AEPE4002 VIBRATION AND AEROELASTICITY (3-0-0)

Course Objectives: The course aims to:

1. Introduce the fundamental principles of vibration in mechanical and structural systems.
2. Develop the ability to model and analyze single and multi-degree-of-freedom vibrating systems.
3. Explain the basic concepts of aeroelasticity and fluid–structure interaction.
4. Familiarize students with aeroelastic instabilities such as divergence and flutter.
5. Provide awareness of practical engineering applications and vibration control techniques in aerospace and allied fields.

Module I: Fundamentals of Mechanical Vibrations (9 Hours)

Introduction to vibration: Definitions, types, and examples
Degrees of freedom and modeling of vibrating systems
Free vibration of single-degree-of-freedom (SDOF) systems
Undamped and damped vibration
Logarithmic decrement and damping ratio
Forced vibration of SDOF systems
Resonance and its engineering significance
Vibration isolation and transmissibility

Module II: Multi-Degree-of-Freedom and Continuous Systems (9 Hours)

Free vibration of two-degree-of-freedom systems
Natural frequencies and mode shapes
Introduction to matrix method in vibration analysis
Orthogonality of modes
Introduction to continuous systems
Longitudinal vibration of bars
Transverse vibration of beams (basic concepts)
Introduction to finite element approach in vibration

Module III: Fundamentals of Aeroelasticity (9 Hours)

Introduction to Aeroelasticity: Definition and scope
Static and dynamic aeroelasticity
Interaction of aerodynamic, elastic, and inertial forces
Typical section model
Divergence: Concept and analysis (basic understanding)
Control reversal
Flutter phenomenon: Concept, types, and physical interpretation
Historical case studies (e.g., Tacoma Narrows Bridge, aircraft flutter incidents)

Module IV: Aeroelastic Analysis and Control (9 Hours)

Mathematical modeling of aeroelastic systems
Two-dimensional typical section analysis (basic formulation)
Methods for flutter prediction
Wind-induced vibrations in tall structures

Aeroelasticity in turbine blades and UAVs
Vibration and aeroelastic control techniques: Passive control (dampers, structural modification), Active control, Modern computational tools in vibration and aeroelastic analysis

Course Outcomes (COs):
After successful completion of the course, students will be able to:
CO-1: Define fundamental concepts of vibration and aeroelasticity, including resonance, damping, divergence, and flutter.
CO-2: Explain the behavior of single and multi-degree-of-freedom vibrating systems and basic aeroelastic interactions.
CO-3: Apply fundamental equations of motion to analyze simple vibration and aeroelastic problems.
CO-4: Analyze resonance conditions and aeroelastic instability phenomena in engineering systems.
CO-5: Evaluate appropriate vibration and aeroelastic control strategies for practical engineering applications.

Textbooks
1. S. S. Rao, Mechanical Vibrations, Pearson Education India.
2. W. T. Thomson & M. D. Dahleh, Theory of Vibration with Applications, Pearson India.
3. Bisplinghoff, Ashley & Halfman, Aeroelasticity, Dover Publications.

Reference Books
1. Y. C. Fung, An Introduction to the Theory of Aeroelasticity, Dover Publications.
2. D. J. Inman, Engineering Vibration, Pearson Education India.
3. R. L. Bisplinghoff & H. Ashley, Principles of Aeroelasticity, Wiley.
4. E. H. Dowell, A Modern Course in Aeroelasticity, Springer India.
5. C. Beards, Structural Vibration: Analysis and Damping, Butterworth-Heinemann (Elsevier India).