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	3	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

COURSE 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.

COURSE OUTCOMES (COs):

CO1: Understand the concept of vibrations, equation of motion, response to harmonic excitation, impulsive excitation, step excitation, periodic excitation (Fourier series), Fourier transform), Laplace transform (Transfer Function).
CO2: Remember and describe the concept of Eigen value problem, damping effect; Modeling of continuous systems as multi-degree-of-freedom systems, equations of motion of undamped systems in matrix form, unrestrained systems, free and forced vibration vibration of undamped systems; using modal analysis, forced vibration of viscously damped systems.
CO3: Determine and apply the concept of nonlinear vibrations physical properties of nonlinear systems single-degree-of-freedom and multi-degree-of-freedom nonlinear systems. Random vibrations;, single-degree-of-freedom response, response to a white noise.
CO4: Describe about 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.
CO5: Understand the concept of Collar's aero elastic triangle, static aero elasticity aero elastic problems at transonic speeds, active flutter suppression. Effect of aero elasticity in flight vehicle design.

COURSE LEARNING OUTCOMES (CLOs):

1. Apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations) to model, analyze, design, and realize physical systems, components or processes, and work professionally in mechanical systems areas.
2. Become proficient in the modeling and analysis of one degree of freedom systems - free vibrations, transient and steady-state forced vibrations, viscous and hysteric damping.
3. Understanding the response to periodic excitation (Fourier series ,Fourier transform)

4. Using Laplace transforms and the Convolutional integral formulations to understand shock spectrum and system response for impact loads.
5. Become proficient in the modeling and analysis of multi-dof systems - Lagrange's equations, reduction to one-dof systems for proportionally damped systems, modal analysis, vibration absorbers, vibration transmission, Fourier transforms.
6. Convert the physical domain to mathematical formulation and development of governing equation based on number of masses in the system.
7. Understanding the phenomenon of generalized coordinates and generalized forces, Lagrange's equations to derive equations of motion.
8. Apply the Eigen value problem and describe expansion theorem, unrestrained systems, free vibration of undamped systems; forced vibration of undamped systems.
9. Understand the concepts of nonlinear vibrations, simple examples of nonlinear systems, physical properties of nonlinear systems
10. Formulate simple problem solutions of the equation of motion of a single-degree-of-freedom nonlinear system, multi-degree-of-freedom nonlinear systems.
11. Understand the concept of random processes, probability distribution and density functions, description of the mean values in terms of the probability density function
12. Understand the concept of autocorrelation function, power spectral density function, properties of the power spectral density function, white noise and narrow and large bandwidth
13. Understand the concepts of transverse vibration of a string or cable
14. Derive the equations longitudinal vibration of a bar or rod, torsional vibration of shaft or rod
15. Solve the problems for lateral vibration of beams, and the Rayleigh-Ritz method.
16. Understand the concepts of Collar's aeroelastic triangle, static aeroelasticity phenomena
17. Understand the concept of dynamic aeroelasticity phenomena
18. Calculate the aeroelastic problems at transonic speeds, aeroelastic tailoring, active flutter suppression. Effect of aeroelasticity in flight vehicle design.

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: 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 AERO ELASTICITY	Classes: 07

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,
2. 2nd Edition, 1999.
3. Rao, S.S., ―Mechanical Vibrations‖, Prentice-Hall, 5th Edition, 2011.
4. 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.,
2. Inc., 2nd Edition, 1996.
3. Leissa, A.W., Vibration of continuous system, The McGraw-Hill Company, 2nd Edition, 2011.
4. Inman, D.J., Vibration Engineering, Prentice Hall Int., Inc., 3rd Edition, 2001.

Web References:

1. www.knovel.com/web/toc.v/cid:kpasdpdid1/viewertype:toc
2. www.nptel.ac.in/courses/112104116/
3. www.soaneemrana.org/onewebmedia/airframe%20stress%20analysis.pdf
4. www.wikipedia.org/wiki/airframe

E-Text Books:

1. https://www.pdfdrive.com/airframe-structural-design-e6774355.html
2. https://the-eye.eu/public/Books/Airframe%20Structural%20Design%20.pdf
3. https://www.smartzworld.com/notes/airframe-structural-design-pdf-notes-asd/