributors.
2. N. K. Giri, “Automotive Mechanics”, Khanna Publishers, Delhi, Eighth Edition
3. C. P. Nakra ,“Basic Automobile Engineering”, Dhanpat Rai Publishing Company (Pvt) Ltd.

Reference Books:

- Bosch “Automotive Handbook”, Robert Bosch GmbH, Germany.
- W. H. Crouse and D. L. Anglin ,“Motor Vehicle Inspection”,
- Ramlingam , “Automobile Engineering” (Anna University)
- Josepf Heitner , “Automotive Mechanics”.
- J.G .Giles “Vehicle Operation and Performance”.
- George Pieters, Barbara Pieters, “Automotive Vehicle Safety”.
- Jousha H. M, “Engine performance Diagnosis and Tune up Shop Manual”.
- Newton, Steed & Garrot, “Motor Vehicles”, 13th Edition, Butterworth London
- W. Judge, “Modern Transmission”, Chapman & Hall Std., 1989,
- Chek Chart, “Automatic Transmission”, A Harper & Raw Publications,
- Heisler, “Vehicle and Engine Technology”, Second Edition, SAE International Publication

Web References:

1. https://nptel.ac.in/courses/107/106/107106088/
2. https://nptel.ac.in/courses/107/103/107103084/

Savitribai Phule Pune University, Pune
Third Year of Automobile Engineering(2024 Course)
PEC361A-ABE : Finite Element Analysis

Teaching Scheme: TH: 03 hrs./week	Credits: TH: 03	Examination Scheme: CCE: 30 End-Sem: 70

Prerequisite Courses:

Prerequisites: -

1. Prerequisites: Solid Mechanics,
2. Numerical and Optimization Methods,
3. Engineering Mathematics,
4. Manufacturing Processes,
5. Fluid Mechanics,
6. Heat and Mass Transfer.

Course Objectives: -

This course “Finite Element Analysis” is designed with the following objectives:

1. UNDERSTAND fundamentals of numerical and finite element methods.
2. FORMULATE finite element equations for engineering problems.
3. ANALYZE structural, thermal and dynamic systems using FEA.
4. APPLY finite element software tools for engineering applications.
5. EVALUATE engineering components under different loading conditions using simulation techniques.

Course Outcomes:-

After successful completion of the course, learner will be able to:
CO1: EXPLAIN the working of finite element analysis.
CO2: APPLY material properties and boundary condition to SOLVE 1D- stiffness matrices to obtain nodal or elemental solution.
CO3: APPLY material properties and boundary condition to SOLVE 2-D element stiffness matrices to obtain nodal or elemental solution.
CO4: EVALUTE Thermal Analysis problems .
CO 5: ANALYZE the results obtained and Factors influencing the results

Course Contents

Unit - I	Introduction of FEA	8 hours

Introduction of FEA: Brief History of FEM, general fem procedure, applications of fem in various field, advantages and disadvantages of fem, difference between FEM and FDM consistent units’ system, approximate methods of solving differential equations, weighted residual method (Galerkin method, variation method , Ritz method).

Real World Assignment

1 Identification of different types of finite elements used in automobile components.

2 Study of FEA applications in chassis and suspension systems.

3 Meshing practice for simple engineering geometries.

4 Comparison between analytical and FEA solutions for simple structures.

Exemplar / Practical Applications

- Automobile Chassis Analysis
- Engine Mount Bracket Analysis
- Leaf Spring Simulation

Unit - II	1D Elements	7 hours

Introduction to different approaches used in FEA such as direct approach, variational approach, weighted residual (Galerkin) for 1D elements. Types of 1D element. Displacement function, Global and local coordinate systems, Order of element, primary and secondary variables, shape functions and its properties. Bar, Beam and Truss Element - Element stiffness matrix, Assembling stiffness Equation, Load vector, and stress and reaction forces calculations.

Real World Assignment

1. Analysis of tie rod subjected to axial loading.
2. Temperature distribution analysis in automobile exhaust pipe.
3. Truss analysis of vehicle roof structure.
4. Comparison of linear and quadratic elements.

Exemplar / Practical Applications

- Connecting Rod Axial Stress Analysis
- Automotive Frame Member Analysis

Unit-III	2D Elements	7 hours

Types of 2D elements, Plane Stress, Plane Strain, axi-symmetric problems in 2D elasticity. Constant Strain Triangle (CST) - Element Stiffness matrix, Shape Function of CST , Shape function of Linear Strain Triangle (LSR) and Linear Strain Rectangle (LSR), compression of 2D elements.

Real World Assignment

1 Stress analysis of automobile wheel rim.

2 Analysis of brake disc under thermal loading.

3 Finite element modeling of pressure vessel.

4 Comparison of plane stress and plane strain conditions.

Exemplar / Practical Applications

- Disc Brake Thermal Analysis
- Wheel Rim Stress Distribution

Unit - IV	Thermal Analysis problems	7 hours

1D Steady State Heat Transfer Problems: Introduction, Governing differential equation, steady state heat transfer formulation of 1D element for conduction and convection problem, boundary conditions and solving for temperature distribution.		
Real World Assignment 1 Thermal analysis of piston crown.		
Exemplar / Practical Applications Disc Brake Thermal Analysis		
Unit - V	**FEA modelling Technique**	**7 hours**
Introduction to Commercial FEA Software, Pre-processing, Geometry Creation, Meshing Techniques, Material Assignment, material model, modelling of linear and nonlinear problem, Boundary Conditions, Solver Settings, Post-processing, Interpretation of Results, Convergence Study, Error Estimation, effects of mesh quality on results, priori and post error estimation, Case Studies in Automobile Engineering.		
Real World Assignment 1. Static structural analysis of knuckle joint using ANSYS/HyperMesh/Abaqus. 2. Stress analysis of alloy wheel. 3. Mesh convergence study for automobile bracket.		
Exemplar / Practical Applications 1. Piston Thermal Analysis **2.** Alloy Wheel Structural Simulation **3.** Automotive Bracket Optimization		
Books:		

Text Book:

1. S. S. Bhavikatti, Finite Element Analysis, New Age International Publishers, Third Edition, 2015.
2. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
3. G Lakshmi Narasaiah, Finite Element Analysis, BS Publications / BSP Books, 2nd edition, 2020.
4. J. N. Reddy, An Introduction to the Finite Element Method, Mcgraw Hill Series in Mechanical, 2005.
5. P. Seshu, Text book of Finite Element Analysis, PHI Learning Private Limited, New Delhi, 10th Printing, 2012.
6. Daryl L. Logan , 'A First Course in the Finite Element Method', Cengage Learning .

Reference Books:

1. K. J. Bathe, Finite Element Procedure, Prentice-Hall of India (P) Ltd., New Delhi, 1996.
2. Cook R. D., Finite Element Modeling for Stress Analysis, John Wiley and Sons Inc, 1995. 3. G.R. Liu S. S. Quek, The Finite Element Method- A Practical Course, Butterworth Heinemann, 2013.
4. Fagan M. J., Finite Element Analysis Theory and Practice, Harlow Pearson/Prentice Hall, 2012.
5. S. Moaveni, Finite element analysis, theory and application with Ansys, Pearson, Third Edition, 2011.
6. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill, 2017.
7. Mukhopadhyay M and Sheikh A. H., Matrix and Finite Element Analyses of Structures, Ane Books Pvt. Ltd., 2009
8. Daryl L. Logan, A First Course in the Finite Element Method, Fourth Edition, Thomson Canada

Limited, 2007.
9. O.C. Zienkiewicz, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, Elsevier Butterworth-Heinemann, 2005.
10. J. N. Reddy, An Introduction to Nonlinear Finite Element, Oxford University Press-New Delhi, 2014

MOOC / NPTEL/YouTube Links: -
https://nptel.ac.in/courses/112/104/112104116 /-for Basics of Finite Element Analysis by Prof.Nachiketa Tiwari, IIT Kanpur
https://nptel.ac.in/courses/112/106/112106130 /for Advanced Finite Element Analysis by Dr. R. Krishnakumar, Department of Mechanical Engineering, IIT Madras
https://nptel.ac.in/courses/112/103/112103299 /for Finite Element Analysis for Welding Analysis by Prof. Swarup Bag, Department of Mechanical Engineering, IIT Guwahati.

Savitribai Phule Pune University, Pune Third Year of Automobile Engineering (2024Course) PEC361B-ABE: Computational Fluid Dynamics		
Teaching Scheme: TH: 03 hrs./week	**Credits: TH: 03**	**Examination Scheme:** **CCE: 30** **End-Sem: 70**

Prerequisite Courses:

Prerequisites: -

1. Mathematics,
2. Physics,
3. Systems in Mechanical Engineering,
4. Engineering Thermodynamics,
5. Applied Thermodynamics,
6. Fluid Mechanics,
7. Numerical & Statistical Methods,
8. Heat & Mass Transfer,
9. Computer Aided Engineering

Course Objectives: -

This course "Fundamentals of Computational Fluid Dynamics" is designed with the following objectives in mind:

1. Students should be able to model fluid / heat transfer problems and apply fundamental conservation principles.
2. Students should be able to discretize the governing differential equations and domain by Finite Difference Method.
3. Students should be able to solve basic convection and diffusion equations and understands the role in fluid flow and heat transfer.
4. To prepare the students for career in industry in CAE through use of software tools.
5. To prepare the students for research leading to higher studies

Course Outcomes: -

On completion of the course the learner will be able to;

CO1.DISTINGUISH and ANALYSE the governing equations of fluid mechanics and heat

CO2.EXPLAIN different types of Discretization Techniques

CO3.ANALYZE and MODEL the 2D heat conduction problem

CO4.APPLY the numerical method to solve Convection – Diffusion system

CO5.EVALUATE the Incompressible fluid flow problem using Navier-Stoke's equation

CO6.USE a CFD tool effectively for practical problems and research.

Course Contents		
Unit - I	**Introduction to Computational Fluid Dynamics**	**8hours**

Introduction to Computational Fluid Dynamics, CFD as a research and design tool, Applications in various branches of Engineering, Derivation and physical interpretation of governing equations (conservation of mass, momentum and energy) in differential form, Concept of substantial derivative, divergence and curl of velocity, Mathematical behavior of Governing Equations and boundary conditions, Discretization methods for the CFD (FDM, FVM, FEM, Hybrid Methods), Intro to Meshless Methods, Meshed Vs Meshless Methods

Real World Assignment

1. Identification of CFD applications in automobile and aerospace industries.
2. Study of airflow around automobile bodies for drag reduction.
3. Comparison of meshed and meshless CFD methods for engineering problems.
4. Analysis of governing equations used in fluid flow and heat transfer problems.

Exemplar / Practical Applications

- Vehicle Aerodynamic Analysis
- Airflow Over Car Body
- Heat Transfer in Cooling Systems

Unit - II	Basic Discretization Techniques	7 hours

Introduction to grid generation (Types of grids such as structured, unstructured, hybrid, multiblock, Cartesian, body fitted and polyhedral etc.), Need to discretize the domain and governing equations, Finite difference approximation using Taylor series, for first order (Forward Difference Approximation, Backward Difference Approximation, Centra difference Approximation) and second order (based on 3 node, 4 node and 5 node points),explicit and Implicit approaches applied to 1D transient conduction equation, Couette flow equation ($\partial p/\partial x = 0$) using FTCS and Crank Nicholson's Method, Stability Criteria concept and physical interpretation, Thomas Tri-diagonal matrix solver

Real World Assignment

1. Generation of structured and unstructured grids for simple fluid domains.
2. Comparison of finite difference, finite volume and finite element methods.
3. Study of stability criteria in numerical simulations.
4. Solution of one-dimensional transient conduction equation using numerical methods.

Exemplar / Practical Applications

1. Mesh Quality Analysis
2. Numerical Simulation of Pipe Flow
3. Stability Analysis in CFD

Unit-III	Two Dimensional Steady and unsteady heat conduction	7 hours

Solution of two dimensional steady and unsteady heat conduction equation with Dirichlet, Neumann, Robbins and mixed boundary condition – solution by Explicit and Alternating Direction Implicit method (ADI Method), Approach for irregular boundary for 2D heat conduction problems.

Real World Assignment

1. Thermal analysis of automobile engine components.
2. Study of heat conduction through radiator fins.
3. Analysis of temperature distribution in brake discs.
4. Simulation of two-dimensional transient heat conduction problems

Exemplar / Practical Applications

- Radiator Heat Transfer Analysis
- Brake Disc Thermal Analysis
- Engine Cooling System Simulation

Unit - IV	Application of Numerical Methods to Convection – Diffusion system	7 hours

Convection: first order wave equation solution with upwind, Lax–Wendroff, Mac Cormack scheme, Stability Criteria concept and physical interpretation Convection –Diffusion: 1D and 2D steady Convection Diffusion system – Central difference approach, Peclet Number, stability criteria, upwind difference approach, 1 D transient convection-diffusion system

Real World Assignment

1. Analysis of convection heat transfer in automobile cooling systems.
2. Simulation of pollutant dispersion in exhaust systems.
3. Study of Peclet number effects in convection-diffusion problems.
4. Comparison of upwind and central difference schemes in fluid flow analysis.

Exemplar / Practical Applications

- Exhaust Gas Flow Simulation
- Convection Cooling Analysis
- Diffusion Analysis in Exhaust Systems

Unit - V	Incompressible fluid flow	7 hours

Solution of Navier-Stoke's equation for incompressible flow using SIMPLE algorithms and its variation (SIMPLER), Application to flow through pipe, Introduction to finite volume method.

Real World Assignment

1. Simulation of incompressible flow through pipes and ducts.
2. Analysis of fluid flow in fuel injection systems.
3. Study of SIMPLE algorithm for incompressible flow problems.
4. Investigation of pressure drop in automotive fluid systems.

Exemplar / Practical Applications

- Pipe Flow Analysis
- Fuel Injection Flow Simulation
- Internal Flow Analysis in Manifolds

Books:

1. Ghoshdastidar, P. S. (2017), "Computational Fluid Dynamics and Heat Transfer," Cengage learning, ISBN: 9788131533079
2. Atul Sharma, A., (2016), "Introduction to Computational Fluid Dynamics: Development, Application and Analysis," Wiley, ISBN: 9781119002994

3. Versteeg, H. K., Malalasekhara, W., (2007), "An Introduction to Computational Fluid Dynamics: The Finite Volume Method," PHI, ISBN: 9780131274983
4. Muralidharan, K., Sundarajan , T., (2009), "Computational Fluid Flow and Heat Transfer," Narosa Pub, ISBN: 9788173195228
5. Rao, J.S., (2017), "Simulation Based Engineering in Fluid Flow Design," Springer, ISBN: 9783319463810
6. Anderson, Jr., D. A. A (2017), "Computational Fluid Dynamics - the Basics with Applications," , McGraw Hill Education, ISBN: 9781259025969
7. Jaiman, R. K. and Joshi, V., (2022), "Computational Mechanics of Fluid-Structure Interaction: Computational Methods for Coupled Fluid-Structure Analysis," Springer, ISBN: 9789811653544

Reference Books:

1. Thompson, J. F., Soni, B. K., Weatherill, N. P., (1998), "Handbook of Grid Generation," CRC Press, ISBN: 9780849326875
2. Ferziger, J. H., Perić, M., Street, R. L., (2019), "Computational Methods for Fluid Dynamics,"Springer, ISBN: 9783319996912
3. Pletcher, R.H., Tannehill, J.C., Anderson, D.A., (2012), "Computational Fluid Mechanics and Heat Transfer," CRC Press, ISBN: 9781591690375
4. Patankar, S. V., (2017), "Numerical Heat Transfer and Fluid Flow," CRC Press, ISBN: 9781138564695
5. Chung, T. J., (2014), "Computational Fluid Dynamics," Cambridge University Press, ISBN: 9781107425255
6. Tu, J., Yeoh, G-H. and Liu, C., (2018), "Computational Fluid Dynamics: A practical approach," Butterworth-Heinemann, ISBN: 9780081011270
7. Date, A. W., (2005), "Introduction to Computational Fluid Dynamics," Cambridge University Press, ISBN: 9780521685337
8. Schlichting, H., Gersten, K., (2016), "Boundary-Layer Theory," Springer, ISBN: 9783662529171
9. Tennekes, H. and Lumley, J. L., (2018), "A First Course in Turbulence," The MIT Press, ISBN: 9780262536301
10. Wilcox, D.C., (1998), "Turbulence Modeling for CFD," DCW Industries, ISBN: 9780963605153
11. Paidoussis M. P., Price, S. and de Langre, E., (2011), "Fluid-Structure Interactions: CrossFlow-Induced Instabilities," Cambridge University Press, ISBN: 9780521119429
12. Bungartz, H-J. and Schäfer, M., (2006), "Fluid-Structure Interaction: Modelling, Simulation, Optimization," Springer, ISBN: 9783540345954

MOOC / NPTEL/YouTube Links: -

https://nptel.ac.in/courses/112107080

Savitribai Phule Pune University, Pune Third Year of Automobile Engineering (2024 Course) PEC361C-ABE : Automotive Control Systems		
Teaching Scheme: TH: 03 hrs./week	**Credits: TH: 03**	**Examination Scheme: CCE: 30 End-Sem: 70**

Prerequisite Courses:

- Systems in Mechanical Engineering,
- Programming and Problem Solving,
- Basic Electronics Engineering,
- Electrical and Electronics Engineering,
- Automobile Electrical and Electronics

Course Objectives: -

This course "Automotive Control Systems" is designed with the following objectives:

1. UNDERSTAND fundamentals of automotive control systems, sensors, actuators and feedback mechanisms used in modern vehicles.
2. ANALYZE mathematical models and dynamic behaviour of automotive systems using control engineering principles.
3. APPLY electronic control units (ECU), controllers and communication systems in engine and vehicle control applications.
4. DEVELOP knowledge of vehicle dynamics, stability control systems and intelligent automotive technologies.
5. EVALUATE modern automotive control systems such as ABS, adaptive cruise control, battery management systems and autonomous vehicle technologies.

Course Outcomes:-

On completion of the course the learner will be able to;

CO1. IMPART basic knowledge about the open loop and close system and modeling of a system

CO2. ACQUIRE the different order of a system with response and its stability concepts.

CO3. ANALYZE the PID controller and design a system with lead and lag compensator

CO4. DEVELOP the state space model for automotive systems

CO5. ANALYZE the model of vehicle control system

CO6. UNDERSTAND modern automotive systems and its requirements

Course Contents		
Unit - I	**Introduction**	**7 hours**

Open loop and closed loop systems-Transfer function of elements - Modeling of physical systems - Mechanical systems - Translational and Rotational systems - Thermal systems - Introduction to Block Diagrams - Signal Flow Graphs.

Real World Assignment

1 Identification of open loop and closed loop control systems used in automobiles.

2 Modeling of translational and rotational mechanical systems.

3 Development of block diagrams for automotive systems.

4 Analysis of thermal systems used in vehicle cooling applications.

Exemplar / Practical Applications

- Cruise Control System
- Power Steering Control
- Engine Speed Control

Unit - II	System Response	7 hours

First order, Second order control system response for Step, Ramp and Impulse inputs - Characteristic Equation, Poles and Zeroes concept.

Real World Assignment

1. Analysis of first order response in automotive temperature control systems.
2. Study of second order response in suspension systems.
3. Determination of poles and zeroes for automotive dynamic systems.
4. Comparison of step, ramp and impulse responses in vehicle applications.

Exemplar / Practical Applications

Suspension Response Analysis
Vehicle Speed Response
Engine RPM Control System

Unit-III	Stability Analysis	7 hours

Stability analysis- Routh Hurwitz stability criteria – stability in the frequency domain –gain and phase margins

Real World Assignment

- Stability analysis of automotive steering systems.
- Determination of gain margin and phase margin for vehicle control systems.
- Application of Routh-Hurwitz criteria for automotive systems.
- Investigation of frequency response characteristics in automobiles.

Exemplar / Practical Applications

- Vehicle Stability Analysis
- Steering Control Stability
- Frequency Response of Suspension System

Unit - IV	Control System Design	7 hours

Proportional, Integral, Derivative controllers, P, PI, and PID control - Design in the frequency domain- lead, lag compensator design		
Real World Assignment 1. Design and analysis of PID controller for cruise control systems. 2. Comparison of P, PI and PID controllers in automotive applications. 3. Design of lead and lag compensators for vehicle systems. 4. Investigation of controller performance in engine speed regulation.		
Exemplar / Practical Applications Cruise Control using PID Controller Engine Speed Regulation Electronic Throttle Control System		
Unit - V	**Modeling of Physical Systems**	**8 hours**
Fundamentals of State Space representation - State Models .Modeling of Suspension System Power steering System. ABS control systems –control of yaw dynamics – engine model for lambda control - knock control		
Real World Assignment • Development of state space model for suspension systems. • Modeling and analysis of power steering systems. • Simulation of automotive dynamic systems using state variables. • Comparative analysis of different automotive physical system models. • Study of Anti-lock Braking System (ABS) operation in vehicles. • Analysis of yaw dynamics control systems. •		
Exemplar / Practical Applications • Suspension System Modeling • Power Steering System • State Space Vehicle Model • Anti-lock Braking System (ABS) • Yaw Stability Control • Engine Knock Control System		
Books:		
Text Book: 1. Uwe Kiencke and Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", 2nd Edition, Springer, 2010		

1. I.J. Nagrath and M. Gopal, "Control Systems Engineering", 4th Edition, New Age International (P) Limited, 2006
2. Norman S. Nise, "Control Systems Engineering", 6th Edition, Wiley, 2010
3. Katsuhiko Ogata, "Modern Control Engineering", 5th Edition, Prentice Hall, 2009

MOOC / NPTEL/YouTube Links: -nptel.ac.in/courses/108106098

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

PEC362A- ABE: Vehicle Product Design and Development

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

Prerequisite Courses, if any: Students should have basic knowledge of:

Engineering Graphics and CAD, Manufacturing Processes, Automobile Engineering Fundamentals, Strength of Materials, Material Science, Basic CAE concepts, Electric Vehicle fundamentals

Course Objectives:

After completion of the course, students will be able to:

1. Understand the fundamentals of automotive product development processes, vehicle lifecycle stages, and industrial design methodologies. *(Bloom's Level: Understand – K2)*
2. Apply systematic engineering approaches for vehicle concept generation, product planning, ergonomics, and automotive system design. *(Bloom's Level: Apply – K3)*
3. Analyze automotive components and systems using CAD/CAE tools for design evaluation, manufacturability, and performance optimization. *(Bloom's Level: Analyze – K4)*
4. Evaluate prototype development methods, testing procedures, validation techniques, and reliability aspects of vehicle systems. *(Bloom's Level: Evaluate – K5)*
5. Develop sustainable and industry-oriented automotive product solutions using PLM, Industry 4.0, and emerging mobility technologies. *(Bloom's Level: Create – K6)*

Course Outcomes:

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

CO1	**Explain** the stages of automotive product development, customer requirements, and vehicle design methodologies.
CO2	**Apply** concept generation and system engineering techniques for development of vehicle layouts and automotive subsystems.
CO3	**Analyze** automotive components using CAD/CAE tools for structural, ergonomic, and manufacturability considerations.
CO4	**Evaluate** prototype development, testing, validation, and reliability procedures for automotive products.

CO5	**Develop** sustainable and technology-driven automotive product solutions using PLM, Industry 4.0, and smart mobility concepts.

Course Contents		
Unit I	**Fundamentals of Vehicle Product Development**	**(08 Hours)**

Introduction to Vehicle Product Development: need of product development, product lifecycle in automotive industry, role of design and development teams.

Stages of Vehicle Development: concept development, feasibility study, prototype development, pilot production, mass production.

Product Planning and Benchmarking: product planning process, competitor benchmarking, vehicle performance comparison.

Automotive Market and Customer Analysis: market segmentation, customer requirements, Voice of Customer (VOC), customer expectation mapping.

Automotive Standards and Regulations: safety regulations, emission norms, BS-VI regulations, homologation overview.

Introduction to Electric Vehicle Development: EV architecture basics, battery electric vehicles, hybrid electric vehicles, EV market trends.

Real World Assignment

CCE Assignments

1. Benchmark any two passenger vehicles based on performance, features, safety and cost.
2. Study the development stages of an Electric Vehicle (EV).
3. Prepare a report on BS-VI regulations and their impact on vehicle design.
4. Conduct customer requirement analysis for a compact SUV.

Exemplar / Practical Applications:

- Development cycle of Tata Motors Nexon EV
- Vehicle benchmarking between Hyundai Creta and Kia Seltos
- BS-VI emission compliance implementation in passenger cars
- Product planning for compact urban EVs

Unit II	**Vehicle Concept Design and System Engineering**	**(07 Hours)**

Product Requirement Specification (PRS): functional requirements, performance requirements, safety requirements, cost targets.

Concept Generation Techniques: brainstorming, morphological analysis, functional decomposition, concept screening.

Vehicle Architecture Selection: front engine layout, rear engine layout, mid-engine layout, FWD, RWD and AWD systems.

Chassis and Powertrain Layout: ladder frame chassis, monocoque chassis, powertrain integration, transmission layout.

EV Battery Packaging: battery placement methods, thermal management basics, weight distribution, packaging constraints.

Ergonomics and Vehicle Packaging: driver seating position, human comfort factors, visibility considerations, cabin space optimization.

Concept Evaluation: Pugh matrix method, feasibility analysis, performance comparison, cost-performance trade-off.

CCE Assignments

1. Develop conceptual layout of an electric scooter or compact EV.
2. Prepare Product Requirement Specification (PRS) for a city commuter vehicle.
3. Compare FWD, RWD and AWD systems with suitable applications.
4. Design ergonomic seating layout for a passenger vehicle cabin.

Exemplar / Practical Applications

- Skateboard platform used in modern EVs
- Monocoque chassis design in passenger cars
- Battery packaging in electric scooters
- Ergonomic dashboard design in premium vehicles

Unit III	Automotive Product Engineering and CAE	(07 Hours)

Design for Manufacturing (DFM): manufacturing constraints, ease of production, cost-effective design, tolerance considerations.

Design for Assembly (DFA): assembly sequence, fastener reduction, modular assembly concepts, serviceability.

Automotive Material Selection: steel alloys, aluminium alloys, composite materials, lightweight materials.

CAD Modeling: 2D drafting, 3D part modeling, surface modeling, assembly modeling.

Finite Element Analysis (FEA): meshing basics, boundary conditions, static structural analysis, stress and deformation analysis.

Crashworthiness Basics: impact loading, energy absorption, structural reinforcement, safety zones.

NVH (Noise, Vibration and Harshness): vibration sources, noise reduction methods, ride comfort, vibration isolation.

Lightweight Vehicle Design: weight optimization, material substitution, structural optimization, fuel efficiency improvement.

CAE Software Exposure: CATIA, SolidWorks, ANSYS, HyperMesh.

CCE Assignments

1. Create CAD model of an automotive component using Modeling tools.
2. Perform basic FEA on suspension bracket or chassis member.
3. Study lightweight materials used in modern automobiles.
4. Analyze crashworthiness features of any passenger vehicle.

Exemplar / Practical Applications

- Lightweight aluminium body structures in EVs
- Crash simulation in modern passenger vehicles
- NVH improvement in luxury vehicles
- CAD/CAE-based chassis optimization

Unit IV	Prototype Development, Testing and Validation	(07 Hours)

Prototype Development: physical prototypes, digital prototypes, functional prototypes, prototype fabrication methods.

Rapid Prototyping Techniques: 3D printing, additive manufacturing, CNC prototyping, laser cutting.

Prototype Stages: alpha prototype, beta prototype, pre-production prototype, production prototype.

Vehicle Testing Procedures: performance testing, road testing, brake testing, suspension testing.

Durability and Reliability Testing: fatigue testing, life cycle testing, environmental testing, reliability prediction.

Failure Analysis: Failure Mode and Effects Analysis (FMEA), root cause analysis, corrective actions, risk assessment.

Design Verification and Validation: Design Verification Plan and Report (DVP&R), validation procedures, compliance testing, quality assurance.

Homologation Basics: regulatory approvals, vehicle certification, safety compliance, emission compliance.

CCE Assignments

1. Prepare prototype development plan for a vehicle subsystem.
2. Develop testing and validation procedure for brake or suspension system.
3. Perform Failure Mode and Effects Analysis (FMEA) for an automotive component.
4. Prepare DVP&R sheet for an EV battery enclosure or chassis component.

Real World Examples

- 3D printed automotive prototype components
- Durability testing of suspension systems
- Crash testing procedures for passenger vehicles
- EV battery thermal validation testing

Unit V	PLM, Industry 4.0 and Sustainable Mobility	(07 Hours)

Product Lifecycle Management (PLM): product data handling, lifecycle stages, engineering change management, collaborative development.
Product Data Management (PDM): design data storage, BOM management, version control, documentation management.
Industry 4.0 in Automotive Manufacturing: smart factories, IoT in manufacturing, cyber-physical systems, automation and robotics.
Digital Manufacturing Systems: digital twins, virtual manufacturing, simulation-based production, real-time monitoring.
Reverse Engineering: 3D scanning, CAD reconstruction, product redesign, dimensional inspection.
Sustainable Automotive Design: green manufacturing, eco-friendly materials, energy-efficient vehicles, sustainable mobility concepts.
Vehicle Recycling and Carbon Reduction: end-of-life vehicle recycling, recyclable materials, carbon footprint reduction, circular economy concepts.
Connected and Autonomous Vehicles: vehicle connectivity, ADAS basics, autonomous driving concepts, smart mobility systems.

CCE Assignments

1. Prepare report on Industry 4.0 applications in automotive manufacturing.
2. Study PLM implementation in automotive industries.
3. Analyze sustainability practices adopted in EV manufacturing.
4. Prepare case study on connected or autonomous vehicle technologies

Exemplar / Practical Applications

- Smart manufacturing in automotive assembly plants
- Digital twin technology in vehicle production
- Vehicle recycling systems and circular economy
- ADAS and connected vehicle technologies

Learning Resources

Text Books:

- Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw Hill Education.
- Richard Stone and Jeffrey K. Ball, Automotive Engineering Fundamentals, SAE International.
- James D. Halderman, Automotive Technology: Principles, Diagnosis and Service, Pearson Education.
- William F. Milliken and Douglas L. Milliken, Race Car Vehicle Dynamics, SAE International.

Gillespie Thomas D., Fundamentals of Vehicle Dynamics, SAE International.

Reference Books:

- Pawlowski, Vehicle Body Engineering, Springer Publications.
- Bosch, Automotive Handbook, Robert Bosch GmbH.
- Reimpell, Stoll and Betzler, The Automotive Chassis: Engineering Principles, SAE International.
- Heisler Heinz, Advanced Vehicle Technology, Butterworth-Heinemann.
- Degarmo, Materials and Processes in Manufacturing, Wiley Publications.
- Juvinall and Marshek, Fundamentals of Machine Component Design, Wiley Publications.
- Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson.

MOOC / NPTEL/YouTube Links: -

SAE International – Automotive Engineering Resources **— Vehicle engineering, automotive standards, mobility systems, product development.**

NPTEL Engineering Courses **— Product design, manufacturing, CAD/CAM, automobile engineering.**

CATIA Official Learning Platform **— 3D modeling, surface design, assembly design, automotive body design.**

ANSYS Student Learning Resources **— FEA, CFD, crash simulation, structural and thermal analysis.**

EICTA Vehicle Design and Analysis Course **— Vehicle design, CAD, CAE, motion simulation, ANSYS applications.**

MATLAB & Simulink Academy **— Vehicle dynamics, EV simulation, control systems, powertrain modeling.**

Siemens Digital Manufacturing — PLM, Industry 4.0, digital twins, smart manufacturing.

DIYguru Automotive Design & Simulation **— CAD, CAE, vehicle dynamics, EV systems, suspension and steering simulation.**

SolidWorks Student Resources — Part modeling, assemblies, simulation and drafting.

Skill-Lync Automotive Resources **— BIW design, EV technology, CAD/CAE, GD&T, automotive product design.**

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

PEC362B-ABE: Automotive Driver Assistance Systems

Teaching Scheme		Credits	Examination Scheme	
Theory	**03 Hr./Week**	**03**	**CCE**	**30 Marks**
Practical	**NA**		**End-Semester**	**70 Marks**

Prerequisite Courses: Automotive Electrical and Electronics Systems, Automobile Engineering Fundamentals, Vehicle Dynamics Basics, Sensors and Instrumentation, Basic Electronics Engineering.

Course Objectives

1. To introduce the need, scope, terminology, levels of automation and safety relevance of automotive driver assistance systems.
2. To develop understanding of ADAS sensors, perception principles, sensor limitations, calibration needs and vehicle communication requirements.
3. To explain the working of common driver assistance features related to longitudinal, lateral, parking, visibility and driver monitoring functions.
4. To familiarize students with ADAS control logic, sensor fusion basics, human-machine interface and interaction with braking, steering and powertrain systems.
5. To develop awareness of ADAS testing, validation, Indian road challenges, functional safety, cybersecurity and regulatory considerations.

Course Outcomes

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

CO1. EXPLAIN ADAS terminology, system architecture, levels of automation, safety objectives and vehicle-level integration.

CO2. CLASSIFY and COMPARE ADAS sensors, perception methods, communication networks and calibration requirements.

CO3. ANALYZE the working of longitudinal, lateral, parking, visibility and driver monitoring assistance systems.

CO4. INTERPRET basic sensor fusion, control logic, HMI and actuator interface used in ADAS features.

CO5. EVALUATE ADAS testing, validation, functional safety, cybersecurity, regulatory and Indian road implementation challenges.

Course Contents

Unit I	Introduction to ADAS and Vehicle-Level Architecture	[07 Hr.]

Need and scope of Advanced Driver Assistance Systems; active safety, passive safety and driver assistance; ADAS terminology; SAE levels of driving automation with emphasis on Level 0 to Level 2 systems; block diagram of ADAS; vehicle, driver and environment interaction; basic architecture consisting of sensors, ECU/domain controller, communication network, actuators and HMI; overview of longitudinal, lateral, parking and driver monitoring assistance; role of ADAS in reducing driver error and improving road safety; limitations, misuse and driver responsibility; Indian road conditions and ADAS adoption challenges.

Real World Assignment

1. **ADAS Feature Identification in Modern Vehicles:** Prepare a feature list of ADAS functions available in two Indian passenger vehicles using brochures/service information. Objective: To understand ADAS terminology, feature classification and vehicle-level purpose. Deliverable: Comparative table of ADAS features with vehicle application and safety relevance.
2. **ADAS System Block Diagram:** Draw a block diagram of a selected ADAS feature such as AEB, ACC, LDWS or parking assist. Objective: To identify sensor, controller, actuator and HMI interaction. Deliverable: Labelled system block diagram with signal-flow explanation.
3. **SAE Automation Level Case Study:** Classify selected vehicle features under SAE Level 0, 1 or 2. Objective: To distinguish driver assistance from automated driving. Deliverable: Short report with justification and driver responsibility notes.
4. **Indian Road Challenge Report:** Observe real traffic situations and identify ADAS limitations due to mixed traffic, lane discipline, animals, pedestrians or weather. Objective: To connect ADAS theory with Indian operating conditions. Deliverable: Field observation report with photographs/sketches and limitation analysis.

Unit II	ADAS Sensors, Perception and Communication	[07 Hr.]

ADAS sensors: camera, radar, ultrasonic sensor, lidar, GPS/GNSS and IMU; working principles, range, field of view, resolution, advantages and limitations; sensor mounting locations and environmental effects such as rain, fog, dust, glare, shadows and occlusion; object detection, lane detection, distance measurement, relative speed estimation and road sign recognition basics; introduction to sensor fusion and redundancy; sensor calibration and alignment awareness; communication requirements in ADAS - CAN, CAN-FD, automotive Ethernet and diagnostic interface; data quality, latency and failure modes.

Real World Assignment

1. **ADAS Sensor Comparison:** Compare camera, radar, lidar and ultrasonic sensors for range, cost, accuracy and limitations. Objective: To select suitable sensor types for different ADAS functions. Deliverable: Comparison matrix with recommended application for each sensor.
2. **Ultrasonic Parking Sensor Demonstration:** Use a parking sensor trainer or ultrasonic module to record detection distance for different targets. Objective: To observe sensor range, angle and surface limitation. Deliverable: Observation table with distance, target material and detection status.
3. **Camera-Based Lane Detection Study:** Use sample road images/videos or simulator output to identify lane marking challenges. Objective: To understand basic perception issues in camera-based ADAS. Deliverable: Annotated image set with explanation of lighting, marking and obstruction effects.
4. **Sensor Calibration Awareness:** Study mounting and alignment requirements of camera/radar/ultrasonic sensors from service information. Objective: To understand why calibration is required after bumper, windshield or wheel-alignment work. Deliverable: Calibration checklist and fault-symptom chart.

Unit III	Longitudinal and Lateral Driver Assistance Systems	[07 Hr.]

Longitudinal assistance systems: adaptive cruise control, forward collision warning, automatic emergency braking, emergency brake assist and traffic jam assist overview; time headway, time-to-collision, safe distance and braking intervention concepts; lateral assistance systems: lane departure warning, lane keeping assist, lane centering assist, blind spot detection, rear cross traffic alert and evasive steering support overview; steering, braking and powertrain actuator interface; system operating conditions, warnings, limitations, fail-safe behaviors and driver override.

Real World Assignment

1. **Adaptive Cruise Control Case Study:** Study the working sequence of ACC using a block diagram or simulation video. Objective: To understand distance control, speed control and driver override. Deliverable: ACC control-flow chart with inputs, outputs and limitations.

2. AEB and FCW Scenario Analysis: Analyze a rear-end collision scenario using speed, distance and warning/braking stages. Objective: To understand time-to-collision and emergency braking logic. Deliverable: Scenario table with warning zone, braking zone and possible limitations.

3. Lane Assistance Feature Study: Compare LDWS, LKA and lane centering assist. Objective: To differentiate warning-only and control-intervention systems. Deliverable: Comparative chart with sensors, output action and driver responsibility.

4. Blind Spot Detection Observation: Study blind spot zones for a car/two-wheeler interaction using sketches or parking-lot demonstration. Objective: To understand side/rear sensing requirement and warning logic. Deliverable: Blind spot zone sketch and risk-reduction notes.

Unit IV	Parking, Visibility, Driver Monitoring and HMI Systems	[07 Hr.]

Parking and low-speed assistance: rear parking sensor, reverse camera, 360-degree surround view, rear cross traffic alert and smart parking assist; visibility systems: adaptive front lighting, automatic high beam, traffic sign recognition and head-up display overview; driver and occupant monitoring: driver drowsiness detection, distraction monitoring, seat belt reminder and occupant detection; HMI design for ADAS: visual, audio and haptic warnings; warning priority, driver acceptance, false alarms and nuisance alerts; service precautions for cameras, radar, ultrasonic sensors, airbags and safety-related systems.

Real World Assignment

1. **Parking Assist System Study:** Demonstrate or study rear parking sensor/reverse camera operation at different object distances. Objective: To observe low-speed obstacle detection and warning strategy. Deliverable: Distance-warning table with photographs/sketches and safety notes.
2. **360-Degree Surround View Layout:** Prepare layout of four-camera surround-view system. Objective: To understand camera placement, image stitching and blind zones. Deliverable: Top-view layout diagram with limitations.
3. **Driver Monitoring System Case Study:** Study drowsiness or distraction monitoring using camera/sensor-based information. Objective: To understand driver state monitoring and warning logic. Deliverable: Short report with inputs, symptoms detected, HMI output and limitations.
4. **ADAS HMI Warning Audit:** Compare warning symbols, sounds and messages for different ADAS features. Objective: To understand clear driver communication and warning priority. Deliverable: Warning-lamp/message table with recommended HMI improvements.

Unit V	ADAS Testing, Validation, Safety and Future Trends	[08 Hr.]

Need for ADAS testing and validation; requirement-based testing; simulation, software-in-loop, hardware-in-loop, driver-in-loop and proving-ground testing overview; basic test scenarios for AEB, ACC, LDWS, parking assist and blind spot detection; diagnostic trouble codes, service calibration and maintenance awareness; functional safety overview with ISO 26262 concepts at introductory level; SOTIF awareness for performance limitations; cybersecurity and data privacy awareness; NCAP and regulatory trends; connected vehicle and V2X overview; future trends toward software-defined vehicles and autonomous driving.

Real World Assignment

1. **ADAS Test Scenario Preparation:** Prepare test scenario sheet for AEB, LDWS or parking assist using safe classroom/simulation assumptions. Objective: To understand requirement-based ADAS validation. Deliverable: Test case table with objective, input condition, expected output and safety precaution.
2. **ADAS Fault and DTC Case Study:** Study a sensor blocked/mis calibrated/faulty case using service literature or simulation. Objective: To understand diagnostic approach for ADAS faults. Deliverable: Fault tree with symptom, probable cause, diagnostic step and recommendation.
3. **Functional Safety Awareness Report:** Prepare a simple hazard analysis for one ADAS feature failure.

Objective: To understand risk, fail-safe behaviour and driver warning. Deliverable: Hazard table with severity, controllability, exposure and safety measure.

4. Future ADAS and V2X Review: Review V2X, connected vehicle, SDV or autonomous driving trend relevant to India. Objective: To connect ADAS with emerging automotive technologies. Deliverable: Two-page technical review with benefits, challenges and implementation concerns.

Learning Resources

Text Books:

1. Tom Denton, Advanced Automotive Fault Diagnosis, Routledge / Taylor & Francis.
2. Tom Denton, Automobile Electrical and Electronic Systems, Elsevier Butterworth-Heinemann.
3. Bosch, Automotive Handbook, Robert Bosch GmbH.
4. Rajesh Rajamani, Vehicle Dynamics and Control, Springer.

Reference Books:

1. Hermann Winner, Stephan Hakuli, Felix Lotz and Christina Singer, Handbook of Driver Assistance Systems, Springer.
2. Markus Maurer, J. Christian Gerdes, Barbara Lenz and Hermann Winner, Autonomous Driving: Technical, Legal and Social Aspects, Springer.
3. William B. Ribbens, Understanding Automotive Electronics, Elsevier.
4. Uwe Kiencke and Lars Nielsen, Automotive Control Systems, Springer.
5. SAE International papers and ISO standards related to ADAS, functional safety and road vehicles.

MOOC / NPTEL / Online References:

1. NPTEL / SWAYAM courses related to automotive electronics, vehicle dynamics, control systems and autonomous vehicles.
2. Bosch Mobility and automotive safety technology resources.
3. SAE International resources on driver assistance, automation and vehicle safety.
4. Euro NCAP / Global NCAP resources on safety assistance technologies.
5. MATLAB/Simulink, CARLA and open-source simulator tutorials for introductory ADAS demonstrations.

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

PEC362C-ABE: Alternative Fuels and Emission Control

Teaching Scheme		Credits	Examination Scheme	
Theory	03 Hr./Week	03	CCE	30 Marks
Practical	NA		End-Semester	70 Marks

Prerequisite Courses: Basic Chemistry, Applied Thermodynamics and Heat Transfer, Automotive Design, Environmental Science.

Course Objectives

1. To understand the need, classification, properties, production pathways and sustainability aspects of alternative fuels for IC engine and automotive applications.
2. To evaluate alcohol fuels, biodiesel, renewable diesel, gaseous fuels and hydrogen with respect to combustion, storage, safety, performance and emissions.
3. To analyze pollutant formation mechanisms in SI and CI engines and relate them to engine design, calibration, fuel quality and operating conditions.
4. To understand BS-VI/OBD/RDE compliant emission measurement, certification, inspection and real-world emission testing methods used in India and globally.
5. To select and evaluate suitable in-cylinder and after-treatment emission control technologies for modern gasoline, diesel, gaseous-fuel and alternative-fuel vehicles.

Course Outcomes

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

1. CLASSIFY and EVALUATE alternative automotive fuels based on fuel properties, production route, safety, engine compatibility and sustainability.
2. ANALYZE alcohol fuels, biodiesel/renewable diesel, gaseous fuels and hydrogen for SI/CI engine applications with respect to performance and emission behavior.
3. EXPLAIN pollutant formation mechanisms and ASSESS the effect of fuel quality, combustion, engine calibration and operating variables on emissions.
4. INTERPRET BS-VI, OBD and RDE emission test procedures, emission measurement systems and regulatory requirements for vehicle certification and compliance.
5. SELECT and EVALUATE emission control technologies such as EGR, TWC, GPF, DOC, DPF, SCR, LNT, EVAP and PCV for modern automotive applications.

Course Contents

Unit I	Alternative Automotive Fuels: Need, Properties and Sustainability	[08 Hr.]

Need for alternative fuels; Indian and global energy scenario; fuel property requirements for SI and CI engines - calorific value, density, viscosity, volatility, flash point, auto-ignition temperature, octane number, cetane number, lubricity, sulphur, oxygen content and carbon intensity; classification of alternative fuels - alcohol fuels, biodiesel, renewable diesel/HVO, biogas/CBG, LPG, CNG, LNG, hydrogen, e-fuels and synthetic fuels; well-to-wheel and life-cycle emission concepts; feedstock, food-vs-fuel, land/water use, safety, storage, transport and dispensing considerations; overview of fuel testing standards and engine compatibility.

Real World Assignment

1. Alternative Fuel Selection Matrix - Compare petrol, diesel, E20, biodiesel blend, CNG/CBG and hydrogen for one selected vehicle application. Deliverable: comparative table with fuel properties, engine modification need, safety points, emission impact and final recommendation.

2. Alternative Fuel Availability Survey- Survey nearby fuel stations or online fuel supplier data for petrol, diesel, CNG, LPG, ethanol-blended fuel and biodiesel availability. Deliverable**:** Table showing fuel type, availability, price, application and limitations.

3. Fuel Property Comparison Chart- Compare petrol, diesel, ethanol, methanol, biodiesel, CNG, LPG and hydrogen based on calorific value, octane/cetane number, storage and safety. Deliverable**:** Comparative chart with conclusion on suitable fuel for SI and CI engines.

4. Well-to-Wheel Emission Comparison- Study life-cycle emissions of petrol, diesel, CNG, ethanol and hydrogen from production to vehicle use. Deliverable**:** One-page report with block diagram and sustainability ranking.

5. India's Alternative Fuel Policy Review- Study current Indian initiatives such as ethanol blending, CNG expansion, green hydrogen mission and biofuel policy. Deliverable: Short policy summary with impact on automobile sector.

Unit II	Alcohol Fuels, Biodiesel and Renewable Liquid Fuels	[07 Hr.]

Ethanol and methanol as automotive fuels; production routes, properties, advantages and limitations; E10, E20, E85, E100, M15 and M100 concepts; flex-fuel vehicle requirements - fuel system material compatibility, cold starting, corrosion, calibration and oxygenated-fuel effects; biodiesel production by transesterification, feedstocks, fuel properties, biodiesel blends and quality issues; renewable diesel/HVO and sustainable biofuel pathways; DME as a CI engine fuel; effect of alcohols and biodiesel on engine performance, combustion, fuel economy, NOx, CO, HC, PM and aldehyde emissions; storage, handling and safety precautions.

Real World Assignment

1. E20/Flex-Fuel Case Study - Study a current flex-fuel or E20 compatible vehicle/engine. Deliverable: report covering fuel blend, material compatibility, engine calibration changes, expected emission changes and Indian implementation challenges.

2. Ethanol Blend Feasibility Study for SI Engine- Compare E10, E20 and E85 fuels with respect to engine compatibility, fuel consumption, emissions and material compatibility. Deliverable: Comparison table with recommendation for Indian passenger vehicles.

3. Hydrogen Safety Awareness Assignment- Study hydrogen storage, leakage, flame visibility, ventilation and safety precautions in vehicle applications. Deliverable: Hydrogen safety checklist for automobile workshop or laboratory.

4. Alcohol Fuel Material Compatibility Study- Identify rubber, plastic and metallic components affected by alcohol-blended fuels in fuel tanks, hoses and injectors. Deliverable: Component-wise compatibility table with preventive measures.

5. Green Hydrogen vs Grey Hydrogen Case Study- Compare green, grey and blue hydrogen based on production method, cost, emissions and automotive suitability. Deliverable: Short report with flowchart and conclusion.

Unit III	Gaseous Fuels, Hydrogen and Advanced Low-Carbon Fuels	[07 Hr.]

LPG, CNG, LNG, biogas and compressed biogas (CBG/Bio-CNG): production, composition, storage cylinders, pressure regulation, fuel supply systems, safety devices, engine modifications and emission characteristics; dual-fuel and bi-fuel operation; methane number, methane slip and greenhouse gas concerns; hydrogen as an IC engine fuel - production routes including green hydrogen, storage methods, safety, backfire/pre-ignition, NOx tendency, mixture formation and combustion control; hydrogen blending with CNG/natural gas; synthetic fuels and e-fuels overview; suitability of alternative fuels for two-wheelers, passenger cars, buses, tractors and heavy-duty applications.

Real World Assignment

1. CBG/CNG/Hydrogen Application Study - Select a city bus, goods vehicle or tractor application and evaluate CNG/CBG/hydrogen feasibility. Deliverable: fuel supply layout, safety checklist, infrastructure requirement and emission benefit-risk summary.
2. Biodiesel Feedstock Selection Study- Compare edible and non-edible oil sources such as soybean, palm, jatropha, used cooking oil and animal fat for biodiesel production. Deliverable: Feedstock comparison table with Indian suitability conclusion.
2. Used Cooking Oil to Biodiesel Awareness Survey-Survey local hotels/canteens for used cooking oil disposal practices and biodiesel conversion awareness. Deliverable: Survey report with collection challenges and possible local solution.
3. CNG vs LPG Vehicle Application Study-Compare CNG and LPG vehicles based on storage cylinder, fuel system modification, safety, cost and emissions. Deliverable: Comparative report for passenger car and three-wheeler applications.
4. Biogas for Rural Transport Feasibility-Study whether biogas produced from agricultural/animal waste can be used for rural transport or stationary engines. Deliverable: Feasibility note with source, purification need, storage issue and application.

Unit IV	Automotive Emissions, Standards and Measurement Techniques	[07 Hr.]

Sources and classification of vehicular emissions: CO, HC, NOx, PM, PN, smoke, SOx, CO_2, N_2O, ammonia, aldehydes and evaporative emissions; health, environmental and climate effects; emission formation in SI and CI engines; effect of air-fuel ratio, combustion temperature, injection timing, EGR, turbocharging, compression ratio, ignition timing, fuel properties and transient operation; Bharat Stage norms with focus on BS-VI, fuel sulphur reduction, OBD Stage I/II and Real Driving Emissions; emission test cycles and methods - chassis dynamometer, engine dynamometer, CVS, WLTC, WMTC, PEMS, SHED/EVAP test, free acceleration smoke test and inspection/maintenance; emission analyzers - NDIR, FID, CLD/chemiluminescence, PM/PN measurement and smoke meter.

Real World Assignment
1. Emission Inventory and Test Method Mapping - Choose a BS-VI two-wheeler, car or diesel utility vehicle and map applicable pollutants, test methods and control devices. Deliverable: 1 to 2-page compliance map with pollutants, measurement instrument, test cycle and control strategy.
2. BS-VI Emission Norms Study- Compare BS-IV and BS-VI norms for CO, HC, NOx and PM emissions for petrol and diesel vehicles. Deliverable: Emission limit comparison chart with key changes.
3. Vehicle Pollution Certificate Analysis-Collect sample PUC certificate data from petrol, diesel or CNG vehicles and study measured parameters. Deliverable: PUC analysis sheet with interpretation of CO, HC, smoke or lambda values.
4. Emission Sources Mapping in Vehicle-Identify emission sources such as exhaust, crankcase blow-by, fuel evaporation and tyre/brake dust. Deliverable: Labelled vehicle diagram showing pollutant source and control method.
5. Driving Habits and Emission Impact Study- Study how idling, harsh acceleration, poor maintenance, low tyre pressure and overloading affect emissions. Deliverable: Awareness poster or one-page report with emission reduction tips.

Unit V	Emission Control Technologies and Diagnostics	[07 Hr.]

In-cylinder emission control: combustion chamber design, air motion, fuel injection strategy, ignition control, EGR, turbocharging, after-cooling, variable valve timing and engine calibration; gasoline after-treatment - three-way catalytic converter, oxygen sensor feedback, closed-loop lambda control, gasoline particulate filter, EVAP system, charcoal canister, purge control and PCV system; diesel after-treatment - diesel oxidation catalyst, diesel particulate filter, active/passive regeneration, selective catalytic reduction, urea/AdBlue dosing, ammonia slip catalyst, lean NOx trap and sensor feedback; alternative-fuel engine emission control strategies; OBD monitoring of catalyst, oxygen sensor, EGR, DPF/SCR, misfire and evaporative systems;

fault symptoms, diagnostic trouble codes, limp-home strategy, maintenance and durability issues; future trends - onboard emission monitoring, remote sensing and carbon-neutral fuel integration.

Low Temperature Combustion Technologies: Concept and need of LTC for simultaneous reduction of NOx and soot; NOx–PM trade-off in conventional diesel combustion; role of EGR, premixing, injection timing, compression ratio and fuel reactivity; HCCI, PCCI/PPCI and RCCI combustion concepts; comparison of HCCI, PCCI and RCCI with conventional SI and CI combustion; use of alternative fuels in LTC; advantages, limitations, engine control challenges, HC/CO emissions, cold-start issues and practical implementation barriers.

Real World Assignment

1. After-Treatment Diagnostic Case Study - Study one fault such as DPF clogging, SCR/AdBlue fault, catalyst efficiency below threshold or EVAP leak. Deliverable: fault tree with symptoms, DTCs, possible causes, diagnostic tests and corrective actions.

2. LTC Technology Comparison Report: Compare HCCI, PCCI and RCCI combustion strategies with conventional diesel combustion based on combustion principle, fuel requirement, NOx, PM, HC, CO, efficiency, control complexity and practical implementation challenges. Deliverable**:** Comparative matrix with one recent research-paper summary and conclusion on the most suitable LTC strategy for future IC engines.

3. Catalytic Converter Case Study- Study construction and working of three-way catalytic converter used in petrol vehicles. Deliverable: Labelled diagram with pollutants controlled, working conditions and failure causes.

4. Diesel After-Treatment System Mapping- Prepare a layout of EGR, DOC, DPF and SCR system used in modern diesel vehicles. Deliverable: System block diagram with function of each component.

5. DPF Regeneration Awareness Study- Study passive and active regeneration of diesel particulate filter and reasons for DPF clogging. Deliverable: Short report with symptoms, causes and preventive driving practices.

Learning Resources

Text Books:

1. Ganesan.V., "Internal Combustion Engines", Tata McGraw-Hill Publishing Co., New Delhi, 2017
2. George E. Totten, Editor, Fuels and Lubricants Handbook: Technology, Properties, Performance, and Testing, ASTM International.
3. B.P Pundir , Engine Emissions, Narosa publications 2nd edition 2017
4. D.J.Patterson and N.A.Henin, 'Emission from Combustion Engine and their Control', Anna Arbor Science Publication,1985.
5. G.P.Springer and D.J.Patterson, Engine Emissions, Pollutant formation, Plenum Press, NewYork
6. S. S. Thipse, Alternative Fuels, Jaico Publishing House.

Reference Books:

1. Paul Richards "Automotive fuels reference book" SAE International, Third edition 2014
2. Roger Frederick Haycock, John Hillier, Arthur J. Caines "Automotive lubricants Reference book", SAE International, Second edition 2004
3. Wilfrid Francis– Fuels and Fuel Technology, Vol. I & II
4. A.Alexander, J.P.Barde, C.lomure and F.J. Langdon, 'Road traffic noise', Applied science publisher ltd., London,1987.
5. Crouse and Anglin, 'Automotive Emission Control', McGraw Hill company., New York 1993.
6. C.Duerson, 'Noise Abatement', Butterworths ltd., London1990.
7. L.L Beranek, 'Noise Reduction', McGraw-Hill Company., New York 1993.

Web References:

1. NITI Aayog - Roadmap for Ethanol Blending in India 2020-2025;
2. ARAI - Indian Emission Regulation Booklet and CMVR/AIS downloads.
3. ICCT - India Bharat Stage VI emission standards and Real Driving Emissions / PEMS testing reports.

Savitribai Phule Pune University Third Year of Automobile Engineering (2024 Pattern)			
MDM371-ABE: Metrology and Quality Engineering			
Teaching Scheme		**Credit**	**Examination Scheme**
Theory	**2 Hours/Week**	**2**	**CCE:50 Marks**

Prerequisite Courses, if any:

Fundamentals of engineering measurements and instrumentation, Basic knowledge of manufacturing processes and machine tools, statistics and probability concepts.

Course Objectives:

After completing this course, students will be able to:

1. Understand measurement standards, standard measuring instrument and calibration used in Industry.
2. Apply recent metrology tools such as CMM, Profile Projector, Machine Vision Systems, Laser interferometers techniques for industrial inspection.
3. Understand Total Quality Management (TQM) principles to improve processes and enhance quality performance.
4. Understand the quality control tools and techniques used for inspection.
5. Analyze and control manufacturing processes using statistical quality control techniques and acceptance sampling.

Course Outcomes:

On completion of the course, Student will be able to

CO1: APPLY principles of metrology, calibration and measurement uncertainty in engineering applications

CO2: UNDERSTAND and USE recent metrology systems like CMM and Machine Vision Systems, Laser interferometers techniques for inspection

CO3: IMPLEMENT total quality management tools for continuous improvement

CO4: Analyze processes using quality control techniques for inspection.

CO5: ANALYZE process performance using statistical quality control and sampling techniques

Course Content

Unit: 1	**Introduction to Metrology and their fundamentals**	**5 Hrs.**

Introduction: Principles of Engineering metrology and Applications, Measurement standards: line standards, end standards, Types and sources of errors, Accuracy and Precision, calibration.

Measurement Instruments: Vernier Caliper, Micrometer, Gear Tooth vernier calliper, Slip gauges.

Types of Gauges and Comparators: Different types of gauges and gauge materials, limits, fits, tolerances, Comparators: mechanical, optical, electrical, pneumatic comparators.

CCE Activities:

1) Measure the dimensions of components using digital instruments such as Vernier calliper and micro meter.
2) Measure any mechanical component multiple times using measuring instruments and analyze:

Unit:2	**Recent Trends in Metrology**	**4 Hrs**

Introduction of Coordinate Measuring Machine, Types of Coordinate Measuring Machine, Types of probes: scanning and optical probes.
Profile Projector, Machine Vision Systems, Laser interferometers, Applications.

Real World Assignment

CCE Activities:

1) Study modern optical measuring instruments used in industries and compare:
   - CMM
   - Profile Projector
   - Machine Vision System
   - Laser Interferometer.

Unit:3	**Total Quality Management**	**5 Hrs.**

Quality Tools: Introduction to TQM, 5S, Kaizen, Poka yoke, Kanban, JIT, FMECA, zero defect, TPM, Six Sigma, Quality Function Deployment and Quality Management System.

Real World Assignment

CCE Activities:

1) Student should select and apply any one technique such as 5S, Kaizen, Poka-Yoke, or Kanban for process improvement.
2) Identify a real problem in college, workshop, hostel, or industry and propose small continuous improvements using the Kaizen approach.

Unit:4	**Quality Engineering**	**5 Hrs.**

Introduction to Quality: Definition, Quality characteristics, Seven Quality Tools, Quality of performance, Cost of quality and value of quality, Quality Circles, Deming's cycles & 14 Points, Juran Trilogy approach. Quality assurance, Cost of rework and repair, Quality and Inspection.

Real World Assignment

CCE Activities:

1) Select a real problem (college canteen, traffic management, machine breakdown, product defects, etc.) and apply Seven Quality Tools for analysis and improvement.
2) Study causes of defects and estimates the cost of rework and repair in a workshop or manufacturing process.

Unit:5	**Statistically Quality Control**	**5 Hrs**

Statistical quality control: Concept, Control Chart for Variable (X & R Chart) & Attribute (P & C Chart), Process capability Indices: cp, cpk, ppk, Statistical Process Control (Numerical), Frequency diagram, Concept of variance analysis.
Acceptance Sampling: Concept, sampling methods, Different types of sampling plans and Numerical, OC Curve, merits and demerits of acceptance sampling, Comparison of Plan, calculation of sample size, Probability of Acceptance (Numerical)

Real World Assignment

CCE Activities:

1) Student should solve the numerical based on control chart.
2) Compare:

- Single Sampling Plan
- Double Sampling Plan
- Multiple Sampling Plan

Based on inspection cost, time, and quality performance.

Text Books:

1. Jain R.K., Engineering Metrology, Khanna Publication.
2. C. Gupta, Engineering Metrology, Dhanpath Rai.
3. Bewoor A. K. and Kulkarni V. A., Metrology and Measurements, Tata McGraw hill Publication.
4. Juran J. M., Quality Handbook, McGraw Hill Publications. Grant S.P., Statistical Quality Control, Tata McGraw hill Publication.

Reference Books:

1. Narayana K.L., Engineering Metrology.
2. Galyer J.F & Shotbolt C.R., Metrology for engineers.
3. Gupta I.C., Engineering Metrology, Dhanpatrai Publiartions.
4. Judge A.W., Engineering Precision Measurements, Chapman and Hall
5. Francis T. Farago, Mark A. Curtis, Handbook of dimensional measurement.
6. ASTME, Handbook of Industrial Metrology, Prentice Hall of India Ltd.
7. Connie Dotson, Fundamentals of Dimensional Metrology, Thamson Publn., 4th Edition.
8. Basterfield D. H., Quality control, Pearson Education India, 2004.
9. A textbook of metrology, M. Mahajan, Dhanpat Rai & co., New Delhi, 2010 onwards.
10. Statistical quality control, M. Jeya Chandra, CRC Press, 2001 onwards.
11. Statistical quality control, Douglas Montgomery, Wiley, 2001 onwards

MOOC / NPTEL/ YouTube Links: -

1. nptel.ac.in/courses/112106179;
2. www.nptelvideos.in/2012/12/mechanical-measurements-and-metrology.html
3. www.me.iitb.ac.in/~ramesh/courses/ME338/metrology6.pdf; nptel.ac.in/courses/110101010/; freevideolectures.com › Mechanical › IIT Madras nptel.ac.in/courses/112107143/37;

Savitribai Phule Pune University Third Year of Automobile Engineering (2024 Pattern)			
MDM372-ABE: Measurement and Quality LAB			
Teaching Scheme		**Credit**	**Examination Scheme**
Practical	**2 Hours/Week**	**1**	**Practical: 25 marks**

Prerequisite Courses, if any:

Fundamentals of Linear measurements, Basic knowledge of manufacturing processes, statistics and probability concepts.

Course Objectives:

After completing this course, students will be able to:

1. Select suitable measuring instrument gauges for determining geometrical and dimensional measurements.
2. Understand Total Quality Management (TQM) principles to improve processes and enhance quality performance.
3. Analyze processes using statistical quality control techniques and acceptance sampling.

Course Outcomes:

On completion of the course, Student will be able to

CO1. Apply Precision Measuring Instruments.
CO2. Evaluate Gear and Thread Parameters.
CO3. Analyze Form and Surface Metrology.
CO4. Implement Quality Control Tools.
CO5. Synthesize Industrial Inspection and Quality Management.

Course Content

It is representative list of Practical's. The course coordinator may choose minimum **eight practical's** as per requirement.

1) Determination of linear / angular dimensions of part using vernier calliper, screw gauge, dial gauge, height gauge, micrometer and bevel protractor.
2) Measurement of spur gear parameters using gear tooth vernier calliper calliper.
3) Measurement of roundness and circularity using mechanical comparator.
4) Demonstration of surfaces inspection using optical flat / interferometers. Students should also draw the fringe pattern.
5) Determination of geometry and dimensions of given threaded component / single point tool, using profile projector.
6) Study the different types of gauges used in manufacturing industry.
7) Analyze the fault in given batch of specimens by using Seven quality control tools for engineering application.
8) Measurement of thread parameters using floating carriage diameter measuring machine.

9) Determination of process capability and prepare the control chart.
10) Error determination of linear / angular measuring instruments and determination of linear and angular dimensions of given part.
11) Introduction to metrology and Calibration of measuring instrument. Example – Dial gauge, Micrometer, Vernier (any one)
12) Case study on various tools in Total Quality Management (TQM).

Savitribai Phule Pune University, Pune Third Year of Automobile Engineering(2024 Course) MDM373-ABE: Industrial Hydraulics & Pneumatics- LAB		
Teaching Scheme: **PR: 02 hrs./week**	**Credits:** **PR: 01**	**Examination Scheme:** **TW: 25**

Hydraulic and pneumatic operated machines and equipment are widely used in various industries due to its versatility and adaptability to automation. Mechanical engineering technologists are required to maintain such systems in different segments of industries. This competency needs the knowledge of construction and working of different components of hydraulic and pneumatic systems. This course will give the students, the basic skills and knowledge to use and maintain different types of hydraulic systems and pneumatic systems.

Prerequisite Courses:

1. Fluid Mechanics,
2. Manufacturing Processes,
3. Machine Tools,
4. Mathematics.

Course Objectives: -

This course "Industrial Hydraulics & Pneumatics- LAB" is designed with the following objectives:

1. Perform experiments to **understand** the working principles of hydraulic and pneumatic components.

2. Develop skills to assemble, operate, and analyze basic hydraulic and pneumatic circuits.

3. Evaluate performance characteristics of fluid power devices such as pumps and control valves.

4. Design different hydraulic and pneumatic circuits for given simple application.

5. Apply modern tools such as simulation software and IoT platforms for monitoring and control of fluid power systems.

Course Outcomes: -

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

CO.1 Identify various components of hydraulic & pneumatic systems.
CO.2 Select pump and actuators for given hydraulic system.
CO.3 Select appropriate control valves for given fluid operated system.
CO.4 Select compressor and appropriate accessories for given pneumatic system.
CO.5 Develop different hydraulic and pneumatic circuits for given simple applications.

Course Contents

1 Identify the components of hydraulic and pneumatic trainers.
2 List and draw ISO symbols used in hydraulic and Pneumatics.
3 Use of Pump and actuators mounted on hydraulic trainer,
4 Use of control valves used in hydraulics and pneumatics.
5 Use of compressor, FRL unit, special valves and accessories of pneumatics.
6 Construct and actuate hydraulic circuit for Single Acting Cylinder and Double Acting Cylinder,
7 Construct and actuate Meter-in, Meter out hydraulic circuit.
8 Construct and actuate any suitable sequencing hydraulic circuit.
9 Develop circuit for simple machine tool applications such as milling machine, shaper machine, grinding

machine
10 Construct pneumatic circuits using Pneumatic simulation software
11 Construct and actuate Pneumatic circuit for Single Acting Cylinder and Double Acting Cylinder & Air motor
12 Construct and actuate speed control Pneumatic circuits.
13 Construct and actuate indirect (pilot) control Pneumatic circuit.
14 Develop any suitable sequencing Pneumatic circuit.
15 Construct and actuate Pneumatic circuit for Logic functions (AND/OR/TIME DELAY)
16 Construct Hydraulic circuits using Hydraulic simulation software.

Note: Conduct any twelve experiments from the above-mentioned list

Text Books:

1. Anthony Esposito, “Fluid Power with Applications”, Pearson Prentice Hall, 2009, Edition 7, ISBN
2. 0135136903
3. S. R. Majumdar, “Oil Hydraulic Systems: Principles and Maintenance”, McGraw-Hill Edu., 2018, Edition 1, ISBN 0071406697
4. S. R. Majumdar, “Pneumatic Systems: Principles and Maintenance”, McGraw-Hill Education, 1995, Edition 1, ISBN 0074602314

Reference Books:

1. John J. Pippenger and Tyler G. Hicks, “Industrial Hydraulics”, McGraw-Hill (Gregg Division), 1979, Edition 3, ISBN 0070501408
2. S. Ilango, “Introduction to Hydraulics and Pneumatics”, Prentice-Hall of India Pvt Ltd, 2007, Edition 1, ISBN 8120329877
3. Andrew Parr, “Hydraulics and Pneumatics: A Technician’s and Engineer’s Guide”, Jaico Pub. House, 2005, Edition 1, ISBN 8172241895 .

Savitribai Phule Pune University Third Year of Automobile Engineering (2024 Pattern)					
VSE381: Simulation and Analysis Lab.					
Teaching Scheme		**Credit**	**Examination Scheme**		
Theory	**NA**	**1**	**PR**	**50 Marks**	
Practical	**2 Hours/Week**		**CCE**	**NA**	

Prerequisite Courses, if any:

Students must have successfully completed or possess foundational knowledge in the following domains: Mechanics of Structure, Material Science & Metallurgy, Kinematics and Dynamics of Machines, Automotive Chassis & Transmission Systems, Automotive HVAC, Automotive Design I, Automotive Design II, Fluid Power, Automotive Thermal & Heat Transfer Engineering, Fluid Statics & Dynamics.

Course Objectives:

1. To develop a rigorous foundational understanding of finite element analysis (FEA) methodology by formulating and executing numerical solutions for specialized 1D automotive links, structural chassis brackets, and multi-layer thermal problems.
2. To upskill students in applying industrial FEA software suites to analyze stress concentration fields, deflection profiles, and safety factors of structural automotive elements under static road and braking conditions.
3. To equip students with the capabilities to execute dynamic modal analysis to identify fundamental natural frequencies, structural resonance thresholds, and normalized mode shapes of complex vehicular sub-assemblies like chassis frames and multi-link suspensions.
4. To introduce advanced computational validation schemes including sub-modeling for critical structural zones (e.g., suspension wishbone joints, chassis cross-member intersections) and multi-physics coupled thermal-structural analysis for powertrain elements.
5. To cultivate engineering proficiency in evaluating complex simulation contours, verifying FEA mathematical outputs against empirical analytical formulations, and producing industry-standard structural validation reports.

Course Outcomes:

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

CO1: Analyze axial stress fields, joint deflections, and structural load distributions within specialized 1D vehicle links using FEA packages.

CO2: Evaluate geometric stress concentration factors, principal stress zones, and structural margins of safety across 3D vehicular parts with distinct architectural discontinuities.

CO3: Interpret computational modal metrics—extracting global natural frequencies, identifying complex mode shapes (torsional, bending), and predicting resonance risks—to guide structural NVH optimization inside sub-assemblies like vehicle frame structures or driveshafts.

CO4: Implement sub modeling techniques to execute localized mesh refinements within critical high-stress vehicle junctions, justifying the mapping of boundary conditions and sub-surface cut-boundaries to preserve structural load paths.

CO5: Analyze steady-state thermal gradients through multi-layer automotive composite structures and synthesize coupled thermo-mechanical stress fields inside severe powertrain to evaluate fatigue.

Course Contents

Experiment-1	Stress analysis of 1D bar element	(02 Hours)

Description: Perform stress analysis on a one-dimensional bar element to determine axial stress, strain, and displacement under applied loads using FEA software. Students will interpret the results to understand material behavior. Students will interpret the results to understand stress distribution and validate structural response calculations.

Exemplars / Practical Applications

Analysis of axial stress and deformation in tie rods, Structural assessment of suspension components, Design verification of connecting rods etc.

Experiment-2	Structural analysis of a 1D truss element	(02 Hours)

Description: Analyzing a 1D truss element using FEA software to determine nodal and force reaction under given loading conditions. The results are used to understand and verify the structural response of the truss member.

Exemplars / Practical Applications:

Analysis of truss members, Design verification of roof trusses used in industrial assessment of transmission tower members subjected to wind and cable loads etc

Experiment-3	Determination of static stress concentration factor calculation for a plate with center hole subjected to axial loading in tension using FEA software	(02 Hours)

Description: Analyze flat plate with a central hole under axial tensile loading and examine how stresses are distributed around the hole. The static stress concentration factor is determined by comparing the peak stress at the hole edge with the average applied stress in the plate.

Exemplars / Practical Applications:

Perforated structural plates and panels used in aerospace and automotive components, stress concentration effects in machine parts such as cylinder heads, brackets, gusset plates, and mounting plates with holes etc**.**

Experiment-4	Stress and deflection analysis of any automotive component consisting of 3-D elements using FEA software.	(02 Hours)

Description:

Analyzing a three-dimensional machine component using FEA software to determine stress distribution and deflection under applied loads. The results are used to evaluate structural performance and identify critical regions of stress and deformation.

Exemplars / Practical Applications:

Gear tooth to assess contact stresses, Structural analysis of a front-axle double-wishbone suspension arm or a steering knuckle, Analysis of a crankshaft to determine stress concentration and deflection under engine loading conditions. Etc.

Experiment-5	**Modal Analysis & Structural NVH Tuning of a Vehicle Drive Shaft.**	**(02 Hours)**
Description: Perform modal analysis of a vehicle drive shaft using FEA software to determine its natural frequencies and corresponding mode shapes. The results are used to understand the dynamic behavior of the component and identify conditions that may lead to resonance.		
Exemplars / Practical Applications Study of a vehicle component to determine mode shapes and prevent failure due to vibrational stresses, Modal, Analysis of an Aero plane wing, Analysis of a bracket or support frame to ensure it does not resonate under operational vibrations etc.		
Experiment-6	**Analysis of automotive system using sub-modeling approach**	**(02 Hours)**
Description: Analyzing an automotive system using the sub-modeling approach in FEA, where a global model is first solved to obtain overall response and boundary conditions. A detailed local model is then created for a critical region to evaluate stresses and deformations with higher accuracy		
Exemplars / Practical Applications Bicycle frame analysis, gear tooth contact region, bracket connected to a large machine assembly, local deflection and stress evaluation in a turbine blade root region etc.		
Experiment-7	**Steady-State Thermal Analysis of Multi-Layer Automotive Composite Firewalls**	**(02 Hours)**
Description: Simulate steady-state thermal behavior through a multi-layer automotive composite structure, such as an engine-bay firewall assembly or a high-performance exhaust heat shield layout. Students will configure layer-specific thermal conductivities, define interior engine-radiation heat loads, and apply external ambient convective boundary fields to track temperature drop distributions and quantify heat flux vectors.		
Exemplars / Practical Applications Thermal behavior engine bay walls with refractory and metal layers, Analysis of heat transfer through exhaust heat shield etc		
Experiment-8	**Coupled Thermal-Structural Analysis using FEA software**	**(02 Hours)**
Description: Performing coupled thermal-structural analysis using FEA software to study the interaction between temperature distribution and resulting mechanical stresses in a component. The results help evaluate how thermal loads influence deformation and structural integrity under operating conditions etc		
Exemplars / Practical Applications Engine components like cylinder heads under combined heat and mechanical loading, brake discs to assess thermal expansion and stress during repeated braking cycles etc		
Learning Resources		
Text Books: 1. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune, 1st Edition, 2008.		

2. S. S. Bhavikatti, Finite Element Analysis, New Age International Publishers, Third Edition, 2015.
3. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
4. G Lakshmi Narasaiah, Finite Element Analysis, BS Publications / BSP Books, 2nd edition, 2020.
5. J. N. Reddy, An Introduction to the Finite Element Method, Mcgraw Hill Series in Mechanical, 2005.
6. P. Seshu, Text book of Finite Element Analysis, PHI Learning Private Limited, New Delhi, 10th Printing, 2012.

Reference Books:

1. Bathe K. J., Finite Element Procedures Prentice, Hall of India (P) Ltd., New Delhi.
2. R. D. Cook, et al., Concepts and Applications of Finite Element Analysis. Wiley, India
3. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill
4. S. Moaveni, Finite element analysis, theory and application with Ansys, Prentice Hall
5. O.C. Zienkiewicz, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, Elsevier Butterworth-Heinemann, 2005.

MOOC / NPTEL/ YouTube Links: -

1. NPTEL – FEM Course by Prof. C.S. Upadhyay, IIT Kanpur
2. ANSYS Learning Hub — ansys.com/training (free student access)
3. SimScale Community — cloud-based FEA practice (free tier available)

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