Ref No:

COURSE PLAN

Academic Year 2019 – 20

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Program:	B E – MECHANICAL
Semester :	V
Course Code:	17ME52
Course Title:	Dynamics of Machines
Credit / L-T-P:	4 / 4-0-0
Total Contact Hours:	50
Course Plan Author:	Dr. K.M. Kenchi Reddy

Academic Evaluation and Monitoring Cell

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Table of Contents

Note : Remove “Table of Content” before including in CP Book
Each Course Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

17ME52 : DYNAMICS OF MACHINERY

A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	ME
Year / Semester :	03/V	Academic Year:	2019
Course Title:	Dynamics of Machines	Course Code:	17ME52
Credit / L-T-P:	04/03-02-0	SEE Duration:	180 Min
Total Contact Hours:	50	SEE Marks:	80Marks
CIA Marks:	40	Assignment	1 / Module
Course Plan Author:	Dr.K.M.Kenchi Reddy/	Sign	Dt:
Checked By:	Harendra Kumar S	Sign	Dt:

2. Course Content

Module	Module Content	Teaching Hours	Module Concepts	Blooms Level
1	Static force Analysis: Static equilibrium. Equilibrium of two and three force members.Members with two forces and torque, Free body diagrams, Static force analysis of four bar mechanism and Slider-crank mechanism with and without friction. Dynamic force Analysis: D'Alembert's principle, Inertia force, Inertia torque. Dynamic forceanalysis of four-bar mechanism and Slider crank mechanism without friction, numerical problems	10	Force and Torque	L3 Apply
2	Balancing of Rotating Masses: Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes. Balancing of Reciprocating Masses: Inertia effect of crank and connecting rod, Single cylinderengine, balancing in multi cylinder-inline engine (primary and secondary forces), numerical problems.	10	Balancing	L3 Apply L4 Analyze
3	Governors: Types of governors, force analysis of Porter and Hartnell governors. Stability, Sensitiveness, Isochronism, Effort and Power. Gyroscope: Vectorial representation of Gyroscopic couple. Effect of gyroscopiccouple on plane disc, aeroplane, forcStatic force Analysis:tatic force Analysis: ship, stability of two wheelers and four wheelers. Numerical problems.	10	Speed, Direction	L3 Apply L4 Analyze
4	Introduction &Undamped free Vibrations (Single Degree of Freedom) Types of vibrations, Definitions, Simple Harmonic Motion (SHM), Work done by harmonic force, Principle of super position applied to SHM.Dynamic force Analysis Methods of analysis –(Newton's, Energy &Rayleigh's methods). Dynamic force Analysis Derivations for spring mass systems, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and problems.	10	Time period and Frequency	L3 Apply L4 Analyze
5	Damped free Vibrations (Single Degree of Freedom) Types of damping, Analysis with viscous damping - Derivations for over,	10	Damping	L3 Apply

	critical and under damped systems. Forced Vibrations (Single Degree of Freed Dynamic force Analysisom): Analysis of forced vibration with constant harmonic excitation, Magnification factor (M.F.), Vibration isolation - Transmissibility ratio, Excitation of support Static force Analysis:(absolute and relative) Logarithmic decrement and numerical problems.			

3. Course Material

Module	Details	Available
1	Text books	
	1.Theory of Machines, Sadhu Singh, Pearson Education, 2nd Edition. 2007 2.Mechanism and Machine Theory, A. G. Ambekar PHI, 2007 3.Mechanical Vibrations, V. P. Singh, Dhanpat Rai and Company, 4.Mechanical Vibrations, G. K.Grover, Nem Chand and Bros.	In Lib
2	Reference books	
	1. Theory of Machines, Rattan S.S. Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2009. 2.Mechanical Vibrations, S. S. Rao, Pearson Education Inc, 4 edition, 2003.	In dept
3	Others (Web, Video, Simulation, Notes etc.)	Available
	❿ https://www.youtube.com/watch?v=tdkFc88Fw-M ❿ https://www.youtube.com/watch?v=YoZgk1xlIW4- ❿ https://www.youtube.com/watch?v=AchBiFAEeLo ❿ https://www.youtube.com/watch?v=YoZgk1xlIW ❿ https://www.youtube.com/watch?v=tdkFc88Fw-M	

4. Course Prerequisites

SNo	Course Code	Course Name	Module / Topic / Description	Sem	Remarks	Blooms Level
1	15ME42	Kinematics of Machines	Mechanism of 4 bar chain ,single slider crank chain	4		L3 Apply
				-		

Note: If prerequisites are not Static force Analysis:taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

B. OBE PARAMETERS

1. Course Outcomes

#		Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
CO1	To gain the knowledge of static and dynamic equilibrium conditions of mechanisms	5	Force and Torque	Chalk and board	Assignment and slip test	L3 Apply,
CO2	Analyse the mechanism subjected to forces and couples with and without friction	5	Balancing	Chalk and board	Assignment and slip test	L3,L4 Apply, Analyze
CO3	To understand the balancing principles of rotating masses	5	Balancing	Chalk and board	Assignment and slip test	L3,L4 Apply, Analyze
CO4	To understand the balancing principles of reciprocating masses	5	Speed	Chalk and board	Assignment and slip test	L3,L4 Apply, Analyze
C05	Abel to know to regulate the speed of the	5	Direction	Chalk and	Assignment	L3,L4

	engine			board	and slip test	Apply, Analyze
CO6	To understand the stability of two wheeler and four wheelers	5	Vibration	Chalk and board	Assignment and slip test	L3,L4 Apply, Analyze
CO7	To understand the different types of vibration and simple harmonic motion	5	Time period and Frequency	Chalk and board	Assignment and slip test	L3,L4 Apply, Analyze
CO8	To understand the vibration characteristics of single degree of freedom systems	5	Single degrees of freedom	Chalk and board	Assignment and slip test	L3,L4 Apply, Analyze
CO9	To understand the characterise the single degree freedom system subjected to free and forced vibration with and with out damping	5	forced vibration	Chalk and board	Assignment and slip test	L3 Apply
Co10	To understand the forced vibration with constant harmonic excitation and logarithmic decrement.	5	forced vibration	Chalk and board	Assignment and slip test	L3 Apply

Note: Identify a max of 2 Concepts per Module. Write 1 CO per concept.

2. Course Applications

SNo	Application Area	CO	Level
1	Four-bar linkages can be used for many mechanical purposes, including to: convert rotational motion to reciprocating motion	CO1	L3,
2	The balancing of rotating bodies is important to avoid vibration. In heavy industrial machines such as gas turbines and electric generators, vibration can cause catastrophic failure, as well as noise and discomfort.	CO2	L3,l4
3	In order to simplify the motion of a crank/slider mechanism, the connecting rod/piston assembly is generally divided into two mass groups, a reciprocating mass, and a rotating mass. The big-end of the rod is generally said to be rotating while the small end is said to be reciprocating.	CO3	L3,l4
4	Five cylinder engines. Inline five cylinder (L5) engine, with crank throws at 72° phase shift to each other, is the common five cylinder configuration.	CO4	L3,l4
5	Governors are used in the field of automobile engineering.	CO5	Ll3,l4
6	Gyroscopes are used in the field of aeronautics and ships.	CO6	L3,l4
7	The gyroscopic effect can be best explained by the principle of behavior of a gyroscope. According to the eBalancing of Reciprocating Masses: Inertia effect of crank and connecting rod, Single cylinderengine, balancing in multi cylinder-inline engine (primary and secondary forces), numerical problems.quation that describes gyroscope behavior, the torque on the gyroscope applied perpendicular to its axis of rotation and also perpendicular to its angular momentum causes it to rotate about an axis perpendicular to both the torque and the angular momentum. This rotational motion is referred to as precession.	CO7	L3,l4
8	Applications in bridges, buildings, mechanical engineering and aerospace ...	CO8	L3,l4
9	Applications in bridges, buildings, mechanical engineering and aerospace	CO9	L3

Note: Write 1 or 2 applications per CO.

3. Articulation Matrix

(CO – PO MAPPING)

-	Course Outcomes	Program Outcomes												
#	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1	PO1	PO1	Level

											0	1	2	
17ME52.1	To gain the knowledge of static and dynamic equilibrium conditions of mechanisms	√	√	-	-	-	-	-	—	-	-	-	-	L1
17ME52.2	Analyse the mechanism subjected to forces and couples with and without friction	√	√	-	-	-	-	-	—	-	-	-	-	L2
17ME52.3	To understand the balancing principles of rotating masses	√	√	-	-	-	-	-	—	-	-	-	-	L1
17ME52.4	To understand the balancing principles of reciprocating masses	√	√	-	-	-	-	-	—	-	-	-	-	L2
17ME52.5	Abel to know to regulate the speed of the engine	√	√	-	-	-	-	-	—	-	-	-	-	L1
17ME52.6	To understand the stability of two wheeler and four wheelers	√	√	-	-	-	-	-	—	-	-	-	-	L2
17ME52.7	To understand the different types of vibration and simple harmonic motion	√	√	-	-	-	-	-	—	-	-	-	-	L1
17ME52.8	To understand the vibration characteristics of single degree of freedom systems	√	√	-	-	-	-	-	—	-	-	-	-	L2
17ME52.9	To understand the characterise the single degree freedom system subjected to free and forced vibration with and with out damping	√	√	-	-	-	-	-	—	-	-	-	-	L1
17ME52.10	To understand the forced vibration with constant harmonic excitation and logarithmic decrement.	√	√	-	-	-	-	-	—	-	-	-	-	L2
Note: Mention the mapping strength as 1, 2, or 3														

4. Mapping Justification

Mapping		Justification	Mapping Level
CO	**PO**	-	-
CO1	PO1	Knowledge of force and torque is required in machines and mechanism	L2
CO1	PO2	Analyzing problems in machine tools and automobiles	L3

Note: Write justification for each CO-PO mapping.

Mapping		Justification	Mapping Level
CO	**PO**	-	-
CO2	PO1	Knowledge of force and torque is required in machines and mechanism	L2
CO2	PO2	Analyzing problems in machine tools and automobiles	L3
CO3	PO1	Knowledge of balancing of mass is required in machine tools and engines to reduce vibration	L2
CO3	PO2	Analysing problems in balancing of rotating masses is used to reduce the vibration	L3

Mapping		Justification	Mapping Level
CO	**PO**	-	-

CO4	PO1	Knowledge of balancing of mass is required in machine tools and engines to reduce vibration	L2
CO4	PO2	Analysing problems in balancing of reciprocating masses is used to reduce the vibration	L3

CO5	PO1	Knowledge of governors is required to regulate the speed of an engine	L2
CO5	PO2	Analysing the problems in four wheelers	L3

CO6	PO1	Knowledge of gyroscope is required to stabilize the engine speed	L2
CO6	PO2	Analysing the problems in four wheelers	L3

CO7	PO1	Knowledge of vibrations is required to know the natural frequency and resonance to the system	L2
CO7	PO2	Analysing problem in vibration is required to calculate the frequency of spring mass system.	L3

CO8	PO1	Knowledge of vibrations is required to know the natural frequency and resonance to the system	L2
CO8	PO2	Analyzing problems in damped and forced vibration is required to know magnification factor and transmissibility ratio	L3

CO9	PO1	Knowledge of damped vibration is used to reduce the loss of energy in system	L2
CO9	PO2	Analyzing the problems of damped vibration is required to know the system whether it is under or critical damped	L3

CO	**PO**	**-**	**-**
CO10	PO1	Knowledge of damped vibration is used to reduce the loss of energy in system	L2
CO10	PO2	Analyzing the problems of damped vibration is required to know the system whether the system it is under or critical damped	L3

5. Curricular Gap and Content

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					
4					
5					

Note: Write Gap topics from A.4 and add others also.

6. Content Beyond Syllabus

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping

1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Note: Anything not covered above is included here.

C. COURSE ASSESSMENT

1. Course Coverage

Module #	Title	Teaching Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Static force Analysis and Dynamic force Analysis	10	2	-	-	1	1	2	CO1, CO2	L3, L3
2	Balancing of rotating and reciprocating masses	10	2	-	-	1	1	2	CO3, CO4	L3, L4
3	Governors and Gyroscopes	10	-	2	-	1	1	2	CO5, CO6	L3, L4
4	Introduction and undamped free vibration	10	-	2	-	1	1	2	CO7, C08	L3, L4
5	Damped free and forced vibration	10	-	-	4	1	1	2	CO9, CO10	L3, L4
-	**Total**	**50**	**4**	**4**	**4**	**5**	**5**	**10**	**-**	**-**

Note: Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

2. Continuous Internal Assessment (CIA)

Evaluation	Weightage in Marks	CO	Levels
CIA Exam – 1	30	CO1, CO2, CO3, CO4	L3, l3, l3, l4
CIA Exam – 2	30	CO5, CO6, CO7, C08	L3, L4, L3, L4
CIA Exam – 3	30	CO9, CO10	L3, L4
Assignment - 1	10	CO1, CO2, CO3, CO4	L2, L3, L4, L3
Assignment - 2	10	CO5, CO6, CO7, CO8	L1, L2, L3, L1
Assignment - 3	10	CO9, CO10	L3, L4
Seminar - 1	-	CO1, CO2, CO3, CO4	L2, L3, L4, L3
Seminar - 2	-	CO5, CO6,CO7,CO8	L1, L2, L3, L1
Seminar - 3	-	CO9, CO10	L3, L4
Other Activities – define – Slip test		CO1 to Co9	L2, L3, L4 . ..
Final CIA Marks		-	-

Note : Blooms Level in last column shall match with A.2 above.
Dynamic force Analysis

D1. TEACHING PLAN - 1

Module - 1

Title:	Static force Analysis and Dynamic force Analysis	Appr Time:	16 Hrs
a	***Course Outcomes***	-	**Blooms**
	The student should be able to	-	**Level**
1	Determine the forces and couples for static and dynamic conditions of four bar and slider crank mechanisms to keep the system in equilibrium	CO1	L3
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Static equilibrium. Equilibrium of two and three force members.Members with two forces and torque,	C01	L3
2	Free body diagrams, Static force analysis of four bar mechanism	C01	L3
3	numerical problems	C01	L3
4	Slider-crank mechanism with and without friction.	C01	L3
5	numerical problems	C01	L3
6	Dynamic force Analysis: D'Alembert's principle, Inertia force, Inertia torque.	C01	L3
7	numerical problems	C01	L3
8	Dynamic force analysis of four-bar mechanism of numerical problems	C01	L3
9	Slider crank mechanism without friction.	C01	L3
10	numerical problems	C01	L3
c	**Application Areas**	**CO**	**Level**
1	Four-bar linkages can be used for many mechanical purposes including to convert rotational motion to reciprocating motion.	CO1	L3
2	Four-bar linkages can be used for many mechanical purposes including to: convert rotational motion to reciprocating motion.	CO1	L3
d	**Review Questions**	-	-
1	Explain the equilibrium with respect to two force of three force member.	CO1	L3
2	the crank and connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the Piston has moved 20mmfrom the top dead centre position, the pressure on the Piston is 800 kN/m2. Determine :i) Net force on the piston ii) Thrust in the connecting rod iii) Thrust on the sides of cylinder wall iv) Engine speed at which the above values are zero.	CO1	L3
3	Drawing free body diagrams and applying equilibrium conditions.	CO2	L3
4	Explain principle of virtual work with an example.	CO2	L3
5	State the condition for static equilibrium of a body subjected to a system of, (i) two forces(ii) three forces (iii) member with two forces and a torque.	CO2	L3
6	With usual notations, explain the principle of virtual work, considering a slider crank mechanism.	CO2	L3

Module – 2

Title:	Balancing of Rotating Masses	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
	The student should be able to	-	**Level**
1	Determine magnitude and angular position of balancing mass under static and dynamic condition of rotating masses in same and different planes	CO3	L3
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**

1	Balancing of Rotating Masses .	CO2	L3
2	Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes.	CO2	L3
3	Balancing of several rotating masses by balancing masses in same plane and in different planes.	CO2	L3
4	Balancing of Reciprocating Masses:	CO2	L3
5	Inertia effect of crank and connecting rod, Single cylinder engine	CO3	L3
6	numerical problems	CO3	L3
7	balancing in multi cylinder-incline engine	CO3	L3
8	primary and secondary forces	CO3	L3
9	numerical problems	CO3	L3
10	numerical problems	CO3	L3
c	**Application Areas**	**CO**	**Level**
1	Balancing of machineries related to simple mechanical systems	CO3	L3
d	**Review Questions**	-	-
1	Prove that the resultant unbalanced force is minimum when half of the reciprocating masses are balanced by rotating masses i.e., when c = 1/2	CO2	L3
2	Explain about Balancing of Reciprocating Masses.	CO2	L3
3	Explain the procedure for balancing several masses rotating in the same plane by analytical method.	CO2	L3
4	Define primary unbalanced force and secondary unbalanced force for a reciprocating engine mechanism.	CO3	L3
5	Explain why only partial balancing is possible in reciprocating masses.	CO3	L3
6	the weights WI, W2, W3 and W4 are 1962 N, 2943N, 2354N and 2550.6N respectively, in a plane perpendicular to shaft axis. The corresponding eccentricities are 20cm, 15cm, 25cm and 30cm respectively and the angles between the successive masses are 45°, 75° and 135°. Are these weights statically balanced?	CO3	L3

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	17ME52	Sem:	V	Marks:	30	Time:	75 minutes
Course:	**Dynamics of Machinery**						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Explain the condition for static equilibrium of a body subjected to a system of, (i) two forces(ii) three forces	07	CO1	L1
	b	Explain the equilibrium with respect to two force and torque	08	CO1	L2
2	a	Drawing free body diagrams and explain the forces on slider crank mechanism	08	CO1	L2
	b	Drawing free body diagrams and explain the forces on four bar chain	07	CO1	L2
3	a	State and explain D'Alembert's principle	05	CO1	L1
	b	With usual notations, explain the principle of virtual work, considering a slider crank mechanism.	10	CO1	L2
4	a	A shaft carries 4 masses A,B,C and D of magnitude 200kg,300kg, 400kg and 200kg respectively revolving at radii 80mm, 70mm, 60mm and 80mm in planes measure from A at 300mm, 400mm, and 700mm. The angles between the cranks measured anti clockwise are A to B 45^0, B to C70^0 and C to D 120^0. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100mm Between X and Y is 400mm and Between Y and D is 200mm, if the balancing masses revolve at a radius of 100mm. Find their magnitude and angular positions	7	CO3	L3
	b	Why balancing is required. Explain balancing of rotating masses by a single mass rotating in the same plane	7	CO3	L3

b. Assignment -1

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	17ME52	Sem:	V	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Dynamics of Machinery						

Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.

SNo	USN	Assignment Description	Marks	CO	Level
1		Prove that the resultant unbalanced force is minimum when half of the reciprocating masses are balanced by rotating masses i.e., when c = 1/2	5	CO3	L2
2		Explain about Balancing of Reciprocating Masses.	5	CO4	L3
3		Explain the procedure for balancing several masses rotating in the same plane by analytical method.		CO3	L3
4		Define primary unbalanced force and secondary unbalanced force for a reciprocating engine mechanism.	5	CO3	L3
5		Explain why only partial balancing is possible in reciprocating masses.	5	CO3	L3
6		the weights WI, W2, W3 and W4 are 1962 N, 2943N, 2354N and 2550.6N respectively, in a plane perpendicular to shaft axis. The corresponding eccentricities are 20cm, 15cm, 25cm and 30cm respectively and the angles between the successive masses are 45°, 75° and 135°. Are these weights statically balanced?	5	CO3	L3

D2. TEACHING PLAN - 2

Module – 3

Title:	Governors and Gyroscope	Appr Time:	16 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Determine sensitiveness , synchronism, effort and power of porter and hartnell governors.	CO4	L3
2	Determine gyroscopic couple and effects related to 2, 4 wheeler, plane disc, ship and aeroplanes.	CO5	L3
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	Types of governors, force analysis of Porter governors.	CO4	L3
2	Force analysis of Hartnell governors.	CO4	L3
3	Stability, Sensitiveness, Isochronism, Effort and Power.	CO4	L3
4	Numerical problems.15	CO4	L3
5	Numerical problems.	CO4	L3
6	Gyroscope: Vectorial representation of Gyroscopic couple.	CO5	L3
7	Effect of gyroscopic couple on plane disc, aeroplane,	CO5	L3
8	Effect of gyroscopic couple on ship, stability of two wheelers and four wheelers.	CO5	L3
9	Numerical problems.	CO5	L3
10	Numerical problems.	CO5	L3
c	**Application Areas**	**CO**	**Level**
1	Governors are used in the field of automobile engineering.	CO4	L3
2	Gyroscopes are used in the field of automobile engineering, aeronautics and ships.	CO5	L3
d	**Review Questions**	-	-
1	Explain in brief 'the effect of friction at sleeve on the performance of Porter Governor'.	CO4	L2
2	spring loaded governor of the Hartnell type has arms of equal lengths. The weights rotate in a circle of 13cm diameter when the sleeve is in the mid-position and the weight arms are vertical. The equilibrium speed for this position is 450rpm, neglecting friction. The maximum sleeve movement is to be 2.5cm and the maximum variation of speed, taking	CO4	L3

	friction into account is to be ± 5% of mid-position equilibrium speed. The weight of sleeve is 39N and the friction may be considered equivalent to 29N at the sleeve. The power of the governor must be sufficient to overcome the friction by a 1% change of speed either way at mid position. Determine, neglecting obliquity effect, i) Weight of each rotating mass ii) Spring stiffness i		
3	explain in brief: i) Angular momentum ii) Spin motion (iii) Processional motion.	CO4	L2
4	Define height of the governor and derive an expression for the height of the Hartwell governor.	CO4	L2
5	The arms of a porter governor are 300 mm long. The upper arms are pivoted on the axis of rotation. The lower arms are attached to a sleeve at a distance of 400 mm from the axis of rotation the mass of the load on the sleeve in 70 kg and the mass of each ball is 10 kg. Determine the equilibrium speed when the radius of rotation of the balls is 200 mm. If the friction is equivalent to a load of 20 N at the sleeve. What will be the range of speed for this position?	CO5	L3
6	Explain the effect of Gyroscopic couple on Naval ship when it is steering and pitching.	CO5	L2
7	Define the following with respect to the working of governors : (iv) Stability of a governor. (iii) Effort of a governor (ii) Isochronism (i) Sensitiveness	CO5	L2
8	derive an expression for the gyroscopic couple.	CO5	L3
9	derive the expression for speed of a porter Governor with usual notations, taking friction into account.	CO5	L3
10	In a spring loaded Hartnell type governor, the extreme radii of rotation of the balls are 80mm and 120mm. The ball and sleeve arms of the bell crank lever are equal in length. The mass of each ball is 2kg. If the speeds at the two extreme positions are 400 and 420rpm. Find: i) The sleeve lift; ii) Stiffness of the spring; iii) Initial compression of the spring.	CO5	L3
11	With neat sketches, explain the effect of gyroscopic couple on steering of aeroplane, when it takes a right turn. The engine runs in clockwise when viewed from rear.	CO5	L2

Module – 4

Title:		Appr Time:	16 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand types of vibration, SHM and methods of finding natural frequencies of simple mechanical systems.	CO6	L2
2	Determine equation of motion, natural frequency, damping factor, logarithmic decrement of damped free vibration (SDOF) systems.	CO7	L3
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction & Undamped free Vibrations (Single Degree of Freedom)	CO6	L2
2	Types of vibrations, Definitions, Simple Harmonic Motion (SHM),	CO6	L2
3	Work done by harmonic force, Principle of super position applied to SHM.	CO6	L2
4	Dynamic force Analysis Methods of analysis –(Newton's, Energy &Rayleigh's methods). Dynamic force Analysis	CO6	L2
5	Derivations for spring mass systems,	CO6	L2
6	Natural frequencies of simple systems,	CO7	L2
7	Springs in series and parallel, Torsional and transverse vibrations,	CO7	L2
8	Effect of mass of spring and problems.	CO7	L2
9	Numerical problems	CO7	L3

10	Numerical problems	CO7	L3
c	**Application Areas**	**CO**	**Level**
1	Suspension systems in automobiles	CO6	L3
2	Hydraulic systems aircrafts	CO7	L3
d	**Review Questions**	-	-
1	Determine the natural frequency of a spring-mass system in which the mass of the spring is not negligible.	CO6	L3
2	A spring-mass-damper system is subjected to harmonic excitation of Fsin (IA , having maximum value of 250 N with a frequency of 5 Hz. If the mass is 10 kg, spring with spring constant 2 kN/m and a dashpot of damping constant 50 N-s/m, determine the complete solution for the motion of the mass.	CO6	L3
3	Define: i) Deterministic and random vibration, ii) Linear and non-linear vibration.	CO6	L2
4	determine the natural frequency of spring-mass system taking the mass of the spring in to account.	CO7	L3
5	Define the following terms : (i) Periodic motion (ii) Degree of freedom (iii) Resonance (iv) Phase difference.	CO7	L2
6	Add the following harmonic motion and check the solution graphically : x1 = 2cos (wt + 0.5) x2 = 5sin (wt + 1.0).	CO7	L3
7	Determine the natural frequency of undamped free vibration system using energy method.	CO7	L3

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	17ME52	Sem:	V	Marks:	30	Time:	75 minutes
Course:	Dynamics of Machinery						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Explain about Balancing of Reciprocating Masses.	05	CO5	L3
	b	the weights WI, W2, W3 and W4 are 1960 N, 2940N, 2350N and 2550N respectively, in a plane perpendicular to shaft axis. The corresponding eccentricities are 15cm, 20cm, 25cm and 35cm respectively and the angles between the successive masses are 40°, 70° and 130°. Are these weights statically balanced?	10	CO5	L3
2	a	Define sensitiveness , synchronism, effort and power of porter and hartnell governors.	05	CO6	L2
	b	spring loaded governor of the Hartnell type has arms of equal lengths. The weights rotate in a circle of 15cm diameter when the sleeve is in the mid-position and the weight arms are vertical. The equilibrium speed for this position is 400rpm, neglecting friction. The maximum sleeve movement is to be 3cm and the maximum variation of speed, taking friction into account is to be ± 5% of mid-position equilibrium speed. The weight of sleeve is 40N and the friction may be considered equivalent to 20N at the sleeve. The power of the governor must be sufficient to overcome the friction by a 1% change of speed either way at mid position. Determine, neglecting obliquity effect, i) Weight of each rotating mass	10	CO6	L3
3	a	4 masses M1, M2, M3 and M4 are 200kg, 300kg, 240kg and 260kg respectively. The corresponding radii of rotation are 0.2m, 0.15m, 0.25m and 0.3m respectively and the angles between successive masses are 450,750 and 1350. Find the position and magnitude of the balance mass required if the radius of rotation is 0.2m.	10	CO3	L3
	b	Why balancing is required. Explain balancing of rotating masses by a single mass rotating in the same plane	5	CO3	L3
4	a	A shaft carries 4 masses A,B,C and D of magnitude 200kg,300kg, 400kg and 200kg respectively revolving at radii 80mm, 70mm, 60mm and 80mm in planes measure from A at 300mm, 400mm, and 700mm. The angles between the cranks measured anti clockwise are A to B 45^0, B to C70^0 and C to D 120^0. The balancing masses are	15	CO3	L3

		to be placed in planes X and Y. The distance between the planes A and X is 100mm Between X and Y is 400mm and Between Y and D is 200mm, if the balancing masses revolve at a radius of 100mm. Find their magnitude and angular positions		

b. Assignment – 2

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	17ME52	Sem:	V	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Dynamics of Machinery						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		Explain the equilibrium with respect to two force of three force member.	8	CO1	L3
2		the crank and connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the Piston has moved 20mmfrom the top dead centre position, the pressure on the Piston is 800 kN/m2. Determine :i) Net force on the piston ii) Thrust in the connecting rod iii) Thrust on the sides of cylinder wall iv) Engine speed at which the above values are zero.	7	CO1	L3
3		Drawing free body diagrams and applying equilibrium conditions.	8	CO2	L3
4		Explain principle of virtual work with an example.	7	CO2	L3
5		State the condition for static equilibrium of a body subjected to a system of, (i) two forces(ii) three forces (iii) member with two forces and a torque.	8	CO2	L3
6		With usual notations, explain the principle of virtual work, considering a slider crank mechanism.	8	CO2	L3
7		Prove that the resultant unbalanced force is minimum when half of the reciprocating masses are balanced by rotating masses i.e., when c = 1/2	8	CO2	L3
8		Explain about Balancing of Reciprocating Masses.	7	CO2	L3
9		Explain the procedure for balancing several masses rotating in the same plane by analytical method.	8	CO2	L3
10		Define primary unbalanced force and secondary unbalanced force for a reciprocating engine mechanism.	7	CO3	L3
11		Explain why only partial balancing is possible in reciprocating masses.	8	CO3	L3
12		the weights WI, W2, W3 and W4 are 1962 N, 2943N, 2354N and 2550.6N respectively, in a plane perpendicular to shaft axis. The corresponding eccentricities are 20cm, 15cm, 25cm and 30cm respectively and the angles between the successive masses are 45°, 75° and 135°. Are these weights statically balanced?	7	CO3	L3
13		Explain in brief 'the effect of friction at sleeve on the performance of Porter Governor'.	8	CO4	L3
14		spring loaded governor of the Hartnell type has arms of equal lengths. The weights rotate in a circle of 13cm diameter when the sleeve is in the mid-position and the weight arms are vertical. The equilibrium speed for this position is 450rpm, neglecting friction. The maximum sleeve movement is to be 2.5cm and the maximum variation of speed, taking friction into account is to be ± 5% of mid-position equilibrium speed. The weight of sleeve is 39N and the friction may be considered equivalent to 29N at the sleeve. The power of the governor must be sufficient to overcome the friction by a 1% change of speed either way at mid position. Determine, neglecting obliquity effect, i) Weight of each rotating mass ii) Spring stiffness i	8	CO4	L3
15		explain in brief: i) Angular momentum ii) Spin motion (iii) Processional motion.	7	CO4	L3
16		Define height of the governor and derive an expression for the height of	7	CO4	L3

		the Hartwell governor.			
17		The arms of a porter governor are 300 mm long. The upper arms are pivoted on the axis of rotation. The lower arms are attached to a sleeve at a distance of 400 mm from the axis of rotation the mass of the load on the sleeve in 70 kg and the mass of each ball is 10 kg. Determine the equilibrium speed when the radius of rotation of the balls is 200 mm. If the friction is equivalent to a load of 20 N at the sleeve. What will be the range of speed for this position?	7	CO5	L3
18		Explain the effect of Gyroscopic couple on Naval ship when it is steering and pitching.	7	CO5	L3
19		Define the following with respect to the working of governors : (iv) Stability of a governor. (iii) Effort of a governor (ii) Isochronism (i) Sensitiveness	8	CO5	L3
20		Derive an expression for the gyroscopic couple.	7	CO5	L3
21		Derive the expression for speed of a porter Governor with usual notations, taking friction into account.	8	CO5	L3
22		In a spring loaded Hartnell type governor, the extreme radii of rotation of the balls are 80mm and 120mm. The ball and sleeve arms of the bell crank lever are equal in length. The mass of each ball is 2kg. If the speeds at the two extreme positions are 400 and 420rpm. Find: i) The sleeve lift; ii) Stiffness of the spring; iii) Initial compression of the spring.	8	CO5	L3

D3. TEACHING PLAN - 3

Module – 5

Title:		Appr Time:	16 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Determine the natural frequency, force and motion transmissible of single degree freedom systems.	CO8	L2
2	Determine equation of motion of rotating and reciprocating unbalance systems, magnification factor, and transmissibility of forced vibration (SDOF)Systems.	CO9	L3
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	Damped free Vibrations (Single Degree of Freedom)	CO8	L2
2	Types of damping, Analysis with viscous damping -	CO8	L2
3	Derivations for over, critical and under damped systems.	CO8	L3
4	Forced Vibrations (Single Degree of Freedom):	CO8	L2
5	Analysis of forced vibration with constant harmonic excitation, Magnification factor (M.F.),	CO8	L2
6	Vibration isolation - Transmissibility ratio,	CO9	L2
7	Excitation of support Static force Analysis:(absolute and relative)	CO9	L3
8	Logarithmic decrement and numerical problems.	CO9	L3
9	numerical problems	CO9	L3
10	numerical problems	CO9	L3
c	**Application Areas**	**CO**	**Level**
1	Vibration can be desirable: for example, the motion of a tuning fork, the reed in a wood wind instrument, a mobile phone, or the cone of a loudspeaker	CO9	L3
d	**Review Questions**	-	-
1	A spring mass damper system has a mass of 10 kg, spring stiffness 250 N/m and damping coefficient of 15 N-S/m. Determine the natural frequency, critical damping coefficient, damping factor, damped natural frequency, period of vibration, logarithmic decrement, ratio of two successive amplitudes and number of cycles after which the original amplitude is below 15%.	CO10	L3
2	Define the term "Transmissibility", and derive the expression for transmissibility	CO10	L2

	ratio due to harmonic excitation.		
3	A machine mass on ton is acted upon by an external force 2450N at a frequency of 1500rpm. To reduce the effects of vibration, isolator of rubber having a static deflection of 2mm under the machine load and an estimated damping factor of 0.2 are used. Determine: i) Force transmitted to the foundation ii) Amplitude of vibration of the machine iii) Phase lag of the transmitted force with respect to the external force	CO9	L3
4	A machine of mass 500kg is supported on spring of stiffness 106N/m. if the machine has a rotating unbalance of 0.25 Kg-m, determine i) The force transmitted to the floor at 1200 rpm ii) The dynamic amplitude at this speed iii) The phase angle.	CO9	L3
5	spring mass damper system is having a mass of 10kg and a spring of such stiffness which causes a static deflection of 5mm. The amplitude of vibration reduces to 1/4 the initial value in 10 oscillations, determine i) Logarithmic decrement ii) Actual damping present in the system iii) Damped natural frequency.	CO9	L3
6	A machine of mass one ton is acted upon by an external force 2450N at a frequency of 1500rpm. To reduce the effects of vibration, isolator of rubber having a static deflection of 2mm under the machine load and an estimated damping factor of 0.2 are used. Determine: i) Force transmitted to the foundation; ii) Amplitude of vibration of the machine; iii) Phase lag of the transmitted force with respect to the external force.	CO9	L3
7	A vibratory body of mass 150kg supported on springs of total stiffness 1050 kN/m has a rotating unbalance force of 525 N at a speed of 6000rpm. If the damping factor is 0.3, determine: i)Amplitude of vibration and phase angle. ii) Transmissibility ratio and iii) Force transmitted to the foundation.	CO10	L3

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	17ME52	Sem:	5	Marks:	30	Time:	75 minutes
Course:	Dynamics of Machinery						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	State the condition for the equilibrium of the following systems i) Two force member ii) Three force member	2	1	L2
	b	On the slider crank mechanism shown in fig 1 the value of force applied to slide 4 is 2KN.The dimensions of the various links are AB = 80 mm,BC= 240 mm, Ə=60^0.Determine the forces on various links & the driving torque T_2.	13	1	L2
		OR			
2	a	The crank and connecting rods of a 4 cylinder in line engine rotating at 1800 rpm are 60 mm and 240 mm each respectively. The cylinders are spaced at 150 mm apart and are numbered 1 to 4 in sequence from one end .The cranks appear at intervals of 90^0 in an end view in the order1-4-2-3.The reciprocating mass corresponding to each cylinder is 1.5 kg .Determine a)unbalanced primary and secondary forces if any b) unbalanced primary and secondary couples with reference to central plane of the engine.	15	4	L2
	b	Define logarithmic decrement and derive the equation for same	10	9	L3
3	a	A body of mass 10 kg is suspended from a helical spring having a stiffness of 2 N/mm.A damper having a resistance of 5 N at a velocity of 0.1 m/sec is connected between the mass and fixed end of the spring determine i) Ratio of successive amplitude ii) Amplitude of body after 10 cycles if the initial amplitude is 15 mm.	5	9	L2
		OR			

4	a	A machine of mass 2000 N is mounted on rubber pads which given as initial static deflection of 2mm under the self weight of machine it is also provided with damping such that damping ratio is 0.2 determine a) Resonant frequency b)Max amplitude and corresponding frequency c) The phase angel at ω =100 rad/s.	6	10	L2
	b	**Define magnification factor,vibration isolation and transmissibility ratio**	9	10	L2

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	17ME52	Sem:	v	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Dynamics of Machinery						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		Prove that the resultant unbalanced force is minimum when half of the reciprocating masses are balanced by rotating masses i.e., when c = 1/2	7	CO2	L3
2		Explain about Balancing of Reciprocating Masses.	8	CO2	L3
3		Explain the procedure for balancing several masses rotating in the same plane by analytical method.	7	CO2	L3
4		Define primary unbalanced force and secondary unbalanced force for a reciprocating engine mechanism.	8	CO3	L3
5		Explain why only partial balancing is possible in reciprocating masses.	7	CO3	L3
6		the weights WI, W2, W3 and W4 are 1962 N, 2943N, 2354N and 2550.6N respectively, in a plane perpendicular to shaft axis. The corresponding eccentricities are 20cm, 15cm, 25cm and 30cm respectively and the angles between the successive masses are 45°, 75° and 135°. Are these weights statically balanced?	8	CO3	L3
7		Explain in brief 'the effect of friction at sleeve on the performance of Porter Governor'.	7	CO4	L2
8		spring loaded governor of the Hartnell type has arms of equal lengths. The weights rotate in a circle of 13cm diameter when the sleeve is in the mid-position and the weight arms are vertical. The equilibrium speed for this position is 450rpm, neglecting friction. The maximum sleeve movement is to be 2.5cm and the maximum variation of speed, taking friction into account is to be ± 5% of mid-position equilibrium speed. The weight of sleeve is 39N and the friction may be considered equivalent to 29N at the sleeve. The power of the governor must be sufficient to overcome the friction by a 1% change of speed either way at mid position. Determine, neglecting obliquity effect, i) Weight of each rotating mass ii) Spring stiffness I	8	CO4	L3
9		explain in brief: i) Angular momentum ii) Spin motion (iii) Processional motion.	7	CO4	L2
10		Define height of the governor and derive an expression for the height of the Hartwell governor.	8	CO4	L2
11		The arms of a porter governor are 300 mm long. The upper arms are pivoted on the axis of rotation. The lower arms are attached to a sleeve at a distance of 400 mm from the axis of rotation the mass of the load on the sleeve in 70 kg and the mass of each ball is 10 kg. Determine the equilibrium speed when the radius of rotation of the balls is 200 mm. If the friction is equivalent to a load of 20 N at the sleeve. What will be the range of speed for this position?	7	CO5	L3
12		Explain the effect of Gyroscopic couple on Naval ship when it is steering and pitching.	7	CO5	L2
13		Define the following with respect to the working of governors : (iv) Stability of a governor.	8	CO5	L2

		(iii) Effort of a governor (ii) Isochronism (i) Sensitiveness			
14		Derive an expression for the gyroscopic couple.	7	CO5	L3
15		Derive the expression for speed of a porter Governor with usual notations, taking friction into account.	7	CO5	L3
16		In a spring loaded Hartnell type governor, the extreme radii of rotation of the balls are 80mm and 120mm. The ball and sleeve arms of the bell crank lever are equal in length. The mass of each ball is 2kg. If the speeds at the two extreme positions are 400 and 420rpm. Find: i) The sleeve lift; ii) Stiffness of the spring; iii) Initial compression of the spring.	8	CO5	L3
17		With neat sketches, explain the effect of gyroscopic couple on steering of aeroplane, when it takes a right turn. The engine runs in clockwise when viewed from rear.	8	CO2	L3
18		With neat sketches, explain the effect of gyroscopic couple on steering of aeroplane, when it takes a right turn. The engine runs in clockwise when viewed from rear.	8	CO2	L3
19		Determine the natural frequency of a spring-mass system in which the mass of the spring is not negligible.	7	CO2	L3
20		A spring-mass-damper system is subjected to harmonic excitation of Fsin (IA , having maximum value of 250 N with a frequency of 5 Hz. If the mass is 10 kg, spring with spring constant 2 kN/m and a dashpot of damping constant 50 N-s/m, determine the complete solution for the motion of the mass.	8	CO3	L3
21		Define: i) Deterministic and random vibration, ii) Linear and non-linear vibration.	8	CO3	L3
22		determine the natural frequency of spring-mass system taking the mass of the spring in to account.	7	CO3	L3
23		Define the following terms : (i) Periodic motion (ii) Degree of freedom (iii) Resonance (iv) Phase difference.	8	CO4	L1
24		Add the following harmonic motion and check the solution graphically : x1 = 2cos (wt + 0.5) x2 = 5sin (wt + 1.0).	8	CO4	L3
25		Determine the natural frequency of undamped free vibration system using energy method.	7	CO4	L2

F. EXAM PREPARATION

1. University Model Question Paper

Course:	DYNAMICS OF MACHINERY					Month / Year	May /2019
Crs Code:	17ME52	Sem:	v	Marks:	100	Time:	180 minutes

-	Note	Answer all FIVE full questions. All questions carry equal marks.	Marks	CO	Level
1	a	Discuss the equilibrium of the following systems : i) Two force members ii) Three force members iii) Member with two forces and a torque.	8 / 20	CO1	L1
	b	With usual notations, explain the principle of virtual work, considering a slider crank mechanism.	8 / 20	CO1	L1
	c	A four link mechanism with the following dimensions is acted upon by a force 80N 150° on the link DC. Determine the input torque on the	8 / 20	CO2	L2

		link AB for the static equilibrium of the mechanism for the given configuration. AB = 400mm ; BC — 1000mm, CD = 750m DE = 350mm, AD = 500mm.			
	d	On the slider crank mechanism shown in fig 1 the value of force applied to slide 4 is 2KN.The dimentions of the various links are AB = 80 mm,BC= 240 mm, Ə=60^0.Determine the forces on various links & the driving torque $T_{2.}$	16 / 20	CO2	L2
		OR			
-	a	Determine the condition for stability of a 4 wheel moving in a curved path taking left turn.	8 / 20	CO1	L1
	b	explain the equilibrium with respect to two force of three force member.	8/ 20	CO1	L1
	c	b. The crank and connecting rod of a vertical single cylinder gas engine running at 2800 rpmare 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.4kg. At a point during the power stroke when the Piston has moved 20mm from the top dead centre position, the pressure on the Piston is 800 kN/m2. Determine : i) Net force on the piston ii) Thrust in the connecting rod iii) Thrust on the sides of cylinder wall iv) Engine speed at which the above values are zero	10 / 20	CO2	L2
	d	On the slider crank mechanism shown in fig 1 the value of force applied to slide 4 is 2KN.The dimentions of the various links are AB = 90 mm,BC= 350 mm, Ə=60^0.Determine the forces on various links & the driving torque $T_{2.}$	12 / 20	CO2	L2
2	a	state 'ID' Alembert's principle.	6 / 20	C03	L1
	b	A slider crank mechanism has crank = 0.5m, connecting rod = 1.75m. When the crank is 60°away from IDC, a force of IkN acts on slider, along line of stroke, away from crank centre.Find the torque T, needs to be applied on crank for static equilibrium of m/sm by Virtual work method	10 / 20	CO4	L2
	c	The crank and connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the Piston has moved 20mm from the top dead centre position, the pressure on the Piston is 800 kN/m2. Determine : i) Net force on the piston ii) Thrust in the connecting rod iii) Thrust on the sides of cylinder wall iv) Engine speed at which the above values are zero	16 / 20	CO3	L2
	d	Explain in brief either "D'Alembert's principle" or "dynamically Equivalent system	8 / 20	CO4	L1
3	a	A racing car weighs 21582 N, it has a wheel base of 2.4m and a track of width 1.4m. The centre of mass of the car lies at 0.6m above the ground and 1.4 m from the rear axle. Equivalent mass of engine parts is 140kg with a radius of gyration of 0.15m. The back axle ratio is 5. The engine shaft and flywheel rotate clock wise when viewed from front. Each wheel has a diameter of 0.8m and moment of inertia of	16 / 20	CO5	L2

		0.7kg- m^2. Determine the load distribution on the wheels when the car is taking a turn around a curve of 100m radius at a speed of 72km/hr to the left.			
	b	Determine the condition for stability of a 4 wheel moving in a curved path taking left turn.	8 / 20	CO6	L1
	c	An automobile is traveling along a curved track of 120m radius at 72 km/hr to the left,. Each of the 4 wheels has a movement of inertia 2kg-m^2 and an effective diameter of 0.6m. Rotating parts of an engine having a movement of inertia of 1.5 kg-m^2 and rotates in clockwise direction as seen from front. Gear ratio of the engine to the wheel is 4, Mass of the vehicle is 2tons and the centre of mass is 0.5m above the road level. The width of track is 1.6m. Determine the load distribution on the wheels and mark them on a sketch. How the values differ if the automobile turns right instead of left.	16 / 20	CO5	L2
	d	The crank and connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the Piston has moved 20mm from the top dead centre position, the pressure on the Piston is 800 kN/m2. Determine : i) Net force on the piston ii) Thrust in the connecting rod iii) Thrust on the sides of cylinder wall iv) Engine speed at which the above values are zero.	16 / 20	CO6	L2
		or			
-	a	The weights WI, W2, W3 and W4 are 1962 N, 2943N, 2354N and 2550.6N respectively, in a plane perpendicular to shaft axis. The corresponding eccentricities are 20cm, 15cm, 25cmand 30cm respectively and the angles between the successive masses are 45°, 75° and 135°. Are these weights statically balanced?	16 / 20	CO5	L2
	b	A shaft is supported in bearings 180cm apart and project 45cm beyond bearing at each end.The shaft carries three pulleys one at each end and one at the middle of its is length. The end pulleys weigh 471 N and 196.2N and their eccentricities are 1.5cm and 1.25cm respectively. The central pulley weighs 549.4N and its centre of gravity is 1.5cm from shaft axis. If the pulleys are arranged to give static balance, determine : i) Relative angular positions of the pulleys and ii) Dynamic forces at bearings when the shaft rotates at 300 rpm	16 / 20	CO6	L2
	c	piston of a 4 cylinder vertical in line engine reach their upper most position at 90° interval in order of their axial position, pitch of the cylinder = 0.3m ; length of the connecting rod = 0.42m. the engine runs at 600 rpm. If the reciprocating parts of each engine has a mass of 2.5kg. Find the unbalanced primary and secondary forces and couples. Take central plane of engine as reference plane.	16 / 20	CO5	L2
	d	A porter governor has equal arms each 250mm long and pivoted on the axis of rotation. Each ball has a mass of 5kg and the mass of the central load on the sleeve is 25kg. The radius'of rotation of the ball is 150mm when the governor begins to lift and 200mm when the governor is at maximum speed. Find the minimum and maximum speeds and range of speed of the governor	16 / 20	CO6	L2

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4	a	Split up the harmonic motion X 6 Cos (wt f 45°) into two harmonic motions. One of them having phase angle of zero degree and other having phase angle of 60° Check solution the graphically.	12 / 20	CO7	L2
	b	Obtain the equivalent stiffness of spring when springs are connected in series and parallel.	8 / 20		L1
	c	Briefly explain, Free, Forced, damped and undamped vibration.	8 / 20	C08	L1
	d	Derive the expression for work done by harmonic force.	8 / 20		L1
		OR			
-	a	Add the following harmonic motions analytically and check the solution graphically x1=4 cos(wt+10) x2=6cos(wt+60)	12 / 20	CO7	L2
	b	Determine the natural frquency using newtons method and energy method.	8 / 20	CO8	L1
	c	Obtain the equivalent stiffness of spring when springs are connected in series and parallel	8 / 20		L1
	d	Determine the natural frquency using spring mass system in horizantal position.	8 / 20		L1
5	a	Define logarithmic decrement and derive the equation for same	8 / 20	CO9	L1
	b	A body of mass 10 kg is suspended from a helical spring having a stiffness of 2 N/mm.A damper having a resistance of 5 N at a velocity of 0.1 m/sec is connected between the mass and fixed end of the spring determine i) Ratio of successive amplitude ii) Amplitude of body after 10 cycles if the initial amplitude is 15 mm.	16 / 20	CO10	L2
	c	Define magnification factor,vibration isolation and transmissibility ratio.	8 / 20	CO9	L1
	d	A machine of mass 4000 N is mounted on rubber pads which given as initial static deflection of 3mm under the self weight of machine it is also provided with damping such that damping ratio is 0.2 determine a) Resonant frequency b)Max amplitude and corresponding frequency c) The phase angel at ω =100 rad/s.	16 / 20	CO10	L2
		OR			
	a	vibratory body of mass 150kg supported on springs of total stiffness 1050kN/m has a rotating unbalance force fo 525N at a speed of 6000rpm. If the damping factor is 0.3. Determine : i) The amplitude caused by the unbalance and its phase angle ii) The transmissibility iii) The actual force transmitted and its phase angle.	16 / 20	CO9	L2
	b	Define magnification factor,vibration isolation and transmissibility ratio.	8 / 20	CO9	L1
	c	A machine of mass 2000 N is mounted on rubber pads which given as initial static deflection of 2mm under the self weight of machine it is also provided with damping such that damping ratio is 0.2 determine a) Resonant frequency b)Max amplitude and corresponding frequency c) The phase angel at ω =100 rad/s.	16 / 20	C010	L2
	d	A body of mass 20 kg is suspended from a helical spring having a stiffness of4 N/mm.A damper having a resistance of 5 N at a velocity of 0.1 m/sec is connected between the mass and fixed end of the spring determine i) Ratio of successive amplitude ii) Amplitude of body after 10 cycles if the initial amplitude is 15 mm.	16 / 20	C010	L3

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2. SEE Important Questions

Course:	Dyanamics of Machinery					Month / Year	May /2019	
Crs Code:	17ME52	Sem:	5	Marks:	100	Time:	180 minutes	

	Note	Answer all FIVE full questions. All questions carry equal marks.	-	-	
Module	Qno.	Important Question	**Marks**	**CO**	**Year**
1	1	Explain the equilibrium with respect to two force of three force member.	8/16	co1	2017
	2	A four link mechanism with the following dimensions is acted upon by a force 80N 150° on the link DC. Determine the input torque on the link AB for the static equilibrium of the mechanism for the given configuration. AB = 400mm ; BC — 1000mm, CD = 750mm and ‘,DE = 350mm, AD = 500mm.	12/16	co1	2017
	3	State 'ID' Alembert's principle.	8/16	co2	2016
	4	The crank and connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the Piston has moved 20mm from the top dead centre position, the pressure on the Piston is 800 kN/m2. Determine : i) Net force on the piston ii) Thrust in the connecting rod iii) Thrust on the sides of cylinder wall iv) Engine speed at which the above values are zero.	8/16	co2	2015
2	1	A slider crank mechanism has crank = 0.5m, connecting rod = 1.75m. When the crank is 60°away from IDC, a force of IkN acts on slider, along line of stroke, away from crank centre.Find the torque T, needs to be applied on crank for static equilibrium of m/sm by Virtual work method	10/ 20	co3	2016
	2	The crank and connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the Piston has moved 20mm from the top dead centre position, the pressure on the Piston is 800 kN/m2. Determine : i) Net force on the piston ii) Thrust in the connecting rod iii) Thrust on the sides of cylinder wall iv) Engine speed at which the above values are zero	12/16	co3	2016
	3	b. The crank and connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the Piston has moved 20mm from the top dead center position, the pressure on the Piston is 800 kN/m2. Determine : i) Net force on the piston ii) Thrust in the connecting rod iii) Thrust on the sides of cylinder wall iv) Engine speed at which the above values are zero	16/16	co4	2017
	4	On the slider crank mechanism shown in fig 1 the value of force applied to slide 4 is 2KN.The dimentions of the various links are AB = 80 mm,BC= 240 mm, Ə=60^0.Determine the forces on various links & the driving torque $T_{2.}$	16/16	co4	2018
3	1	For masses m l = 100kg, m2 = 175kg, m3 = 200k and m4 = 125kgs are fixed to the crank of 200mm radius and revolve in planes I st, IInd, III' respectively. The angular position of the planes I I nd. III' and and IVth with respect to Is' plane are 75°, 135°	16 / 20	co5	2017

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		and 240° take in the same sense. Distance of plane II n' IIIrd and IV" from Ist are 600mm, 1800mm and 2400mm. Determine the magnitude and position of the balancing masses at the radius 600mm in planes L and M located in the middle of I s' and IInd and in the middle of IlI rd and IV' respectively			
	2	The crank and connecting rod of a vertical single cylinder gas engine running at 1800 rpm are 60mm and 240mm respectively. The diameter of the Piston is 80mm and the mass of the reciprocating is 1.2kg. At a point during the power stroke when the Piston has moved 20mm from the top dead centre position, the pressure on the Piston is 800 kN/m2. Determine : i) Net force on the piston ii) Thrust in the connecting rod iii) Thrust on the sides of cylinder wall iv) Engine speed at which the above values are zero.	16/16	co6	2012
	3	piston of a 4 cylinder vertical in line engine reach their upper most position at 90°interval in order of their axial position, pitch of the cylinder = 0.35m ; length of the connecting rod = 0.42m. the engine runs at 600 rpm. If the reciprocating parts of each engine has a mass of 2.5kg. Find the unbalanced primary and secondary forces and couples. Take central plane of engine as reference plane	12/16	co5	2014
	4	A porter governor has equal arms each 250mm long and pivoted on the axis of rotation. Each ball has a mass of 5kg and the mass of the central load on the sleeve is 25kg. The radius'of rotation of the ball is 150mm when the governor begins to lift and 200mm when the governor is at maximum speed. Find the minimum and maximum speeds and range of speed of the governor	12/16	co6	2015
4	1	Briefly explain, Free, Forced, damped and undamped vibration	8 / 16	co7	2017
	2	Split up the harmonic motion X 6 Cos (wt f 45°) into two harmonic motions. One of them having phase angle of zero degree and other having phase angle of 60° Check solution by graphically.	8 / 16	co8	2018
	3	Obtain the equivalent stiffness of spring when springs are connected in series and parallel.	8 / 16	co7	2017
	4	Obtain the natural frequency of the system	8 / 16	co8	2018
5	1	Define logarithmic decrement and derive the equation for same. logarithmic decrements, iii) The actual force transmitted and its phase angle.	8/ 16	co9	2018
	2	b. Vibration system consisting of a mass 3kg a springs of stiffness 100kN/m and damper. Damping coefficient 30Ns/m. Determine Damping factor, critical damping coefficient Ratio of two consecutive amplitudes. Number of Cycles after which the initial amplitude is reduced to 20%?	8/16	co10	2018
	3	Derive an expression for magnification factor or amplitude ratio for spring mass system with viscous damping subjected to harmonic force.	8/16	co9	2017
	4	A vibratory body of mass 150kg supported on springs of total striffness 1050kN/m has a rotating unbalance force for 525N at a speed of 6000rpm. If the damping factor is 0.3. Determine : i) The amplitude caused by the unbalance and its phase angle ii) The translatability	8/16	co10	2017

G. Content to Course Outcomes

1. TLPA Parameters

Table 1: TLPA – Example Course

Module- #	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	Static force Analysis: Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque, Free body diagrams, Static force analysis of four bar mechanism and Slider-crank mechanism with and without friction. .	5	L2 L3	L3	Understand Analysis	Lecture/Tutorial	Assignment
1	Dynamic force Analysis: D'Alembert's principle, Inertia force, Inertia torque. Dynamic force analysis of four-bar mechanism and Slider crank mechanism without friction, numerical problems	5	L2 L3	L3	Understand Analysis	Lecture/Tutorial	Assignment
2	Balancing of Rotating Masses: Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes.	5	L2 L3	L3	Understand Analysis	Lecture/Tutorial	Assignment
2	Balancing of Reciprocating Masses: Inertia effect of crank and connecting rod, Single cylinder engine, balancing in multi cylinder-inline engine (primary and secondary forces), numerical problems.	5	L2 L3	L3	Understand Analysis	Lecture/Tutorial	Assignment
3	Governors: Types of governors, force analysis of Porter and Hartnell governors. Controlling force,Stability,Sensitiveness, Isochronism, Effort and Power.	5	L2 L3	L3	Understand Analysis	Lecture/Tutorial	Assignment
3	Gyroscope: Vectorial representation of angular motion, Gyroscopic couple. Effect of gyroscopic couple on plane disc, aeroplane, ship, stability of two wheelers and four wheelers, numerical problems.	5	L2 L3	L3	Understand Analysis	Lecture/Tutorial	Assignment
4	Introduction & Undamped free Vibrations (Single Degree of Freedom) Types of vibrations, Definitions, Simple Harmonic Motion (SHM), Work done by harmonic force, Principle of super position applied to SHM. Methods of analysis – (Newton's, Energy & Rayleigh's methods).	5	L2 L3	L3	Understand Analysis	Lecture/Tutorial	Assignment
4	Derivations for spring mass systems, Natural	5	L2	L3	Understan	Lecture/T	Assignment

	frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and problems.		L3		d Analysis	utorial	
5	Damped free Vibrations (Single Degree of Freedom) Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and numerical problems.	5	L2 L3	L3	Understand Analysis	Lecture/Tutorial	Assignment
5	Forced Vibrations (Single Degree of Freedom):Analysis of forced vibration with constant harmonic excitation, Magnification factor (M.F.),Vibration isolation - Transmissibility ratio, Excitation of support (absolute and relative),Numerical problems.	5	- L1 - L2	L2	Understand Analysis	Lecture/Tutorial	Assignment

2. Concepts and Outcomes:

Table 2: Concept to Outcome – Example Course

Module- #	Learning or Outcome from study of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What all Learning Happened from the study of Content / Syllabus. A short word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	To gain the knowledge of static and dynamic equilibrium conditions of mechanisms -	static and dynamic equilibrium	Force and Torque	Force	- Understand and analysis	To gain the knowledge of static and dynamic equilibrium conditions of mechanisms
1	To gain the knowledge of static and dynamic equilibrium conditions of mechanisms	static and dynamic equilibrium	Force and Torque	Force	Understand and analysis	Analyse the mechanism subjected to forces and couples with and without friction
2	Analyse the mechanism subjected to forces and couples with and without friction	forces and couples	Balancing	Balancing of mass	Understand and analysis	To understand the balancing principles of rotating masses
2	Analyse the mechanism subjected to forces and couples with and without friction	forces and couples	Balancing	Balancing of mass	Understand and analysis	To understand the balancing principles of reciprocating masses

3	To understand the balancing principles of rotating masses	rotating masses	Speed, Direction	Speed	Understand and analysis	Abel to know to regulate the speed of the engine
3	To understand the balancing principles of rotating masses	rotating masses	Speed, Direction	Speed	Understand and analysis	To understand the stability of two wheeler and four wheelers
4	To understand the stability of two wheeler and four wheelers	Natural Frequency	Time period and Frequency	Natural Frequency	Understand and analysis	To understand the different types of vibration and simple harmonic motion
4	To understand the stability of two wheeler and four wheelers	Natural Frequency	Time period and Frequency	Natural Frequency	Understand and analysis	To understand the vibration characteristics of single degree of freedom systems
5	To understand the forced vibration with constant harmonic excitation and logarithmic decrement.	Damping coefficient	Damping	Damping coefficient	Understand and analysis	To understand the characterise the single degree freedom system subjected to free and forced vibration with and with out damping
5	To understand the forced vibration with constant harmonic excitation and logarithmic decrement.	Damping coefficient	Damping	Damping coefficient	Understand and analysis	To understand the forced vibration with constant harmonic excitation and logarithmic decrement.

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