



# GUJARAT TECHNOLOGICAL UNIVERSITY

**Program Name: Bachelor of Engineering**

**Level: UG**

**Branch: Aeronautical Engineering**

**Subject Code: BE05001041**

**Subject Name: Theory of Vibration**

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective course - 1

<b>Prerequisite:</b>	Aeronautical Mechanics of Solids
<b>Rationale:</b>	This course is of basic level. It introduces fundamentals of vibration, vibration of single Degree of Freedom (DoF) system, 2-DoF and multi-DoF systems and continuous systems such as bars and beams and whirling of shafts.

### Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	To understand the basic terminologies, concepts and behaviour of vibrations in machines.	30
CO-2	To understand the determination of frequencies and other parameters in free and forced vibrations.	30
CO-3	To determine vibratory responses of SDOF and MDOF systems to harmonic, periodic and non-periodic excitation.	25
CO-4	To analyze vibrations in different continuous system and find approximate solution.	15

### Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	SL	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/CA (I)	TW/SL (I)	ESE (V)	
45	0	30	15	90	03	70	30	20	30	50	200

### Content:

Sr. No.	Content	Total Hrs	Marks% weightage
1	<b>Fundamentals of Vibration and SDOF Free Vibrations</b> <b>Vibration Terminology and Basic Concepts:</b> Introduction and importance of vibration, Definitions and basic concepts, Methods of vibration analysis, Types of	12	30



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	<p>vibrations, Periodic and harmonic motion, Beats phenomenon, Representation of harmonic motion in complex form</p> <p><b>Undamped Free Vibrations:</b> Derivation of differential equations, Torsional vibrations, Equivalent stiffness of spring combinations, Simple pendulum, Compound pendulum</p> <p><b>Damped Free Vibrations:</b> Types of damping, Differential equation of damped free vibration, Logarithmic decrement</p>		
2	<p><b>Forced Vibrations (SDOF Systems)</b></p> <p>Sources of excitation, Equation of motion with harmonic force, Response of rotating and reciprocating unbalanced systems, Support motion, Vibration isolation, Vibration transmissibility, Vibration measuring instruments, Frequency measuring devices, Critical speed of shaft, Response to arbitrary loading (Duhamel's Integral), Impulse loading</p>	9	30
3	<p><b>Two Degree of Freedom (2-DOF) Systems</b></p> <p>Introduction to multi-degree systems, Principal modes of vibration, Torsional vibrations of 2-DOF systems, Coordinate coupling, Undamped 2-DOF free vibrations, Damped 2-DOF free vibrations, Undamped forced vibrations with harmonic excitation, Vibration absorbers, Difference between vibration absorber and vibration isolator</p>	8	20
4	<p><b>Multi Degree of Freedom (MDOF) Systems</b></p> <p>Derivation of equations of motion, Influence coefficient method, Flexibility and stiffness matrices, Reciprocity theorem, Eigenvalues and eigenvectors, Modal analysis</p>	8	10
5	<p><b>Vibrations of Continuous Systems</b></p> <p>Vibration of strings, Longitudinal vibrations of rods, Torsional vibrations of rods, Transverse vibration of beams (equation of motion &amp; boundary conditions), Natural frequencies and mode shapes of beams, Rayleigh Method, Rayleigh-Ritz Method, Galerkin's Method</p>	8	10
<b>TOTAL</b>		<b>45</b>	

**Suggested Specification table with Marks (Theory): (For B.E. only)**

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	30	20	10	10	0

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



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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.

The syllabus of Theory of Vibration directly contributes to

No.	SDG	Relevance to Syllabus
1	SDG 4	<b>Quality Education</b> Develops strong foundational and advanced knowledge of vibration concepts, analytical methods, and problem-solving skills essential for engineering education.
2	SDG 9	<b>Industry, Innovation and Infrastructure</b> Applies vibration analysis to design efficient, reliable machines and structures, supporting industrial innovation and modern infrastructure development.
3	SDG 11	<b>Sustainable Cities and Communities</b> Helps ensure safety and stability of buildings, bridges, and urban systems by analyzing and controlling vibrations in real-world applications.

## Reference Books:

1. G. K. Grover, *Mechanical Vibrations*, 10th ed., New Delhi, India: Nemchand & Bros., 2013.
2. W. T. Thomson and M. D. Dahleh, *Theory of Vibration with Applications*, 6th ed., Boston, MA, USA: Pearson, 2015.
3. C. Tse, G. Morse, and T. Hinkel, *Mechanical Vibrations*, 2nd ed., London, UK: Chapman & Hall, 2005.
4. J. P. Den Hartog, *Mechanical Vibrations*, 4th ed., New York, NY, USA: Dover Publications, 1985.
5. V. P. Singh, *Mechanical Vibrations*, 4th ed., Delhi, India: Dhanpat Rai & Co., 2014.
6. S. S. Rao, *Mechanical Vibrations*, 6th ed., Boston, MA, USA: Pearson Education, 2017.

## List of Experiments:

1. To investigate the relation ( $T = 2\pi\sqrt{l/g}$ ) for a simple pendulum.
2. To determine the radius of gyration of the given compound pendulum.
3. To verify the theoretical frequency of longitudinal vibrations of a spring-mass system with the experimental frequency.
4. To compare the experimental frequency of undamped free vibrations of an equivalent spring-mass system with the theoretical frequency.
5. To study forced vibrations of an equivalent spring-mass system.
6. To compare the theoretical frequency of undamped torsional vibrations of a single rotor system with the experimental frequency.
7. To study free vibrations of a 2-rotor system and determine its natural frequency.
8. To study the phenomenon of whirling of shafts and determine the critical speed.
9. To verify Dunkerley's rule.
10. To study vibration measuring instruments.



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**Major Equipment:** Simple Pendulum Apparatus, Compound Pendulum Apparatus, Spring–Mass Vibration Apparatus, Torsional Vibration Apparatus, Whirling of Shaft Apparatus

**List of Open Source Software/learning website:**

[https://onlinecourses.nptel.ac.in/noc21\\_me80/preview](https://onlinecourses.nptel.ac.in/noc21_me80/preview)

**List of suggested activities for Term Work / Self Learning:**

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry/Research laboratory Visit (Power converters/electronics/drives company)	Visit = 5 hrs, Report preparation = 5 hrs Total = 10 hrs	Based on report submitted. Report should contain observations and calculations based on industry / lab data.
2	Video Based Learning	Technical Video based learning related to the subject (MOOC/NPTEL Video)	Duration of video = 5hrs Report preparation = 5 hrs Total = 10 hrs	Report / presentation based on the video learning outcomes.
		Self-learning on-line course	Minimum duration of the course should be 10 hrs.	Examination based assessment at the end of course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10 hrs (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
3	Assignment / Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2 hrs each. Total = 10 hrs	Based on the assignment submitted.
		Blog or Technical Article Writing	10 hrs (Research – 6 hrs, Writing – 4 hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solving targeting	Complex problem solving	Maximum 2 problems. Study of the problem and solution finding,	Based on the depth of the solution submitted.



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	relevant SDGs.		Total = 15 hrs	
<b>5</b>	Research Paper Review / Analysis	Discussion on research paper based on relevant subject (SCOPUS Index/any reputed Journal)	5 research paper = 20 hrs	Summarize research paper and evaluation critical parameters
<b>6</b>	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
<b>7</b>	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 hr each	Based on performance in group discussion, technical depth, knowledge etc.
<b>8</b>	Case Study Analysis	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10hrs	Based on quiz scores and reflection report after each quiz.
		Real world case studies-based learning	Duration of data collection / study = 5 hrs Report preparation = 5 hrs Total = 10 hrs	Based on in-depth study, technical depth, data collected, fact finding, etc.
<b>9</b>	Other	Patent Search and Innovation Gap Identification	10 hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

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