AEROSPACE STRUCTURAL DYNAMICS

VII SEMESTER: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AAE015	Core	3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

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 OUTCOME:

After successful completion of the course, students should be able to:

CO 1	**Explain** the concepts of the equation of motion of free vibration andits response for determining the nature of single degree of freedom.	Understand
CO 2	**Apply** the various equations of free and forced vibration for determining the frequency of the spring-mass system.	Apply
CO 3	**Understand** the torsional vibrations of rotor and geared systems fordetermining the DOF of the vibrating systems.	Understand
CO 4	**Develop** the formulation of stiffness and flexibility influence coefficients for simplifying solution of multi DOF systems.	Apply
CO 5	**Apply** the transverse, longitudinal, torsional and lateral vibrations ofcables, rods and beams for the design of continue elastic body.	Apply
CO 6	**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:

UNIT-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).

UNIT-II	MULTI-DEGREE-OF-FREEDOM LINEAR SYSTEMS	Classes: 10

Equations of motion, free vibration, the Eigen value problem, response to an external applied load, damping effect; Modeling of continuous systems as multi-degree-of-freedom systems, using Newtons second law to derive

equations of motion, influence coefficients - stiffness influence coefficients, flexibility influence coefficients, inertia influence coefficients; potential and kinetic energy expressions in matrix form, generalized coordinates and generalized forces, Lagrange's equations to derive equations of motion, equations of motion of undamped systems in matrix form, eigenvalue problem, solution of the Eigen value problem, expansion theorem, unrestrained systems, free vibration of undamped systems; forced vibration of undamped systems using modal analysis, forced vibration of viscously damped systems.

UNIT-III	NONLINEAR AND RANDOM VIBRATION	Classes: 08

Introduction to nonlinear vibrations, simple examples of nonlinear systems, physical properties of nonlinear systems, solutions of the equation of motion of a single-degree-of-freedom nonlinear system, multi-degree-of-freedom nonlinear systems.

Introduction to random vibrations; classification of random processes, probability distribution and density functions, description of the mean values in terms of the probability density function, properties of the autocorrelation function, power spectral density function, properties of the power spectral density function, white noise and narrow and large bandwidth, single-degree-of-freedom response, response to a white noise.

UNIT-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.

UNIT-V	INTRODUCTION TO AEROELASTICITY	Classes: 08

Collar's aeroelastic triangle, static aeroelasticity phenomena, dynamic aeroelasticity phenomena, aeroelastic problems at transonic speeds, aeroelastic tailoring, active flutter suppression. Effect of aeroelasticity in flight vehicle design.

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. Thomson, W.T., "Theory of vibrations with applications", CBS Publishers, , Delhi, 3rd Edition, 2002.

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.

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

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

Course Home Page: