

GUJARAT TECHNOLOGICAL UNIVERSITY

AERONAUTICAL ENGINEERING

THEORY OF VIBRATION

SUBJECT CODE: 2160109

B.E. 6th SEMESTER

Type of course: Engineering Science

Prerequisite: Basics of Physics and Solid Mechanics

Rationale: Each and every component of the aircraft undergoes vibration due to aeroelastic loads, aerodynamic loads and inertia loads. To analyze this; basics of vibration needs to be understood and that is what is intended in this subject.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Elements of Vibrations Introduction and basic concepts of vibration, Importance of vibration, Definitions, Methods of Vibration analysis, Types of vibrations, Periodic and Harmonic Motion, Beats, Representation of harmonic motion in complex form.	4	10
2	Undamped Free Vibrations Introduction, Derivation of differential equations, Torsional Vibrations, Equivalent stiffness of spring combinations, Compound pendulum, Transverse vibration of beams, Beams with several masses.	6	20
3	Damped Free Vibrations: Introduction, Types of damping, Differential equations of damped free vibrations, Logarithmic decrement.	7	20
4	Forced Vibrations: Introduction, Sources of excitation, Equations of motion with harmonic force, Response of rotating and reciprocating unbalanced system, Support motion, Vibration Isolation, Vibration Transmissibility, Vibration measuring instruments, Frequency measuring device, Concept of Critical speed of shaft.	9	20
5	Two degrees of freedom systems: Introduction, Principal modes of vibrations, Torsional Vibrations, Coordinate coupling, Vibrations of undamped two degrees of freedom systems, Vibrations of damped two degrees of freedom systems, Undamped Forced vibrations with harmonic excitation, Vibration absorbers, Difference between vibration absorber and vibration isolator,	7	20

	Torsionally equivalent shaft		
6	Introduction to Multi Degree of freedom systems Introduction, Lagrange's equation, Rayleigh's method and Rayleigh-Ritz method.	3	10

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
35%	25%	20%	15	5	0%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Mechanical vibrations by V.P. Singh.
2. Mechanical Vibrations by G K Grover.
3. Theory of Vibration with Applications by William T. Thomson & Marie
4. Vibration fundamentals & practice by Clarence DeSilva.
5. Mechanical vibrations by Singiresu S. Rao.
6. Vibration analysis by Rao V. Dukkipatti.

Course Outcome:

After learning the course the students should be able to:

1. Understand the how the vibrations of any system can be defined.
2. Know the procedure about how to analyze the problem of free vibration system
3. How the single degree forced vibration problem can be solved.
4. Know the procedure about how to analyze the problem of two degree of vibrations system.

List of Experiments:

1. To investigate the relation $T = 2\pi \sqrt{L/g}$ for simple pendulum.
2. To determine Radius of Gyration of the given compound pendulum.
3. To verify the theoretical frequency of the longitudinal vibrations of a spring mass system with experimental frequency.
4. To compare the experimental frequency of the undamped free vibrations of an equivalent spring mass system with the theo. Frequency.

5. To study forced vibrations of an equivalent spring mass system.
6. To compare the theoretical frequency of the torsional vibrations (undamped) of a single rotor system with experimental frequency.
7. To study free vibrations of a two rotor system and determine the natural frequency.
8. To study the phenomena of whirling of shafts and find the critical speed.
9. To verify the Dunkerley's rule.
10. Study of vibration measuring instrument.
11. To study the gyroscopic behavior of a spinning rotor.

Design based Problems (DP)/Open Ended Problem:

1. Make a SDOF model of washing machine using a spring mass system
2. Make Two DOF model of the motion of an airfoil section
3. Compare the motions of various types of springs
4. Make a Two DOF model of a bike suspension system using spring-mass-damper system

Major Equipment: Stroboscope, Vibrometer / Accelerometer, Whirling of shaft apparatus, Motorized Gyroscope, longitudinal vibrations of a spring mass system etc.

List of Open Source Software/learning website: <http://nptel.ac.in/>

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.