INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	AEROSPACE STRUCTURAL DYNAMICS				
Course Code	AAEC35				
Program	B.Tech				
Semester	VII	AE			
Course Type	Core				
Regulation	IARE	UG-20			
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. K Arun Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC03	I	Engineering Physics
B.Tech	AMEC01	II	Engineering Mechanics
B.Tech	AAEC01	III	Mechanics of Solids

II COURSE OVERVIEW:

The Mechanical Systems as well as Mechanical Structures often experience various periodic Vibrations when they are used in their physical state. These Vibrations have both advantages and disadvantages to the machinery. This course Aims to teach how to address these vibrations by converting the physical models into mathematical models, solving those models using mathematical techniques and then interpreting the results in a physical Context. Additionally, the course also offers introductory to both theoretical and experimental principles of aeroelasticity.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aerospace Structural Dynamics	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
35%	Understand
55%	Apply

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in below table

AAT-II	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to:

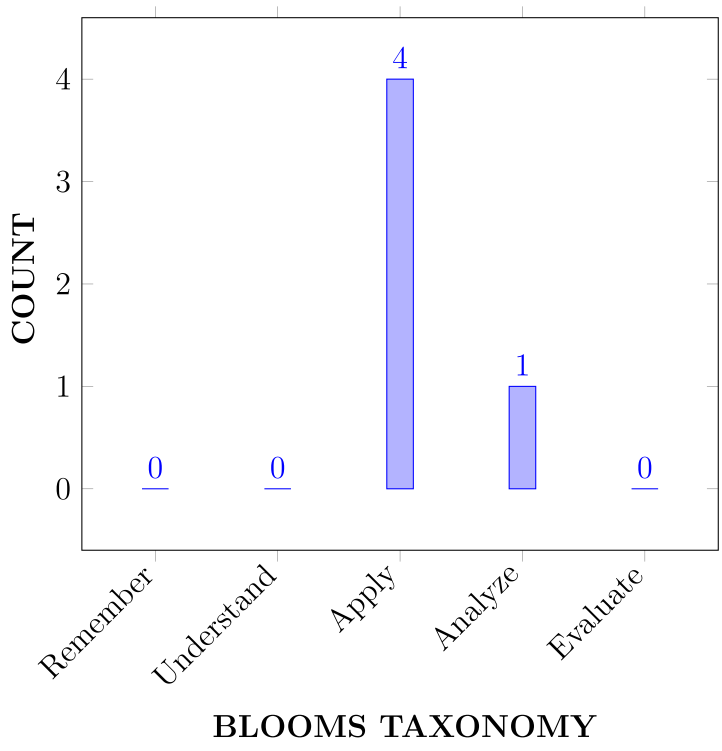
I	Using the newton's 2nd law of motion and energy principles develop the mathematical models for the problems in vibrations.
II	Figure out a comprehensive solution to the modeled mechanical vibration problems.
III	Develop a new mechanical system which has desirable vibrational behavior.
IV	Evaluate the underlying assumptions in the aeroelastic analysis of fixed-wing and rotary-wing aerospace vehicles and systems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** newton's second law of motion and the principle of conservation of energy with various principles of mechanical vibrations to the mathematical models for obtaining their governing equations of motion.	Apply
CO 2	**Generate** the two degrees of freedom systems the mathematical modeling for determining the frequency of spring-mass system.	Analyze
CO 3	**Relate** mode shapes and the natural frequencies of a multi degree of freedom system for distributing parameter systems for the numerical solution	Apply
CO 4	**Compute** various numerical and theoretical procedures for predicting the dynamic response of continuous structural systems under most diverse loading conditions.	Apply
CO 5	**Construct** solutions to the static aeroelasticity problems such as typical section and wing divergence problems; for their selection in real world applications.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	2	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	✓	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-		✓	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-		✓	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-			✓	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand the concepts of the equation of motion of free vibration and its response for determining the nature of single degree of freedom using the knowledge of **mathematics, science and Engineering fundamentals.**	3
	PO 2	Identify the formula to simplify the harmonnic response problems on free vibration by using mathematics and engineering knowledge.	2
	PSO 2	Apply the equation of free vibration system for the solving of the undamped system using engineering fundamentals.	1
CO 2	PO 1	Explain various equations of forced vibration for identifying the frequency of the vibrating system by applying the **principles of mathematics, science and engineering fundamentals.**	3
	PO 2	Understand the given **problem statement and formulate** variation of phase angle across different waves by the **provided information and data** in reaching substantiated conclusions by the interpretation of results.	2
	PSO 2	Use the equation of free and forces vibrating system for the solving of the damped and undamped system by using mathematics, science and Engineering fundamentals.	1
CO 3	PO 1	Understand the torsional vibrations of rotor and geared systems for determining the DOF of the vibrating systems based on **mathematical principles and engineering fundamentals** of vibrations.	3
	PO 2	Identify the formula to simplify the torsional vibrations of rotor and geared systems by **using mathematics and engineering knowledge.**	2
	PSO 2	Use the equation of multi degree of freedom vibrating system for simplifying the complex problems using engineering fundamentals.	1
CO 4	PO 1	Develop the governing equations for a multi degree of freedom vibrating system by applying the principles of **mathematics, science and Engineering fundamentals.**	3
	PO 2	Identify the formula of stiffness and flexibility influence coefficients for simplifying solutions of multi DOF systems by using **mathematics and engineering knowledge**	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 2	Apply the equation of free vibrating system for the solving of the damped and damped system using **mathematics, science and Engineering fundamentals.**	1
CO 5	PO 1	Understand the concepts of the vibration for determining the frequency of cable, rod, shaft by using the knowledge of **mathematics, science and Engineering fundamentals.**	3
	PO 2	Apply the given **problem statement and formulate** transverse, longitudinal, torsional and lateral vibrations of cables, rods and beams information and data in reaching substantiated conclusions by the interpretation of results.	2
	PSO 2	Analyse the frequency of cable, shafts, beam for developing the new solutions on vibrating body using **appropriate mathematics, science and engineering fundamentals.**	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 2	2	3	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	20	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 2	66.6	30	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 4	100	20	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 5	100	20	-	-	-	-	-	-	-	-	-	-	-	50	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - $40\% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
TOTAL	27	5	-	-	-		-	-	-	-	-	-	-	10	-
AVERAGE	3	1	-	-	-		-	-	-	-	-	-	-	2	-

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	✓				

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
x	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**SINGLE-DEGREE-OF-FREEDOM LINEAR SYSTEMS**
	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).
MODULE II	**TWO-DEGREE-OF-FREEDOM SYSTEMS**
	Introduction, Equations of Motion for Forced Vibration, Free vibration analysis of an Undamped System, Torsional system, Coordinate coupling and principal coordinates, Forced-vibration analysis, Semi definite Systems, Self excitation and Stability Analysis, Transfer- Function Approach, Solutions Using Laplace Transform, Solutions Using Frequency Transfer Functions.
MODULE III	**MULTI-DEGREE-OF-FREEDOM LINEAR SYSTEMS**

	Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties; Free and forced vibration by Modal analysis; Method of matrix inversion; Torsional vibrations of multi- rotor systems and geared systems; Discrete- Time systems.
MODULE IV	**DYNAMICS OF CONTINUOUS ELASTIC BODIES**
	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.
MODULE V	**INTRODUCTION TO AEROELASTICITY**
	Static Aeroelasticity; Typical Section Model of an Airfoil: Typical Section Model with Control Surface, Typical Section Model—Nonlinear Effects. One Dimensional Aeroelastic Model of Airfoils: Beam-Rod Representation of Large Aspect Ratio Wing, Eigenvalue and Eigen function Approach, Galerkin's Method. **Dynamic Aeroelasticity;** Hamilton's Principle: Single Particle, Many Particles, Continuous Body, Potential Energy, Non potential Forces, Lagrange's Equations.

TEXTBOOKS

1. Bismarck-Nasr, M.N., —Structural Dynamics in Aeronautical Engineering‖, AIAA Education Series, 2 nd Edition, 1999.
2. Rao, S.S., —Mechanical Vibrations‖, Prentice-Hall, 5th Edition, 2011.
3. Earl H. Dowell, —A Modern Course in Aeroelasticity‖ Volume 217, Duke University, Durham, NC, USA.

REFERENCE BOOKS:

1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, —Aeroelasticity‖, 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.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Basic concepts and importance of vibration	CO 1, 2	T2: 1.1-1.5, T1: 4.1
3	Classification of vibrations with exxamples	CO 1	T2: 2.1-2.2, R1: 3.1

S.No	Topics to be covered	CO's	Reference
4	**Harmonic Analysis:** Fourier Series Expansion, Complex Fourier Series and Frequency Spectrum	CO 1	T2: 2.1-2.2, R1: 3.1
5	**Harmonic Analysis:**Time- and Frequency-Domain Representations Even and Odd Functions, Half-Range Expansions	CO 1	T2: 2.8
6	Equation of Motion Using Newton s Second Law of Motion,	CO 1	T2: 2.3-2.4
7	Response of an Undamped System Under Harmonic Force	CO 1	T2: 2.7.1
8	Transfer-Function Approach	CO 1	T2: 3.4
9	Free Vibration of an undamped torsional system	CO 1	T2: 3.4
10	Laplace transform: Transient and steady-state responses	CO 1	T2: 3.4
11	Equations of motion for forced vibration	CO 1	T2: 3.3
12	Free vibration analysis of an Undamped System	CO 2	T2:7.1
13	Torsional system, Numerical problems	CO 2	T2: 6.3.3
14	Coordinate coupling and principal coordinates	CO 2	T2: 3.2
15	Forced-vibration analysis	CO 2	T2: 3.2
16	Semidefinite systems	CO 2	T2: 3.2
17	Self-Excitation and stability Analysis	CO 2	T1 5.5
18	Transfer-function approach	CO 2	T2: 7.1
19	Solutions using Laplace transform	CO 2	T2: 5.1
20	Solutions using frequency transfer functions	CO 2	T2: 5.2
21	Using Newton's second law to derive Equations of Motion	CO 3	T2: 4.2.1
22	Influence coefficients: Stiffness influence coefficients Flexibility influence coefficients	CO 3	T2: 4.2.2
23	Equations of motion of undamped Systems in matrix form	CO 4	T1: 5.2
24	Eigenvalue problem and solution of the eigenvalue problem	CO 4	T1: 5.2
25	Free vibration of undamped systems	CO 4,5	T2: 5.2
26	Forced vibration of undamped systems using modal analysis	CO 4	T2: 5.2
27	Torsional vibrations of multi- rotor systems and geared systems	CO 4	T2: 5.2
28	Introduction to discrete time systems	CO 4	T2: 3.1-3.2
29	Transverse vibration of a string or cable: Equation of Motion	CO 4	T2: 3.1-3.2
30	Free vibration of a uniform string and free vibration of a string with both ends fixed	CO 4	T2: 3.1
30	Equation of motion and solution for a longitudinal vibration of a bar	CO 4	T2: 13.2
31	Torsional vibration of a uniform shaft	CO 4	T2:11.1-11.2
32	Lateral vibration of beams: Equation of motion	CO 4	T2:11.2-11.4
33	Lateral vibration of beams: Effect of Axial force and Effects of rotary inertia and shear deformation	CO 5	T1:11.1, T4:14.1
34	The Rayleigh-Ritz method	CO 5	T1:11.1, T4:14.4

S.No	Topics to be covered	CO's	Reference
35	Effects of Aeroelastic Forces: Divergence, Control Surface Reversal, Flutter Buffeting, and Thermal Instabilities.	CO 5	T1:11.2-11.4, T4:14.3
36	Static Aeroelasticity – Effect of Wing Flexibility on Lift Distribution and Divergence	CO 5	T2:15.3.1
37	One dimensional aeroelastic model of airfoils	CO 5	T1:11.1, T4:14.3-14.4
38	Beam-Rod representation of large aspect ratio wing	CO 5	T2:15.4
39	Eigen value and Eigen function Approach, Galerkin Approach	CO 5	T2:15.3.1
40	Dynamic Aeroelasticity: Hamilton‘s Principle:	CO 5	T4:14.3-14.4
41	Single Particle, Many Particles, Continuous Body	CO 5	T4:14.3-14.4
42	Eigenvalue solution of flutter equations	CO 5	T4:14.3-14.4
43	Aeroelastic behaviour of a flexible wing	CO 5	T4:14.3-14.4
44	Effect of nonlinearities – limit cycle oscillations	CO 5	T4:14.3-14.4
PROBLEM SOLVING/ CASE STUDIES			
1	Find the period, displaccement, velocity of frequency and acceleration of SHM	CO 1	T2: 1.1-1.5, T1: 4.1
2	Represent the periodic motion by an harmonic motion	CO 1	T2: 3.4
3	Find the natural frequency of a single degree of freedom system.	CO 1	T2: 2.8
4	Detemine the natural frequency of a 2DOF of a vibratory system	CO 2	T2: 3.2
5	Find frequency and mode shapes of a torsional vibrations of a shaft	CO 2	T2: 3.2
6	Determine the equations of motion of a two degree of freedom system	CO 2	T2: 3.2
7	Find the flexibility influence coefficients	CO 4	T2:5.2
8	Determine natural frequencies of a multi degree of freedom of spring mass system	CO 4	T2:5.2
9	Find the steady-state response of the system	CO 4	T2: 5.2
10	Using modal analysis, find the free-vibration response of a two-degree-of-freedom system with equations of motion	CO 3	T2: 3.1-3.2.5
11	Derive the equations of motion, using Newton s second law of motion, for each of the 3DOF systems	CO 3	T2:11.2-11.4
12	Find the natural frequencies and the free-vibration solution of a bar fixed at one end and free at the other.	CO 3	T2: 13.2.6
13	Find the natural frequencies of the tapered cantilever beam by using the Rayleigh- Ritz method.	CO 3	T4:14.3-14.4
14	Derive the frequency equation for the transverse vibration of the cable.	CO 4	T4:14.3-14.4

S.No	Topics to be covered	CO's	Reference
15	Compute the first three natural frequencies and the corresponding mode shapes of the transverse vibrations of a uniform beam	CO 4	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Define these terms: cycle, amplitude, phase angle, linear frequency, period, and natural frequency, parameters corresponding to m, c, k, and x for a torsional system	CO 1	T2: 1.1-1.5
2	logarithmic decrement, How are the amplitude, frequency, and phase of a steady-state vibration related to those of the applied harmonic force for an undamped system?	CO 2	T4:7.3
3	flexibility and stiffness influence coefficients and the relation between. Orthogonality of normal modes?	CO 4	T2:5.1, T2: 6.3-6.4
4	Aeroelasticity: Dynamic and Static, Flutter, Hamiton Principle, Wing sweep, Divergence	CO 5	T1:7.5
5	Kaplan, Francis and Pelton turbines, Centrifugal and Reciprocating pump, Euler turbine equation, characteristic curves of turbine	CO 5	T1: 12.1
DISCUSSION OF QUESTION BANK			
1	Displacement velocity frequency, amplitude of SHM.	CO 1,2	T2: 1.1-1.5
2	Representation of step function by harmonic motion	CO 3	T2: 3.2
3	Equations of motion of a Single, double and multi DOF	CO 4,5	T2:5.1
4	Lateral and lonitudinal vibrations of a bar	CO 5	T2:11.2-11.4
5	Natural frequency using Rayleigh Ritz method	CO 5	T2:5.2-11.4

Signature of Course Coordinator **HOD, AE**
Mr. K Arun Kumar, Assistant Professor