AEROSPACE STRUCTURAL DYNAMICS

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: 30	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 45		

OBJECTIVES:

The students will try to learn:

I	The elements of mechanical vibrations for developing appropriate idealized mathematical model for time varying excitations with respect to forces and moments.
II	The solution for vibration problems for single and multi-degrees of freedom environment with damped and un-damped systems.
III	The nonlinear and random vibratory structures for achieving specified stability requirements.
IV	The structural dynamics and aero elasticity phenomena in flight vehicle design stability to achieve cruising speeds.

COURSE OUTCOMES:

CO 1	Identify degrees of freedom in a vibrating system along with forcing function for configuring the equilibrium.
CO 2	Determine the shock spectrum and system response for impact loads employing Laplace transforms and the Convolution integral formulations
CO 3	Define the static and dynamic coupling of a vibrating system with principal coordinates for structures.
CO 4	Build the equations of natural and damped vibrating system frequencies for compute motion and force transmitted to the machine foundation.
CO 5	Apply the equations of motion for forced vibration system with rotary and base excitation for plot MF and phase angle diagram.
CO 6	Demonstrate the solutions of equation of motion for single and multi-degree-of-freedom nonlinear systems.
CO 7	Demonstrate the various types of time varying random vibration processes and Functions for structures
CO 8	Analyzethe white noise, narrow and large bandwidth single-degree-of- freedom response for random vibrations.
CO 9	Apply the Rayleigh-Ritz method on various types of continuous elastic bodies for perceive the transverse, longitudinal and torsional vibration.
CO 10	Illustrate Collar's aero elastic triangle to integrate static and dynamic aero elasticity phenomena for aircraft wings at transonic speeds.
CO 11	Analyze active flutter suppression effects on aero elastic tailoring for flight vehicle design.
CO 12	Apply static and dynamic principle to obtain the feasible solution for aircraft structural Problems.

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 Newton's 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: 09**
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: 08**
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 AERO ELASTICITY**	**Classes: 08**
Collar's aero elastic triangle, static aero elasticity phenomena, dynamic aero elasticity phenomena, aero elastic problems at transonic speeds, aero elastic tailoring, active flutter suppression. Effect of aero elasticity 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, ―Aero-elasticity, 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