GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Mechanical (I.C Engine and Automobile Engineering)

Subject Code : ME02080031

Subject Name : Automotive Aerodynamics and Safety

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Basic knowledge of fluid mechanics and thermodynamics.
Rationale:	This course focuses on advanced concepts of vehicle aerodynamics and safety systems. Students will gain a deep understanding of drag force, aerodynamic shapes, and safety features in modern vehicles, preparing them for challenges in automotive engineering and research.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Understand the concept of bluff body and aerodynamic drag force analysis.	Remembering, Understanding
2	Perform aerodynamic shape analysis for vehicles.	Analyzing, Understanding
3	Evaluate the importance of vehicle safety systems and regulations.	Evaluating, Analyzing
4	Understand the working of various vehicle safety equipment.	Creating, Applying
5	Analyze and apply active and passive safety systems for vehicles.	Applying, Analyzing
6	Design and evaluate advanced safety systems like object detection and collision mitigation systems.	Applying, Creating

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Unit 1: Introduction to Vehicle Aerodynamics** • Concept of Bluff Body and Aerodynamic Drag Forces: Understanding the bluff body concept and the factors influencing aerodynamic drag forces in vehicles. Exploration of how drag affects vehicle efficiency and performance. • Types of Drag Forces and Drag Coefficients: In-depth study of pressure drag, friction drag, and induced drag. Introduction to drag coefficients and their significance in vehicle design. • Low-Drag Profiles for Vehicles: Examination of vehicle designs that minimize drag. Discussion on streamlined shapes and their applications in modern vehicles. • Strategies for Aerodynamic Optimization and Development: Techniques such as wind tunnel testing, computational fluid dynamics (CFD), and real-world testing for optimizing vehicle aerodynamics.	6	15
2.	**Unit 2: Aerodynamic Shape Analysis** • Front and Rear Modifications: Analysis of front and rear-end designs for reducing drag. Impact of shapes such as round, square, and chamfered edges on performance. • Wind Shield Angles and Tail Designs: Role of windshield inclination and tail designs (boat-tailing, fast-back, square-back) in aerodynamics. Examination of optimal angles for reducing resistance. • Analysis of Dust Flow Patterns: Study of dust accumulation and flow patterns around vehicles. Impact on vehicle cleanliness, visibility, and component efficiency.	6	15
3.	**Unit 3: Vehicle Safety Concepts** • Introduction to Active and Passive Safety: Definitions and distinctions between active and passive safety systems. Importance of these systems in accident prevention and	9	20

	mitigation. • Active Safety: Components such as driving safety (traction control, lane assist), conditional safety (automatic braking), perceptibility safety (lighting, alerts), and operating safety (steering and handling stability). • Passive Safety: Features addressing collision impact such as crumple zones, energy-absorbing materials, and occupant restraint systems. Study of exterior and interior deformation behavior of vehicle bodies.		
4.	**Unit 4: Safety Equipment and Regulations** • Seatbelt Systems: Design and functioning of automatic seatbelt tighteners and advanced seatbelt mechanisms. • Collapsible Steering Columns and Tiltable Steering Wheels: Importance in minimizing driver injuries during collisions. • Electronic Airbag Systems: Functionality, deployment mechanisms, and advancements in airbag technology. • Bumper Safety Designs: Analysis of bumpers designed for impact absorption and pedestrian safety. • Anti-Lock Braking Systems (ABS): Working principles, advantages, and integration with other safety systems.	6	15
5.	**Unit 5: Advanced Safety Systems** • Speed Control Systems: Use of adaptive cruise control and speed governors to enhance driving safety. • Rear Object Detection Systems: Technologies such as ultrasonic sensors and rear-view cameras for preventing collisions. • Frontal Object Detection Systems: Radar and Lidar-based systems for early detection of obstacles and pedestrians. • Object Detection and Braking Mechanisms: Integration of object detection with automated emergency braking systems (AEB) to prevent collisions.	10	20

6	**Unit 6: Emerging Trends in Aerodynamics and Safety** • Integration of AI and IoT in Vehicle Safety: Role of artificial intelligence and the Internet of Things in developing advanced driver-assistance systems (ADAS), predictive maintenance, and connected vehicles. • Simulations and Virtual Testing in Automotive Safety Systems: Use of software tools for simulating crash scenarios, analyzing safety features, and improving system designs without physical testing.	8	15
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**25**	**20**	**20**	**15**	**10**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Hucho, W.H., "Aerodynamics of Road Vehicles," Butterworths Co. Ltd., 1997.
2. J. Powloski, "Vehicle Body Engineering," Business Books Ltd., London, 1969.
3. Ronald K. Jurgen, "Automotive Electronics Handbook," Second Edition, McGraw-Hill Inc., 1999.
4. ARAI Safety Standards.

(b) Open-Source Software and Websites:

1. Open FOAM: Open-source CFD software for aerodynamic simulations.
2. Blender: 3D modelling and simulation tool.
3. ANSYS Student Version: For virtual testing and analysis.
4. Websites:

- www.nhtsa.gov (National Highway Traffic Safety Administration)
- www.iihs.org (Insurance Institute for Highway Safety)
- www.sae.org (Society of Automotive Engineers).

Suggested Course Practical List:

1. Study of aerodynamic drag and bluff body designs.
2. Determination of drag coefficient using wind tunnel or simulation tools.
3. Analysis of dust flow patterns and their impact on vehicle performance.
4. Study of bumper designs for impact absorption and safety.
5. Experiment on airbag deployment mechanisms.
6. Investigation of collapsible and tiltable steering systems.
7. Testing and analysis of anti-lock braking systems (ABS).
8. Study of object detection systems and their integration with braking systems.
9. Simulation of vehicle aerodynamics using CFD tools.
10. Case study analysis of vehicle safety systems.

List of Laboratory/Learning Resources Required:

1. **Laboratory Equipment:**
    - Wind tunnel, Flow Visualization Tools, Pressure Sensors, Force Sensors, Data Acquisition Systems, Vehicle Models and Crash Test Dummies
2. **Software Tools**
    - CFD, FEA, Vehicle Dynamics Simulation Software, Crash Simulation Software, Wind Tunnel Simulation Software and Vehicle Design Software

Suggested Project List

1. Design and analysis of a low-drag aerodynamic vehicle model.
2. Development of a smart bumper system for enhanced safety.
3. Optimization of airbag deployment mechanisms using simulation tools.
4. Study and implementation of adaptive cruise control and speed limiter systems.
5. Design of an object detection and collision prevention system using AI.
6. Integration of IoT for real-time monitoring of vehicle safety systems.
7. Development of a comprehensive thermal management solution for electric vehicle batteries.
8. Comparative analysis of active and passive safety features in modern vehicles.

Suggested Activities for Students

1. Seminars and Workshops: Latest trends in vehicle aerodynamics and safety.
2. Industry Visits: Explore automotive R&D facilities.
3. Hands-on Training: Use simulation tools and testing equipment.
4. Case Studies: Analyze real-world safety system implementations.
5. Group Projects: Collaborate on innovative safety designs.
6. Research Paper Reviews: Present insights on advanced automotive technologies.

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