AUPE3010 AUTOMOTIVE SAFETY (3-0-0)

Course Objectives:

1. To introduce students to the fundamental principles of automotive safety engineering.
2. To understand crash dynamics, vehicle structural integrity, and restraint systems.
3. To study safety standards, regulatory frameworks, and test protocols.
4. To explore emerging technologies in active safety and driver assistance systems.

Module I: Introduction to Automotive Safety and Crashworthiness (08 Hours)

Types of vehicle safety: active, passive, tertiary, and post-crash. Crash dynamics and types of impacts: frontal, side, rear, rollover. Principles of crash energy management. Injury biomechanics: HIC, chest deflection, leg injuries. Concepts of crashworthiness: survival space, energy absorption. Introduction to vehicle crash modeling tools (e.g., LS-DYNA, HyperCrash).

Module II: Vehicle Structural Design and Crumple Zones (08 Hours)

Crash load paths and structural reinforcements. Design of front, rear, and side crumple zones. Materials used in crash structures: HSS, UHSS, composites. Impact beams and safety cage design. Structural intrusion minimization and deformation mapping. Roof crush and rollover protection (FMVSS 216).

Module III: Passive Safety Systems (08 Hours)

Seat belts: 2-point vs 3-point, pre-tensioners, load limiters. Airbags: front, side, curtain, knee airbags – deployment logic, sensors, inflators. Child Restraint Systems (CRS):
ISOFIX, booster seats. Head restraints and anti-whiplash systems. Occupant detection and seatbelt reminder systems. Integration and synchronization of restraint systems (seatbelt + airbag).

Module IV: Crash Testing and Safety Standards (08 Hours)

Crash test types: Frontal (offset, full barrier), side impact, rear impact, rollover. Dummies and instrumentation: Hybrid III, SID, THOR, EuroSID. Injury criteria and assessment tools.
Regulatory bodies and standards:
NCAP: Global NCAP, Euro NCAP, Bharat NCAP. FMVSS, ECE R94/R95, AIS-098, IS 11939.
Overview of test laboratories: ARAI, ICAT, NATRAX. Interpretation of safety ratings and crash reports.

Module V: Active Safety Systems and ADAS (08 Hours)

Introduction to Active Safety: ABS, EBD, Traction Control, ESC. Emergency Brake Assist, Hill Hold, Roll Stability. Advanced Driver Assistance Systems (ADAS): Adaptive Cruise Control (ACC), Lane Keeping Assist, Blind Spot Detection. Forward Collision Warning (FCW), Automatic Emergency Braking (AEB). Driver monitoring and drowsiness detection.
Pedestrian Safety: Head impact zone optimization. Pop-up bonnet mechanisms. Euro NCAP pedestrian safety protocols.

Course Outcomes (COs):

Upon successful completion of the course, students will be able to:
CO1:Analyze vehicle crash scenarios and evaluate structural crashworthiness. CO2: Design crumple zones and occupant protection structures.
CO3:Explain the function and design of passive safety systems such as seat belts and airbags.
CO4:Understand global crash test procedures and safety rating systems.
CO5:Explore modern active safety and Advanced Driver Assistance Systems (ADAS).

Text Books:

1. Reza N. Jazar – Vehicle Dynamics and Control, Springer
2. George A. Peters & Barbara J. Peters – Automotive Vehicle Safety, CRC Press
3. Robert Bosch GmbH – Bosch Automotive Handbook, Wiley

Reference Materials:

1. SAE Technical Papers on Crashworthiness and Safety Systems
2. Bharat NCAP and Global NCAP Test Protocols
3. NHTSA Crash Test Database and FMVSS Regulatory Documents
4. AIS-098 and other Automotive Industry Standards by ARAI