NOISE, VIBRATION AND HARSHNESS

Course Objectives:

1. To provide fundamental knowledge of noise, vibration, and harshness phenomena in automobiles.
2. To develop analytical skills for evaluating vibration characteristics of automotive systems.
3. To introduce acoustic principles and noise generation mechanisms in vehicles.
4. To train students in modern NVH measurement, testing, and diagnostic techniques.
5. To familiarize students with NVH control strategies and computer-aided engineering tools used in automotive industries.

Module I: Fundamentals of Noise and Vibration (9 Hours)

Introduction to NVH and its significance in automotive design. Sources of automotive noise and vibration. Human perception of sound and vibration. Sound wave characteristics, frequency, wavelength, amplitude, phase, sound pressure level (SPL), decibel scale. Types of noise: airborne, structure-borne, impact, tonal and broadband noise. Fundamentals of vibration: free vibration, forced vibration, damped vibration, resonance. Damping mechanisms and vibration isolation concepts. Effect of NVH on vehicle quality, comfort, and durability.

Module II: Automotive Vibration Analysis (9 Hours)

Single Degree of Freedom (SDOF) systems – equations of motion, natural frequency, damping ratio, transmissibility. Multi Degree of Freedom (MDOF) systems – vibration modes and mode shapes. Engine-induced vibrations and balancing considerations. Driveline vibrations and torsional oscillations. Suspension and steering system vibrations. Ride and handling characteristics. Vehicle body vibrations. Introduction to modal analysis and experimental modal testing. Case studies on vibration issues in passenger vehicles and commercial vehicles.

Module III: Automotive Acoustics (9 Hours)

Fundamentals of acoustics. Sound propagation in enclosed and open environments. Interior and exterior vehicle noise. Engine combustion noise and mechanical noise. Intake and exhaust system noise generation. Tire-road interaction noise. Aerodynamic and wind noise. Structure-borne noise transmission paths. Cabin acoustics and passenger comfort. Acoustic materials used in vehicles. Sound absorption, transmission loss, reflection, and insulation techniques. Noise regulations and standards for automotive vehicles.

Module IV: NVH Measurement and Testing Techniques (9 Hours)

Noise and vibration measurement principles. Instrumentation for NVH testing. Microphones, sound level meters, accelerometers, laser vibrometers, and data acquisition systems. Frequency analysis and Fast Fourier Transform (FFT). Spectrum analyzers and signal conditioning. Order tracking analysis. Experimental modal analysis. Transfer path analysis (TPA). Vehicle pass-by noise testing. Chassis dynamometer testing. NVH diagnosis during road tests. Data interpretation and report preparation.

Module V: NVH Control, Optimization and Modern Trends (9 Hours)

Noise control techniques at source, path, and receiver. Vibration isolation methods and resilient mounting systems. Dynamic vibration absorbers and tuned mass dampers. Damping treatments and constrained-layer damping. Acoustic insulation and sound package development. Active noise control (ANC) systems. Computer-Aided Engineering (CAE) applications in NVH. Finite Element Method (FEM) and Boundary Element Method (BEM) for NVH analysis. NVH challenges in Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs). Emerging trends in smart materials and active vibration control systems.

Course Outcomes (COs):

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

CO1: Explain the principles of sound, vibration, and their effects on vehicle comfort and performance.

CO2: Analyze free and forced vibration characteristics of automotive components and systems.

CO3: Identify and evaluate major sources of vehicle noise and vibration using measurement techniques.

CO4: Perform NVH testing and interpret frequency-domain and time-domain data.

CO5: Recommend suitable noise and vibration control measures using analytical and simulation approaches.

Text Books:

1. Rao, S. S., Mechanical Vibrations, 6th Edition, Pearson Education.
2. Beranek, L. L. and Ver, I. L., Noise and Vibration Control Engineering, Wiley Publications.
3. Thomson, W. T., Theory of Vibration with Applications, CRC Press.

Reference Books:

1. Harrison, M., Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles, Butterworth-Heinemann.
2. Randall, R. B., Vibration-Based Condition Monitoring, Wiley.
3. Ewins, D. J., Modal Testing: Theory, Practice and Application, Research Studies Press.
4. Norton, M. P. and Karczub, D. G., Fundamentals of Noise and Vibration Analysis for Engineers, Cambridge University Press.
5. Heisler, H., Advanced Vehicle Technology, Butterworth-Heinemann.