AEROSPACE STRUCTURAL DYNAMICS

VII SEMESTER: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEB25	Core	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

I. COURSE OVERVIEW:

The course aim is to teach basic concepts and recent developments related to mechanical vibrations, structural dynamics and vibration control. The course seeks to introduce students to the fundamentals of dynamics by providing an overview on mechanical vibration. Vibrations in machines and structures are typically undesirable as they produce stresses, energy losses and increased bearing loads. They contribute to structural wear and can lead to passenger discomfort in vehicles. This course covers the vibrations of discrete systems and continuous structures and introduces the computational dynamics of linear engineering systems. Learn how to derive equations of motion and design vibration isolation systems. Gain an understanding of the concepts of natural frequencies and mode shapes and their significance. Complete system modeling tasks and formulate equations to measure and ultimately minimize vibrations. The concepts of aero elasticity phenomena, effect of aero elasticity in flight vehicle design.

II. OBJECTIVES:

The course should enable the students to:

I. Demonstrate the knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free and forced response.
II. Understand to identify, formulate and solve engineering problems. This will be accomplished by having students' model, analyze and modify a vibratory structure order to achieve specified requirements.
III. Introduce to structural vibrations which may affect safety and reliability of engineering systems.
IV. Describe structural dynamic and steady and unsteady aerodynamics aspects of airframe and its components of space structures.

III. COURSE OUTCOMES:

CO 1	**Explain** the concepts of the equation of motion of free vibration and its response for determining the nature of single degree of freedom.	Understand
CO 2	**Demonstrate** the response of step function, periodic excitation (Fourier series and transform, Laplace transform) of Single DOF for determining the freely vibrating of a body.	Understand
CO 3	**Construct** the equation of motion of free vibration for the design of the analysis of the spring-mass system.	Apply
CO 4	**Apply** the various equations of forced vibration for determining the frequency of the body.	Apply
CO 5	**Understand** the torsional vibrations of rotor and geared systems for determining the DOF of the vibrating systems.	Understand
CO 6	**Develop** the formulation of stiffness and flexibility influence coefficients for simplifying solution of multi DOF systems.	Apply

CO 7	**Analyze** the transverse, longitudinal, torsional and lateral vibrations of cables, rods and beams for the design of continue elastic body.	Analyze
CO 8	**Understand** the difference between the static and dynamic aeroelasticity for determining the aeroelastic model of airfoils.	Understand
CO 9	**Analyze** the static and dynamic aeroelasticity of the typical airfoil and wing sections of aircraft using Eigen functions and Laplace equation for design of aircraft wing.	Analyze

IV. SYLLABUS:

MODULE-I	SINGLE-DEGREE-OF-FREEDOM LINEAR SYSTEMS	Classes: 10

Introduction to theory of vibration, equation of motion, free vibration, response to harmonic excitation, response to an impulsive excitation, response to a step excitation, response to periodic excitation (Fourier series), response to a periodic excitation (Fourier transform), Laplace transform (Transfer Function).

MODULE-II	TWO-DEGREE-OF-FREEDOM SYSTEMS	Classes: 10

Introduction, Equations of Motion for Forced Vibration, Free Vibration Analysis of an Undamped System, Torsional System, Coordinate Coupling and Principal Coordinates, Forced-Vibration Analysis, Semi definite Systems, Self-Excitation and Stability Analysis, Transfer- Function Approach, Solutions Using Laplace Transform, Solutions Using Frequency Transfer Functions.

MODULE-III	MULTI-DEGREE-OF-FREEDOM LINEAR SYSTEMS	Classes: 08

Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties; Free and forced vibration by Modal analysis; Method of matrix inversion; Torsional vibrations of multi- rotor systems and geared systems; Discrete- Time systems.

MODULE-IV	DYNAMICS OF CONTINUOUS ELASTIC BODIES	Classes: 09

Introduction, transverse vibration of a string or cable, longitudinal vibration of a bar or rod, torsional vibration of shaft or rod, lateral vibration of beams, the Rayleigh-Ritz method.

MODULE-V	INTRODUCTION TO AEROELASTICITY	Classes: 08

Static Aeroelasticity; Typical Section Model of an Airfoil: Typical Section Model with Control Surface, Typical Section Model—Nonlinear Effects. One Dimensional Aeroelastic Model of Airfoils: Beam-Rod Representation of Large Aspect Ratio Wing, Eigenvalue and Eigen function Approach, Galerkin's Method. **Dynamic Aeroelasticity;** Hamilton's Principle: Single Particle, Many Particles, Continuous Body, Potential Energy, Non potential Forces, Lagrange's Equations.

V. Text Books:

1. Bismarck-Nasr, M.N., "Structural Dynamics in Aeronautical Engineering", AIAA Education Series, 2nd Edition, 1999.
2. Rao, S.S., "Mechanical Vibrations", Prentice-Hall, 5th Edition, 2011.
3. Earl H. Dowell, "A Modern Course in Aeroelasticity" Volume 217, Duke University, Durham, NC, USA.

VI. Reference Books:

1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, “Aeroelasticity”, Addison Wesley Publishing Co., Inc., 2nd Edition, 1996.
2. Leissa, A.W., Vibration of continuous system, The McGraw-Hill Company, 2nd Edition, 2011.
3. Inman, D.J., Vibration Engineering, Prentice Hall Int., Inc., 3rd Edition, 2001.

VII. Web References:

1. http://ase.sbu.ac.ir/FA/Staff/abbasrahi/Lists/Dars/Attachments/11/Vibrations%20of%20Continuous%20Systems.pdf
2. http://arc-test.aiaa.org/doi/book/10.2514/4.862458
3. http://arc-test.aiaa.org/doi/abs/10.2514/5.9781600862373.0719.0728

VIII. E-Text Books:

1. http://www.gregorypaulblog.com/structural-dynamics-in-aeronautical-engineering-aiaa-education-series.pdf
2. https://aerocastle.files.wordpress.com/2012/10/mechanical_vibrations_5th-edition_s-s-rao.pdf