**INSTITUTE OF AERONAUTICAL ENGINEERING**

**(Autonomous)**

Dundigal, Hyderabad - 500 043

**AERONAUTICAL ENGINEERING**

**DEFINITIONS AND TERMINOLOGY**

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| **Course Title** | AEROSPACE STRUCTURAL DYNAMICS | | | | |
| **Course Code** | AAEB25 | | | | |
| **Program** | B.Tech | | | | |
| **Semester** | VII | | | | |
| **Course Type** | Core | | | | |
| **Regulation** | IARE - R18 | | | | |
| **Course Structure** | **Theory** | | | **Practical** | |
| **Lectures** | **Tutorials** | **Credits** | **Laboratory** | **Credits** |
| 3 | - | 3 | - | - |
| **Course Coordinator** | Mr. GootyRohan, Assistant Professor | | | | |

**OBJECTIVES:**

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| **The students will try to learn:** | |
| 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:**

At the end of the course the students should be able to:

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| **After successful completion of the course, students will be able to:** | | |
| **Course Outcomes** | | **Knowledge Level (Bloom’s Taxonomy)** |
| CO 1 | **Explain**the concepts of the equation of motion of free vibration and its responsefor 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 vibrationfor determining the frequency of the body. | Apply |
| CO 5 | **Understand**the torsional vibrations of rotor and geared systemsfor determining the DOF of the vibrating systems. | Understand |
| CO 6 | **Develop**the formulation of stiffness and flexibility influence coefficientsfor simplifying solution of multi DOF systems. | Apply |
| CO 7 | **Analyze**the transverse, longitudinal, torsional and lateral vibrations of cables, rods and beamsfor the design of continue elastic body. | Analyze |
| CO 8 | **Understand**the difference between the static and dynamic aeroelasticityfor 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 equationfor design of aircraft wing. | Analyze |

**DEFINITIONS AND TERMINOLOGY**

| **S.No** | **QUESTION** | **ANSWER** |
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| **MODULE-I** | | |
| 1 | Amplitude | The maximum displacement of a vibrating body from its equilibrium position is called the amplitude of vibration. |
| 2 | Displacement | Amount of movement from one point to another. E.g. I just walked 100 meters. |
| 3 | Velocity | The rate of movement, E.g. I moved the 100 meters in 10 seconds |
| 4 | Acceleration | The rate of change of velocity. E.g. The car has the capability to go from 0 mph to 100 mph in 8 Seconds. |
| 5 | Frequency: | Denoting how often something occurs, the same thing applies in vibration too. This denotes how frequently something occurs. For example, made to appear at regular intervals based on their relative motion. |
| 6 | What is Hertz | The Hz denotes Hertz, the unit for frequency |
| 7 | **Time Domain** | To say in a graph with Time in the X – Axis and Amplitude in the Y – Axis. You can assume the amplitude to be for example the amount of height a body jumps due to vibration |
| 8 | Cycle. | The movement of a vibrating body from its undisturbed or equilibrium position to its extreme position in one direction, then to the equilibrium position, then to its extreme position in the other direction, and back to equilibrium position is called a cycle of vibration. |
| 9 | Period of oscillation. | The time taken to complete one cycle of motion is known as the period of oscillation τ =2 π/ ω  Time period and is denoted by τ  Rotate through an angle of 2 π  The circular frequency ω |
| 10 | Frequency of oscillation. | The number of cycles per unit time is called the frequency of oscillation |
| 11 | synchronous | Consider two vibratory motions denoted by x1 = A1 sin ω t  x2 = A2 sin(ω t + φ)  The two harmonic motions given by above Eqs. are called synchronous |
| 12 | Phase angle | Consider two vibratory motions denoted by x1 = A1 sin ω t  x2 = A2 sin(ω t + φ)  The two harmonic motions given by above Eqs. are called synchronous  Because they have the same frequency or angular velocity, Two synchronous oscillations need not have the same amplitude, and they need not attain their maximum values at the same time, the second vector leads the first one by an angle known as the phase angle. |
| 13 | Natural frequency. | If a system, after an initial disturbance, is left to vibrate on its own, the frequency with which it oscillates without external forces is known as its natural frequency. |
| 14 | Octave | When the maximum value of a range of frequency is twice its minimum value, it is known as an octave band. |
| 15 | Decibel | The various quantities encountered in the field of vibration and sound (such as displacement, velocity, acceleration, pressure, and power) are often represented using the notation of decibel. |
| MODULE-II | | |
| 1 | Resonance | Whenever the natural frequency of vibration of a machine or structure coincides with the frequency of the external excitation, there occurs a phenomenon known as resonance |
| 2 | vibration or oscillation | Any motion that repeats itself after an interval of time is called vibration or oscillation |
| 3 | generalized coordinates | The coordinates necessary to describe the motion of a system constitute a set of generalized coordinates. These are usually denoted as and may represent Cartesian and/or non-Cartesian coordinates |
| 4 | discrete or lumped  parameter systems | Systems with a finite number of degrees of freedom are called discrete or lumped parameter systems |
| 5 | continuous or distributed systems | Systems with a finite number of degrees of freedom are called discrete or lumped parameter systems, and those with an infinite number of degrees of freedom are called continuous or distributed systems |
| 6 | Free Vibration. | If a system, after an initial disturbance, is left to vibrate on its own, the ensuing vibration is known as free vibration. No external force acts on the system. The oscillation of a simple pendulum is an example of free vibration. |
| 7 | Forced Vibration. | If a system is subjected to an external force (often, a repeating type of force), the resulting vibration is known as forced vibration. |
| 8 | When resonance will occur | If the frequency of the external force coincides with one of the natural frequencies of the system, a condition known as resonance occurs. |
| 9 | undamped vibration | If no energy is lost or dissipated in friction or other resistance during oscillation, the vibration is known as undamped vibration. |
| 10 | linear vibration | If all the basic components of a vibratory system the spring, the mass, and the damper behave linearly, the resulting vibration is known as linear vibration. |
| 11 | nonlinear vibration | . If, however, any of the basic components behave nonlinearly, the vibration is called nonlinear vibration. |
| 12 | deterministic | If the value or magnitude of the excitation (force or motion) acting on a vibratory system is known at any given time, the excitation is called deterministic. |
| 13 | deterministic vibration | If the value or magnitude of the excitation (force or motion) acting on a vibratory system is known at any given time, the excitation is called deterministic. The resulting vibrationis known as deterministic vibration. |
| 14 | Random vibration | If the excitation is random, the resulting vibration is called random vibration |
| 15 | Damped vibration. | If any energy is lost in this way, however, it is called damped vibration. |
| MODULE-III | | |
| 1 | Spring constant or spring stiffness or spring rate. | A spring is said to be linear if the elongation or reduction in length x is related to the applied force F as F = kx  Where k is a constant, known as the spring constant or spring stiffness or spring rate. |
| 2 | Damping | The mechanism by which the vibrational energy is gradually converted into heat or sound is known as damping. |
| 3 | Viscous damping | In viscous damping, the damping force is proportional to the velocity of the vibrating body. |
| 4 | Coulomb or Dry-Friction Damping. | The damping force is constant in magnitude but opposite in direction to that of the motion of the vibrating body. It is caused by friction between rubbing surfaces that either are dry or have insufficient lubrication. |
| 5 | Material or Solid or Hysteretic Damping. | When a material is deformed, energy is absorbed and dissipated by the material. The effect is due to friction between the internal planes, which slip or slide as the deformations take place. |
| 6 | Periodic motion. | Oscillatory motion may repeat itself regularly, as in the case of a simple pendulum, or it may display considerable irregularity, as in the case of ground motion during an earthquake. If the motion is repeated after equal intervals of time, it is called periodic motion. |
| 7 | Harmonic motion | The simplest type of periodic motion is harmonic motion. |
| 8 | Simple harmonic motion | It can be seen that the acceleration is directly proportional to the displacement. Such a vibration, with the acceleration proportional to the displacement and directed toward the mean position, is known as simple harmonic motion. |
| 9 | Torsional vibration | If a rigid body oscillates about a specific reference axis, the resulting motion is called torsional vibration. |
| 10 | Orthogonality | As the number of degrees of freedom increases, the solution of the characteristic equation becomes more complex. The mode shapes exhibit a property known as orthogonality. |
| 11 | Proportional damping. | The solution of forced-vibration problems associated with viscously damped systems can also be found conveniently by using a concept called proportional damping. |
| 12 | lumped-parameter or lumped-mass or discrete-mass systems | The lumped masses are assumed to be connected by massless elastic and damping members. Linear (or angular) coordinates are used to describe the motion of the lumped masses (or rigid bodies). Such models are called lumped-parameter or lumped-mass or discrete-mass systems |
| 13 | Finite element method | Method of approximating a continuous system as a multi degree-of freedom system involves replacing the geometry of the system by a large number of small elements. By assuming a simple solution within each element, the principles of compatibility and equilibrium are used to find an approximate solution to the original system. This method, known as the finite element method. |
| 14 | Influence coefficients | The equations of motion of a multi degree-of-freedom system can also be written in terms of influence coefficients, which are extensively used in structural engineering. Basically, one set of influence coefficients can be associated with each of the matrices involved in the equations of motion. |
| 15 | Flexibility influence coefficients | The influence coefficients corresponding to the inverse stiffness matrix are called the flexibility influence coefficients. |
| MODULE-IV | | |
| 1 | Nodes | The points at which wn=0for all times are called nodes. |
| 2 | Euler-Bernoulli or  thin beam theory | From the elementary theory of bending of beams. |
| 3 | Thick beam theory or Timoshenko beam theory | If the cross-sectional dimensions are not small compared to the length of the beam, we need to consider the effects of rotary inertia and shear deformation. Is known as the thick beam theory or Timoshenko beam theory. |
| 4 | Timoshenko s shear coefficient | Where G denotes the modulus of rigidity of the material of the beam and k is a constant, also known as Timoshenko s shear coefficient. |
| 5 | Rayleigh-Ritz method | Based on Rayleigh s quotient, for finding the approximate fundamental frequencies of continuous systems is outlined. The extension of the method, known as the Rayleigh-Ritz method. |
| 6 | Distributed or continuous systems | Systems where mass, damping, and elasticity were assumed to be present only at certain discrete points in the system. In many cases, known as distributed or continuous systems. |
| 7 | System of infinite degrees of freedom | A continuous system is also called a system of infinite degrees of freedom. |
| 8 | Wave equation | The Equation  is also known as the wave equation. |
| 9 | Frequency or characteristic equation | Equation  is called the frequency or characteristic equation. |
| 10 | Eigen values | Equation is called the frequency or characteristic equation and is satisfied by several values of ω The values of ω are called the eigen values (or natural frequencies or characteristic values) of the problem. |
| 11 | Fundamental mode | The mode corresponding to n = 1 is called the fundamental mode. |
| 12 | Fundamental frequency. | The mode corresponding to n = 1 is called the fundamental mode, and ω1 is called the fundamental frequency. |
| 13 | Torsional stiffness | Where G is the shear modulus and GJ(x) is the torsional stiffness. |
| MODULE-V | | |
| 1 | Aeroelasticity | The term used to denote the field of study concerned with the interaction between the deformation of an elastic structure in an airstream and the resulting aerodynamic force |
| 2 | Classical aerodynamic theory | The theory provide a prediction of the forces acting on a body of a given shape |
| 3 | Elasticity in Aeroelasticity | Provides a prediction of the shape of an elastic body under a given load. |
| 4 | Dynamics in Aeroelasticity | Introduces the effects of inertial forces |
| 5 | Structural dynamics deals with | Between elasticity and dynamics |
| 6 | Static aeroelasticity deals with | Between aerodynamics and elasticity |
| 7 | Dynamic aeroelasticity deals with | Among elasticity, dynamics and aerodynamics |
| 8 | Torsional divergence phenomena | A major factor in the predominance of the biplane design until the early 1930s when “stressed skin” metallic structural configurations were introduced to provide adequate torsional stiffness form on planes |
| 9 | Structural dynamics | To describe the dynamic behavior of conventional aircraft. |
| 10 | Aeroelastic flutter | Which is associated with dynamic aeroelastic instabilities due to the mutual interaction of aerodynamic, elastic and inertial forces? |

**Signature of the Faculty Signature of HOD**

**Mr. K Arun Kumar, Assistant Professor**