INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICALENGINEERING

COURSE DESCRIPTOR

Course Title	**DYNAMICS OF MACHINERY**				
Course Code	AMEB17				
Programme	B. Tech				
Semester	FIVE				
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	2	1	3	-	-
Chief Coordinator	Dr. K Viswanath Allamraju, Professor				

I. COURSE OVERVIEW:

This course focuses on mechanical devices that are designed to have mobility to perform certain functions. In this process they are subjected to some forces. The study of Dynamics of machinery leads us to design machines by understanding the relationship between the movement of various parts of machine and the different forces that are acting on them. This course will provide the knowledge on how to analyze the motions of mechanisms and design mechanisms to give required strength. This includes relative static and dynamic force analysis and consideration of gyroscopic effects on aero planes, ships, automobiles like two wheelers and four wheelers.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
B. Tech	AME009	IV	Kinematics of Machinery	4
B. Tech	AME001	I	Engineering Drawing	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Dynamics of machinery	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

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). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

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 units and each unit 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 unit. 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 Table: 1.

Table1: The expected percentage of cognitive level of questions in SEE

Percentage of Cognitive Level	Blooms Taxonomy Level
10 %	Remember
50 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks Alternative Assessment Tool (AAT).

Table 2: Assessment pattern for CIA

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

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 centre. 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 table 3**.**

Table 3: Assessment pattern for AAT

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	30%	30%	10%	10%

VI. COURSE OBJECTIVES:

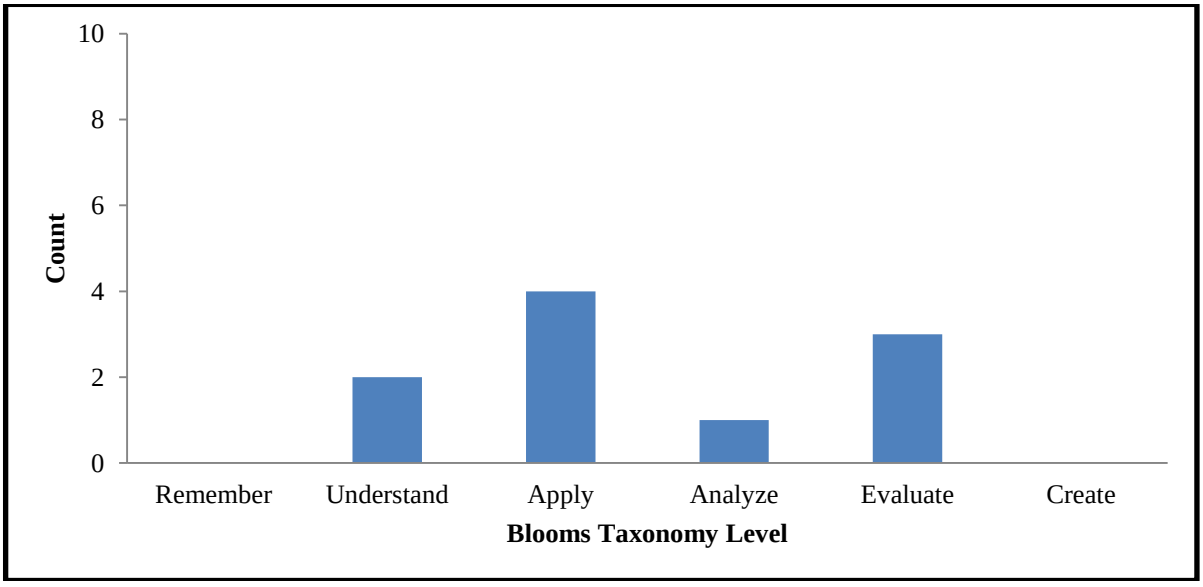
The students will try to learn:	
I	The concepts of precision, static and dynamic forces of planer mechanisms by neglecting friction of aero planes, sea vessels, auto mobiles and various force members.
II	The knowledge of engineering mechanics for identifying the coefficient of friction and engine speed of the various contact bodies (Clutches and Brakes) and speed controlled devices, variations of torques and fluctuation of speeds of IC engines.
III	The magnitude and direction of balanced mass for unbalanced rotary and reciprocating engines with the fundamentals of applied physics.
IV	Mathematical modeling of various degree of freedom systems to interpret the various vibration parameters.
V	The affluence of real world engineering problems and examples towards gaining the experience for how dynamics of machinery is applied in engineering practice.

VII. COURSE OOUTCOMES:

After successful completion of the course, students will be able to:		
Course Outcomes		Knowledge Level (Bloom's Taxonomy)
CO 1	**Discuss** the Gyroscopes, effect of precession motion on the stability of moving vehicles such as motor car, motor cycle, aero-planes and ships.	Understand

CO 2	**Determine** the angle of heel to avoid upside down of a two wheeler vehicle while taking in left and right turns.	Evaluate
CO 3	**Illustrate** the static and dynamic force analysis of two and three force members by graphical super position method.	Understand
CO 4	**Apply** the laws of friction on clutches, brakes and dynamometers to reduce the power losses for the effective torque transmission.	Apply
CO 5	**Justify** the importance of torque and fluctuation of speeds for single and multi cylindered engines to increase the mechanical efficiency.	Evaluate
CO 6	**Estimate** the height of a governor to regulate the speed of a prime mover at various load conditions.	Apply
CO 7	**Determine** the balanced mass for unbalanced rotary and reciprocating engines by analytical and graphical methods.	Evaluate
CO 8	**Develop** a mathematical modelling of free and forced vibration systems under damped and un-damped conditions to avoid the vibratory damages of aero-mechanical-civil structures and electrical and electronic components at various operated frequencies.	Apply
CO 9	**Use** the resonance phenomenon to predict the critical or whirling or whipping speeds of various structures under vibrations to avoid catastrophic failures.	Analyze
CO 10	**Apply** the principles of dynamics of machinery to a real world problems for obtaining optimum solutions.	Apply

COURSE KNOWLEDGE COMPETENCY LEVELS



VIII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		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

Program Outcomes		Strength	Proficiency Assessed by
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.	2	Seminar/ conferences/ Research papers

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Strength	Proficiency assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	1	Research papers/ Group discussion/ Short term courses
PSO 2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining.	2	Research papers / Industry exposure
PSO 3	Make use of computational and experimental tools for creating innovative creative paths, to be an entrepreneur and desire for higher studies.	3	Research papers / Industry exposure

3 = High; 2 = Medium; 1 = Low

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

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	√	-	√	-	-	-	-	-	-	-	-	-	-	-
CO 4	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	√	-	√	-	-	-	-	-	-	-	-	√	-	-
CO 7	-	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 8	√	√	-	-	-	-	-	-	-	-	-	-	√	-	-
CO 9	√	-	-	-	-	-	-	-	-	-	-	-	√	-	-
CO 10	-	√	-	-	-	-	-	-	-	-	-	-	-	-	-

XI. JUSTIFICATIONS FOR CO-PO MAPPING:

Course Outcomes	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO 1	PO 1	**Discuss** the knowledge and principals of mathematics to engineering problems for determining gyroscopic effect using the knowledge of **mathematics and science fundamentals**	2
	PO 2	**Analyse** and **formulate** the engineering problems to determine the gyroscopic couple and angel of heel. Analyse and **identify the problem statement**, **formulation and abstraction** for the **development of solution.**	4
CO 2	PO 2	**Collect the data** from complex engineering problems and **implement** them to draw the free body diagrams and **interpret the results** for static and dynamic forces of four bar mechanisms.	3
CO 3	PO 2	**Formulate** the forces of four bar mechanism and **identify** the appropriate equilibrium equation and **develop the solution** from the **first principals of mathematics**.	4
	PO 4	**Understand** the principals of engineering and **apply** them to brakes and clutches in order to observe the effect of friction.	2
CO 4	PO 1	**Apply the mathematical principles** and **engineering fundamentals** to get the solutions in friction engineering problems.	2
CO 5	PO 1	Use the **fundamentals of engineering** and **science** in identifying the coefficient of fluctuation of speed and torque of various cylindered engines.	2
CO 6	PO 2	Formulate the **problem statement** and **model the system** for **getting the solution** for governors to regulate the speed of machines	3
	PO 4	**Understand** the technical concepts of dead weight and spring loaded governors and **interpret** the equilibrium conditions for various applications.	2
	PSO 1	**Understand, analyze**, design and supervise the height of governors under various loading conditions.	2
CO 7	PO 2	Identify the unbalanced force of various engines from the **first principals of engineering mechanics** and **generate the solution.**	2
CO 8	PO 1	**Derive** the characteristic equation of motion of one, two and multi degree of freedom systems by using the **engineering fundamentals.**	2
	PO 2	**Determine** the natural frequencies of free and forced un-damped and damped vibration systems for **analyzing the given engineering problems** and **generate the solution.**	3
	PSO 1	**Understand and analyse** the vibration displacements of free and forced, longitudinal, transverse systems for observing the vibration isolation and transmissibility	2
CO 9	PO 1	Apply the knowledge of **mathematics and science** to **determine whirling speed** of rotating beams.	2
	PSO 1	**Understand and analyze** the critical speeds of machine components under eccentric and non eccentric loadings.	2
CO 10	PO 2	**Collect the data** by **identifying** the natural frequencies and amplitudes of real world free and forced vibration systems and **generate the solutions**.	3

XII. TOTAL COUNT OF KEY COMPETENCIES FOR CO , PO & PSO MAPPING

Course Outcomes	Program Outcomes / Number of Vital Features												Program Specific Outcomes / Number of Vital Features		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	12	2	2	1
CO 1	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	3	-	2	-	-	-	-	-	-	-	-	2	-	-
CO 7	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 8	2	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 9	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 10	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-

XIII. PERCENTAGE FOR KEY COMPETENCIES FOR CO-(PO, PSO):

Course Outcomes	Program Outcomes/ Number of Vital Features												Program Specific Outcomes / Number of Vital Features		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	12	2	2	1
CO 1	66.7	40.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO 2	0.00	30.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO 3	0.00	40.0	0.00	18.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO 4	66.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO 5	66.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO 6	0.00	30.0	0.00	18.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0	0.00	0.00
CO 7	0.00	20.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO 8	66.7	30.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0	0.00	0.00
CO 9	66.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0	0.00	0.00
CO 10	0.00	30.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

XIV. COURSE ARTICULATION MATRIX (CO-PO/PSO MAPPING)

COs and POs and COs and PSOs on the scale of 0 to 3, **0** being **no correlation**, **1** being **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 – **0**≤ ***C***≤ 5%– No correlation; **2** – 40 % <***C***< 60% –Moderate

1 – 5 <***C***≤ 40%– Low/ Slight; **3** – 60% ≤ ***C***< 100% – Substantial /High

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	1	-	1	-	-	-	-	-	-	-	-	2	-	-
CO 7	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 8	3	1	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 9	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 10	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	15	7		2									6		
AVERAGE	**3.0**	**1.0**		**1.0**									2.0		

XV. ASSESSMENT METHODOLOGIES –DIRECT

CIE Exams	PO 1,PO 2, PO3,PSO1	SEE Exams	PO 1, PO 2, PO 3,PSO 1	Assignments	PO 3	Seminars	PO 3,PSO 1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XVI. ASSESSMENT METHODOLOGIES-INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XVII. SYLLABUS

MODULE-I	PRECESION, STATIC AND DYNAMIC FORCE ANALYSIS OF PLANAR MECHANISMS
Precession: Gyroscopes, effect of processional motion on the stability of moving vehicles such as motor car, motor cycle, aero-planes and ships, static and dynamic force analysis of planar mechanisms: (Neglecting friction), Introduction to free body diagrams, conditions of equilibrium, two and three force members, inertia forces and D-Alembert's principle, planar rotation about a fixed centre.	
MODULE-II	**CLUTCHES, BRAKES AND DYNAMOMETERS**
Clutches: Friction clutches, Single disc or plate clutch, multiple disc clutches, cone clutch and centrifugal clutch; Brakes and dynamometers: Simple block brakes, internal expanding brake, band brake of vehicle; Dynamometers absorption and transmission types, general description and method of operation.	
MODULE-III	**TURNING MOMENT AND GOVERNORS**
Turning moment diagrams and flywheels: turning moment: Inertia torque, angular velocity and acceleration of connecting rod, crank effort and torque diagrams, fluctuation of energy; Design of flywheels. Governors: Watt, Porter and Proell governors, spring loaded governors, Hartnell and Hartung with auxiliary springs, sensitiveness, isochronism and hunting	
MODULE-IV	**BALANCING OF ROTATORY AND RECIPROCATING MASSES**
Balancing: Balancing of rotating masses, single and multiple-single and different planes-balancing of reciprocating masses, primary and secondary balancing-analytical and graphical methods; unbalanced forces and couples: Balancing of V-engines, multi cylinder, inline and radial engines for primary, secondary balancing and locomotive balancing.	
MODULE-V	**MECHANICAL VIBRATIONS**
Vibrations: Free vibration of mass attached to a vertical spring, simple problems on forced damped vibration; Vibration isolation and transmissibility, whirling of shafts, critical speeds, torsional vibrations, two and three rotor systems.	
Text Books:	
1. Thomas Bevan, "Theory of Machines", Pearson Education, 3rd Edition, 2009. 2. S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014. 3. R. L. Norton, "Kinematics and Dynamics of Machinery", McGraw-Hill, 1st Edition, 2009. 4. P.L. Balleny, "Theory of Machines and Mechanisms", Khanna publishers, 2013.	
Reference Books:	
1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 1st Edition, 2013. 2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition,2013. 3. R.S. Khurmi, Gupta, "Theory of Machines", S.Chand& Co, New Delhi, 14th Edition, 2013.	

XVIII. COURSE PLAN:

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

Lecture No	Topics to be covered	Course Outcomes	Reference
1	Introduction to Gyroscopes, angular motion, precession.	CO 1	T2 17.2
2	Determination of Gyroscopic couple, problems.	CO 2	T2 17.1

Lecture No	Topics to be covered	Course Outcomes	Reference
3	Effect of gyroscopic couple on stability of moving car.	CO 2	T2 17.8
4	Effect of gyroscopic couple on stability of moving motorcycle.	CO 2	T2 17.6
5	Effect of gyroscopic couple on stability of aero-plane.	CO 1	T2 17.3
6	Effect of gyroscopic couple on stability of moving ship.	CO 2	T2 17.4
7	Static and dynamic force analysis of planar mechanisms.	CO 3	T2 12.1
8	Free body diagrams, problems.	CO3	T2 12.6
9	Friction circle, Boundary friction.	CO 3	T2 8.2
10	Introduction to Clutches, types.	CO 4	T2 8.9
11	Introduction to Brakes, classification.	CO 4	T2 15.1
12	Introduction to dynamometers, types.	CO 4	T2 15.8
13	Methods of operation of dynamometers power, Performance test.	CO 4	T2 15.9
14	Calculation of brake torque, problems.	CO 5	T2 15.13
15	Turning moment diagrams explanation.	CO 5	T2 13.12
16	Inertia torque calculation for connecting rod.	CO 5	T2 13.11
17	Problems on inertia torque calculation for connecting rod.	CO 5	T2 13.7
18	Fluctuation of energy.	CO 5	T2 13.13
19	Flywheel and its function.	CO 5	R3 16.12
20	Flywheel design	CO 5	R3 16.18
21	Problems on flywheel	CO 5	R3 16.21
22	Introduction to governors and their classification	CO 6	T2:16.1
23	Watt governor and Porter governor	CO 6	T2 16.3,4
24	Proell governor, Hartnell and Hartung governors	CO 6	T2:16.5, 6
25	Problems on governors	CO 6	T2:16.1 4
26	sensitiveness, isochronisms and hunting, effort and power of governors	CO 6	R318.12
27	Balancing of rotating masses	CO 7	T2:21.2
28	Problems on balancing of rotating masses.	CO 7	T2:21.1
29	Primary balancing of reciprocating masses.	CO 7	T2:22.1
30	Secondary balancing of reciprocating masses.	CO 7	T2:22.2
31	Higher balancing of reciprocating masses.	CO 7	R3 22.10

Lecture No	Topics to be covered	Course Outcomes	Reference
32	Locomotive balancing.	CO 7	R322.4
33	Graphical method of calculating forces and couples.	CO 7	R3 22.3
34	Balancing of Multi cylinder and V- Engines.	CO 7	R3 22.13
35	Balancing of radial engines.	CO 7	R3 22.12
36	Introduction to vibrations and their classification.	CO 8	T2.18.1
37	Free vibrations of mass attached to vertical springs.	CO 8	T2 18.6
38	Transverse vibrations-Problems.	CO 8	R3 23.9
39	Frequency of transverse vibration for concentrated and distributed loads	CO 8	R3 23.11
40	Dunkerley's method for calculating frequency.	CO 8	R3 23.4
41	Raleigh's method for frequency calculations.	CO 8	R3 23.5
42	Critical speeds, Whirling of shafts, problems.	CO 8	R3 23.12
43	Torsional vibrations- one rotor system.	CO 8	R3 24.4
44	Torsional vibrations- two rotor system.	CO 8	R3 24.5
45	Torsional vibrations- three rotor system.	CO 8	R3 24.6
46	Problems on torsional vibrations.	CO 8	R3 24.4
47	Whirliing speed of shaft	CO 9	R3 23.18
48	Applying whirling speed in solving problems	CO 9	R3 23.18
49	Whirling speed of shaft of beams	CO 9	R323.23
50	Applications of vibration transmissibilty to real world problems	CO 10	R3 23.14

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