



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Subject Code: ME03088011

Subject Name: Advanced Tire Technology for EVs and Innovative Tire Solutions

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	MOPEC

Prerequisite:	Basic knowledge of rubber technology, tire technology, processing techniques and compounding ingredients.
Rationale:	The rapid advancements in automotive technology have significantly influenced the development of tire technologies. As vehicles become more efficient, autonomous, and environmentally sustainable, there is an increasing need for innovative tire solutions that can enhance performance, safety, and sustainability. This study explores various aspects of advanced tire technologies, including their design, materials, mechanics, and future trends, with the objective of providing a comprehensive understanding of the latest developments in this field. This study aims to provide an in-depth understanding of advanced tire technologies, their impact on automotive performance, and their future potential. By analysing smart innovations, sustainable solutions, and next-generation manufacturing techniques, this research contributes to the ongoing evolution of the tire industry and its alignment with modern transportation demands.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
C01	Explain the fundamental structure, materials, and performance characteristics of conventional and advanced tires.
C02	Analyze the integration of smart tire technologies with IoT for real-time monitoring and autonomous vehicle applications.
C03	Evaluate the mechanisms, advantages, and challenges of self-sealing, run-flat, and airless tire technologies.
C04	Assess the impact of low rolling resistance and fuel-efficient tires on vehicle performance and energy consumption.
C05	Examine sustainable and innovative tire manufacturing techniques, including 3D printing and eco-friendly materials.



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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
03	00	00	03	70	30	00	00	100

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Introduction to Advanced Tire Technologies: Overview of Tire Types: Conventional vs. Advanced Tires, Tire Structure and Materials: Basic Components, Advances in Reinforcements, Tire Performance Characteristics: Traction, Wear, Rolling Resistance, and Noise, Fundamentals of Tire Mechanics and Dynamics.	4	10
2.	Smart Tires and IoT Integration: Concept of Smart Tires: Definition, Functions, and Benefits, IoT and Sensor Integration in Tires: Embedded Sensors for Monitoring, Data Acquisition and Analysis: Temperature, Pressure, and Wear Monitoring, Wireless Communication in Smart Tires: Real-time Data Transmission, Applications of Smart Tires in Autonomous Vehicles and Fleet Management.	5	10
3.	Self-Sealing Tires: Mechanism of Self-Sealing Technology, Types of Sealant Materials and How They Work, Advantages and Challenges of Self-Sealing Tires, Performance Evaluation: Durability, Safety, and Repairability, Use Cases: EVs, Commercial Vehicles, and Motorcycles.	4	10
4.	Run-Flat Tires (RFT): Principles of Run-Flat Tire Technology, Different Types of RFT: Self-supporting vs. Support Ring Designs, RFT Benefits and Limitations: Safety, Convenience, and Performance, Testing and Durability of Run-Flat Tires, Future Trends: Integration with TPMS and RFT for EVs.	4	10
5.	Airless Tires (Non-Pneumatic Tires - NPT): Concept of Airless Tires: Overview and Benefits, Material and Structural Design of NPTs, Comparison with Pneumatic Tires: Performance, Safety, and Durability, Manufacturing Challenges and Innovations in Airless Tire Technology, Applications in EVs, Commercial Vehicles, and Special Purpose Vehicles.	4	10



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6.	Low Rolling Resistance & Fuel-Efficient Tires: Understanding Rolling Resistance: Definition and Measurement Techniques, Low Rolling Resistance Tires: Design Strategies for EVs and Conventional Vehicles, Tire Materials and Tread Patterns for Fuel Efficiency, Impact of Low Rolling Resistance Tires on EV Range and Energy Consumption, Evaluation and Standards for Fuel-Efficient Tires.	4	10
7.	Sustainable and Eco-friendly Tire Technologies: Environmental Impact of Tire Production and Use, Sustainable Materials for Tire Manufacturing: Bio-based Elastomers and Recycled Materials, Life Cycle Assessment (LCA) of Tires: Carbon Footprint and Eco-Labeling, Tire Recycling Technologies: Devulcanization and Reuse of Materials, Future of Sustainable Tires: Circular Economy and Green Innovations.	5	10
8.	3D-Printed Tires and Custom Tire Manufacturing: Principles of 3D Printing and Additive Manufacturing for Tires, Material Selection and Design Flexibility with 3D-Printed Tires, Benefits: Lightweight, Customization, and Performance Optimization, Challenges: Durability, Standardization, and Large-Scale Production, Case Studies and Potential Applications in EVs and Specialized Vehicles.	5	10
9.	Performance Testing and Quality Assurance: Tire Testing Methods: Mechanical Testing (Tensile, Compression), Durability, and Impact Tests, Real-World Performance Testing: Load Tests, Temperature and Pressure Cycles, Advanced Simulation Techniques for Tire Design and Optimization, Tire Certification and Standards: SAE, ISO, DOT, ECE, In-Field Monitoring and Quality Control of Advanced Tire Technologies.	5	10
10.	Future Trends in Tire Technology: Integration of Smart Technologies: Autonomous Vehicles, Real-Time Analytics, and Maintenance, Development of Multifunctional Tires: Tires with Multiple Capabilities (e.g., Self-healing, Low Rolling Resistance, Smart Sensors), Autonomous Tire Design: Use of AI and Machine Learning for Tire Optimization, Airless Tires for Mass Adoption: Innovations in Materials and Design, Collaborative Projects Between Automakers, Tire Manufacturers, and Tech Companies.	5	10
Total		45	100



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Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	10	20	10	10	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:

Recommended Textbooks:

1. "Tire Engineering" – Brendan Rodgers
2. "Tire and Vehicle Dynamics" – Hans B. Pacejka
3. "The Pneumatic Tire" – National Highway Traffic Safety Administration (NHTSA)
4. "Sustainable Tire Materials and Manufacturing" – Michael H. F. Chisholm
5. "Additive Manufacturing for the Automotive Industry" – David B. Richard

(b) List of Open Source Software/learning website:

- <https://www.tiretechnology-expo.com/en/>
- <https://www.iso.org/home.html>
- https://www.bridgestone.com/regional/asia_pacific/india.html
- <https://www.michelin.com/>

Suggested Course Practical List: If any

1. Analysis of Reinforcement Materials in Modern Tires
2. Development of a Real-Time Tire Monitoring System
3. AI-Based Predictive Maintenance for Smart Tires
4. Development of a Self-Sealing Tire Prototype
5. Durability Testing of Self-Sealing Tires
6. Optimization of Run-Flat Tire Design for Electric Vehicles
7. Development of Low Rolling Resistance Tires for EVs
8. 3D-Printed Airless Tire Prototype



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9. Performance Comparison of Airless and Pneumatic Tires
10. Computational Fluid Dynamics (CFD), Mechanical Testing
11. Design Optimization of 3D-Printed Tires
12. Simulation-Based Analysis of Tire Performance
13. Development of an AI-Based Tire Defect Detection System
14. AI-Driven Tire Optimization for Autonomous Vehicles
15. Exploring Hydrogen-Fueled Vehicles and Tire Adaptation
