JEPPIAAR ENGINEERING COLLEGE

Jeppiaar Nagar, Rajiv Gandhi Salai – 600 119

DEPARTMENT OF

MECHANICAL ENGINEERING

QUESTION BANK

V SEMESTER

ME6505 – Dynamicsof Machines

Regulation – 2013

JEPPIAAR ENGINEERING COLLEGE

Vision of Institution

To build Jeppiaar Engineering College as an institution of academic excellence in technological and management education to become a world class university.

Mission of Institution

- To excel in teaching and learning, research and innovation by promoting the principles of scientific analysis and creative thinking.
- To participate in the production, development and dissemination of knowledge and interact with national and international communities.
- To equip students with values, ethics and life skills needed to enrich their lives and enable them to meaningfully contribute to the progress of society.
- To prepare students for higher studies and lifelong learning, enrich them with the practical and entrepreneurial skills necessary to excel as future professionals and contribute to Nation's economy.

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**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.
PO3	**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
PO4	**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.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**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.
PO7	**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.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**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.
PO11	**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.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

JEPPIAAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

Vision of the Department

To create excellent professionals in the field of Mechanical Engineering and to uplift the quality of technical education on par with the International Standards.

Department Mission

1. **To reinforce** the fundamentals of Science and Mathematics to Mechanical Engineering **and critically and relatively investigate co**mplex mechanical systems and processes.
2. To engage in the **production, expansion and practice** of advanced engineering applications through knowledge sharing activities by interacting with global communities and industries.
3. To**equip** students with **engineering ethics, professional roles, corporate social responsibility** and life skills and **apply** them for the betterment of society.
4. **To promote** higher studies and lifelong learning and entrepreneurial skills and **develop** excellent professionals for empowering nation's economy.

PEO's

1. To **enrich** the technical knowledge of design, manufacturing and management of mechanical systems and **develop creative and analytical thinking** in research.
2. To **relate, strengthen and develop** the theoretical knowledge of the Mechanical Engineering by exhibiting various concepts applied through diverse industrial exposures and experts' guidance.
3. **Facilitate** the students to communicate effectively on complex social, professional and engineering activities with strict adherence to ethical principles.
4. **Create awareness for independent and life long learning and develop the ability to keep abreast of modern trends and adopt them for personal technological growth of the nation.**

PSO's

1. To understand the basic concept of various mechanical engineering field such as design, manufacturing, thermal and industrial engineering.
2. To apply the knowledge in advanced mechanical system and processes by using design and analysis techniques.
3. To develop student's professional skills to meet the industry requirements and entrepreneurial skills for improving nation's economy stronger.

ME6505- DYNAMICS OF MACHINES

COURSE OUTCOMES

C305.1	Students able to understand the force-motion relationship in components subjected to external forces and analysis of standard mechanisms
C305.2	Students able to determine the balanced and unbalanced forces, resulting motions obtained from various mechanisms.
C305.3	Students are able to understand and solve the free vibrations occuring at various conditions
C305.4	Students can understand the various methods to determine the forced vibration
C305.5	Students can able to understand working principles of various types of governors and applications of gyroscopic mechanism.

ME6505 DYNAMICS OF MACHINES L T P C

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UNIT I FORCE ANALYSIS 9

Dynamic force analysis – Inertia force and Inertia torque– D Alembert's principle –Dynamic Analysis in reciprocating engines – Gas forces – Inertia effect of connecting rod– Bearing loads – Crank shaft torque – Turning moment diagrams –Fly Wheels – Flywheels of punching presses- Dynamics of Cam follower mechanism.

UNIT II BALANCING 9

Static and dynamic balancing – Balancing of rotating masses – Balancing a single cylinder engine – Balancing of Multi-cylinder inline, V-engines – Partial balancing in engines – Balancing of linkages – Balancing machines-Field balancing of discs and rotors.

UNIT III SINGLE DEGREE FREE VIBRATION 9

Basic features of vibratory systems – Degrees of freedom – single degree of freedom – Free vibration – Equations of motion – Natural frequency – Types of Damping – Damped vibration– Torsional vibration of shaft – Critical speeds of shafts – Torsional vibration – Two and three rotor torsional systems.

UNIT IV FORCED VIBRATION 9

Response of one degree freedom systems to periodic forcing – Harmonic disturbances – Disturbance caused by unbalance – Support motion –transmissibility – Vibration isolation vibration measurement.

UNIT V MECHANISM FOR CONTROL 9

Governors – Types – Centrifugal governors – Gravity controlled and spring controlled centrifugal governors – Characteristics – Effect of friction – Controlling force curves. Gyroscopes –Gyroscopic forces and torques – Gyroscopic stabilization – Gyroscopic effects in Automobiles, ships and airplanes.

TOTAL : 45 PERIODS

TEXT BOOK:

1. Uicker, J.J., Pennock G.R and Shigley, J.E., "Theory of Machines and Mechanisms" ,3rd Edition, Oxford University Press, 2009.
2. Rattan, S.S, "Theory of Machines", 3rd Edition, Tata McGraw-Hill, 2009

REFERENCES:

1. Thomas Bevan, "Theory of Machines", 3rd Edition, CBS Publishers and Distributors, 2005.
2. Cleghorn. W. L, "Mechanisms of Machines", Oxford University Press, 2005
3. Benson H. Tongue, "Principles of Vibrations", Oxford University Press, 2nd Edition, 2007
4. Robert L. Norton, "Kinematics and Dynamics of Machinery", Tata McGraw-Hill, 2009.
5. Allen S. Hall Jr., "Kinematics and Linkage Design", Prentice Hall, 1961
6. Ghosh. A and Mallick, A.K., "Theory of Mechanisms and Machines", Affiliated East-West Pvt. Ltd., New Delhi, 1988.
7. Rao.J.S. and Dukkipati.R.V. "Mechanisms and Machine Theory", Wiley-Eastern Ltd., New
Delhi, 1992.
8. John Hannah and Stephens R.C., "Mechanics of Machines", Viva Low-Prices Student Edition, 1999.
9. Grover. G.T., "Mechanical Vibrations", Nem Chand and Bros., 1996
10. William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, "Theory of Vibration with Application", 5th edition, Pearson Education, 2011
11. V.Ramamurthi, "Mechanics of Machines", Narosa Publishing House, 2002.
12. Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005.

JEPPIAAR ENGINEERING COLLEGE

Jeppiaar Nagar, Rajiv Gandhi Salai – 600 119

DEPARTMENT OFMECHANICAL ENGINEERING

QUESTION BANK

Subject : ME6505 – Dynamics of Machines

Year / Sem : III / V

UNIT I FORCE ANALYSIS

Dynamic force analysis – Inertia force and Inertia torque– D Alembert's principle –Dynamic Analysis in reciprocating engines – Gas forces – Inertia effect of connecting rod– Bearing loads – Crank shaft torque – Turning moment diagrams –Fly Wheels – Flywheels of punching presses- Dynamics of Cam follower mechanism.

PART-A

CO Mapping :C305.1

Q.No.	Questions	BT Level	Competence	PO
1	Define free body diagram.	**BTL-1**	Remembering	**PO1, PO12**
2	What are the conditions for a body to be in static and dynamic equilibrium?	**BTL-1**	Remembering	**PO1, PO12**
3	Define static force analysis.	**BTL-1**	Remembering	**PO1, PO12**
4	Define Dynamic force analysis.	**BTL-1**	Remembering	**PO1, PO12**
5	When will the two force member is in equilibrium?	**BTL-1**	Remembering	**PO1, PO2, PO12**
6	Give any three advantages of free body diagrams.	**BTL-4**	Analyzing	**PO1, PO12**
7	When will the three force member is in equilibrium?	**BTL-1**	Remembering	**PO1, PO12**
8	State D'Alembert's principle.	**BTL-1**	Remembering	**PO1, PO2, PO12**
9	What is meant by turning moment diagram or crank effort diagram?	**BTL-1**	Remembering	**PO2, PO12**
10	Differentiate between static force analysis and dynamic force analysis.	**BTL-4**	Analyzing	**PO1, PO12**
11	What are the forces acting on the connecting rod?	**BTL-1**	Remembering	**PO2, PO3, PO12**
12	State the principle of virtual work.	**BTL-1**	Remembering	**PO1, PO12**
13	State the principle of superposition.	**BTL-1**	Remembering	**PO1, PO12**
14	Define Inertia forces.	**BTL-1**	Remembering	**PO1, PO12**
15	Define constraint force	**BTL-1**	Remembering	**PO1, PO12**
16	What is meant by correction couple?	**BTL-1**	Remembering	**PO1, PO12**
17	Explain the term Maximum Fluctuation of Energy.	**BTL-2**	Understanding	**PO1, PO12**
18	Define 'Inertia Torque'.	**BTL-1**	Remembering	**PO1, PO12**

Q.No.	Questions	BT Level	Competence	PO
19	Define 'Coefficient of Fluctuation of Energy'.	**BTL-1**	Remembering	**PO2, PO12**
20	Define 'Coefficient of Fluctuation of Speed'.	**BTL-1**	Remembering	**PO2, PO12**
21	Define Coefficient of Steadiness.	**BTL-1**	Remembering	**PO2, PO12**
22	How you will reduce a dynamic analysis problem into an equivalent problem of static equilibrium?	**BTL-1**	Remembering	**PO1, PO12**
23	What do you mean by Equivalent offset inertia force?	**BTL-1**	Remembering	**PO2, PO12**
24	What do you mean by crank effort or turning moment on the crank shaft?	**BTL-1**	Remembering	**PO1, PO12**
25	What do you understand by the fluctuation of energy in Fly wheel?	**BTL-1**	Remembering	**PO1, PO12**
26	Define shaking force.	**BTL-1**	Remembering	**PO2, PO12**
27	Differentiate the function of flywheel and governor.	**BTL-4**	Analyzing	**PO1, PO12**
28	What is meant by piston efforts and crank efforts.	**BTL-1**	Remembering	**PO1, PO12**
29	List out the few machines in which flywheel are used.	**BTL-1**	Remembering	**PO1, PO12**
30	What does 'float' or jump of a follower?	**BTL-1**	Remembering	**PO1, PO12**
31	Why smaller fly wheels are used in multi cylinder engines?	**BTL-1**	Remembering	**PO1, PO12**
32	Why negative loops are formed in turning moment diagrams?	**BTL-1**	Remembering	**PO1, PO12**
33	What is the function of a fly wheel in engines?	**BTL-1**	Remembering	**PO1, PO12**
PART-B&PART-C				
1	A petrol engine has a stroke of 120 mm and connecting rod is 3 times the crank length. The crank rotates at 1500 rpm clockwise direction. Determine 1. Velocity and acceleration of the piston and 2. Angular velocity and angular acceleration of the connecting rod, when the piston has traveled one-fourth of its stroke from I.D.C.	**BTL-5**	Evaluating	**PO1, PO2, PO12**
2	The ratio of the connecting rod length to crank length for a vertical petrol engine is 4:1. The bore/stroke is 80/100 mm and mass of the reciprocating part is 1 kg. The gas pressure on the piston is 0.7 N/mm2 when it has moved 10 mm from TDC on its power stroke. Determine the net load on the gudgeon pin. The engine runs at 1800 rpm at what engine speed will this load be zero.	**BTL-5**	Evaluating	**PO1, PO2, PO12**
3	The turning moment diagram for a four stroke gas engine may be assumed for simplicity to be represented by four triangles, the areas of which from the line of zero pressure are as follows: Expansion stroke = 3550 mm2; Exhaust stroke = 500 mm^2; Suction stroke = 350 mm2; and compression stroke = 1400 mm^2. each mm2 represents 3 N-m. Assuming the resisting moment to be uniform, find the mass of the rim of a fly wheel required to keep the mean speed 200 rpm within ±2%. The mean radius of the rim may be taken as 0.75 m. Also determine the crank positions for the maximum and minimum speeds.	**BTL-5**	Evaluating	**PO1, PO2, PO12**
4	During a trail on steam engine it is found that the acceleration of the piston is 36m/s^2 when the crank has moved 30º from the inner dead center position. The net effective steam pressure on the piston is 0.5MPa and the frictional resistance is equivalent to	**BTL-1**	Remembering	**PO1, PO2, PO12**

	force of 600 N, the diameter of the piston is 300 mm and the mass of the reciprocating parts is 180 kg. If the length of the crank is 300 mm and the ratio of the connecting rod length is 4.5 find (i) reaction on the guide bars (ii) thrust on the crank shafts bearings (iii) turning moment on the crank shaft.			
5	A single cylinder double acting steam engine develops 150 kW at mean speed of 80 rpm. The co efficient of fluctuations of energy is 0.1 and the fluctuations of speed are ± 2% of mean speed. If the mean diameter of the flywheel rim is 2m and the hub and spokes provide 5% of the rotational inertia of the flywheel. Find the mass and cross sectional area of the flywheel rim. Assume density of the flywheel material (cast iron) as 7200 kg/ m^3.	**BTL-1**	Remembering	**PO1, PO2, PO12**
6	(i) Derive the equation of force on the reciprocating parts of an engine, neglecting the weight of the connecting rod (ii) What is turning moment diagram and draw it four stroke IC engine?	**BTL-6** **BTL-1**	Creating Remembering	**PO1, PO2, PO12**

UNIT II BALANCING

Static and dynamic balancing – Balancing of rotating masses – Balancing a single cylinder engine – Balancing of Multi-cylinder inline, V-engines – Partial balancing in engines – Balancing of linkages – Balancing machines- Field balancing of discs and rotors.

PART-A

CO Mapping : C305.2

Q.No.	Questions	BT Level	Competence	PO
1	What is meant by balancing?	**BTL-1**	Remembering	**PO1, PO12**
2	Write the importance of balancing.	**BTL-5**	Evaluating	**PO1, PO12**
3	Mention any two practical examples of balancing.	**BTL-1**	Remembering	**PO1, PO12**
4	Write different types of balancing	**BTL-6**	Creating	**PO1, PO12**
5	What is static balancing?	**BTL-1**	Remembering	**PO1, PO12**
6	State the condition for static balancing.	**BTL-1**	Remembering	**PO1, PO12**
7	What is dynamic balancing?	**BTL-1**	Remembering	**PO1, PO12**
8	Write the conditions for complete balancing.	**BTL-1**	Remembering	**PO1, PO12**
9	State the condition for dynamic balancing.	**BTL-1**	Remembering	**PO1, PO12**
10	What do you understand by the term partial balancing?	**BTL-1**	Remembering	**PO1, PO12**
11	What is the effect of unbalanced primary force in a twin cylinder locomotive?	**BTL-1**	Remembering	**PO1, PO12**
12	Define Tractive force.	**BTL-1**	Remembering	**PO1, PO12**

Q.No.	Questions	BT Level	Competence	PO
13	Whether grinding wheels are balanced or not? If so why?	**BTL-1**	Remembering	**PO1, PO12**
14	Write the equations used to solve balancing of several masses rotating in a single plane.	**BTL-3**	Applying	**PO1, PO12**
15	Why complete balancing is not possible in reciprocating engine?	**BTL-1**	Remembering	**PO1, PO12**
16	Differentiate between the unbalanced force due to a reciprocating mass and that due to a revolving masses.	**BTL-4**	Analyzing	**PO1, PO12**
17	What are the conditions required for complete balancing of reciprocating parts?	**BTL-1**	Remembering	**PO1, PO12**
18	What are the effects of an unbalanced primary force along the line of stroke of two cylinder locomotive?	**BTL-1**	Remembering	**PO1, PO12**
19	What is swaying couple?	**BTL-1**	Remembering	**PO1, PO12**
20	What are in-line engines?	**BTL-1**	Remembering	**PO1, PO12**
21	What are the condition to be satisfied for complete balance of in-line engine?	**BTL-1**	Remembering	**PO1, PO12**
22	What are balancing machines?	**BTL-1**	Remembering	**PO1, PO12**
23	How the different masses rotating in different planes are balanced?	**BTL-4**	Analyzing	**PO1, PO12**
24	State the reason for positioning the cranks of a locomotive at right angles.	**BTL-1**	Remembering	**PO1, PO12**
25	Give the different types of balancing machines used in practice.	**BTL-1**	Remembering	**PO1, PO12**
26	Why the cranks of a locomotive are generally at right angles to one another?	**BTL-1**	Remembering	**PO1, PO2, PO12**
27	What is the effect of hammer blow and what is the cause of it?	**BTL-1**	Remembering	**PO1, PO12**
28	Write short notes on balancing of linkages.	**BTL-3**	Applying	**PO1, PO12**
29	Why radial engines are preferred?	**BTL-1**	Remembering	**PO1, PO12**
30	What are the effects of an unbalanced primary force along the line of stroke of two cylinder locomotive?	**BTL-1**	Remembering	**PO1, PO12**
31	Can a single cylinder engine be fully balanced? Why?	**BTL-1**	Remembering	**PO1, PO12**
32	Differentiate coupled and uncoupled locomotives.	**BTL-4**	Analyzing	**PO1, PO12**
33	Write any two advantages of coupling the wheels of a coupled locomotive.	**BTL-3**	Applying	**PO1, PO12**
34	What is the difference between balancing of rotating &reciprocating masses	**BTL-1**	Remembering	**PO1, PO12**

35	What do you mean by the term 'shaking force' and 'shaking moment'?	**BTL-1**	Remembering	**PO1, PO12**
PART-B&PART-C				
1	Three masses are attached to a shaft as follows: 10 kg at 90 mm radius, 15 kg at 120 mm radius and 9 kg at 150 mm radius. The masses are to be arranged so that the shaft is in complete balance. Determine the angular position of masses relative to 10 kg mass. All the masses are in the same plane.	**BTL-5**	Evaluating	**PO1, PO3, PO12**
2	A.B, C and D are four masses carried by a rotating shaft at radii 100, 125, 200 and 150mm respectively. The planes in which the masses revolve are spaced 600mm apart and the mass of B, C and D are 10kg, 5kg and 4kg respectively. Find the required mass a and the relative angular setting of the four masses so that the shaft shall be ib complete balance.	**BTL-1**	Remembering	**PO1, PO3, PO12**
3	A 90^0-V engine has two cylinders which are placed symmetrically. The two connecting rods operate a common crank. The length of connecting rods is 320mm each and crank radius of 80mm. the reciprocating mass per cylinder is 12kg. If the engine speed is 600 rpm, then find the resultant primary and resultant secondary forces. Also find the maximum resultant secondary force**.**	**BTL-1**	Remembering	**PO1, PO3, PO12**
4	The axes of the three cylinder air compressor are 120 º to one another and their connecting rod are coupled to a single crank. The length of each connecting rod is 240mm and the stroke is 160 mm. the reciprocating parts have a mass of 2.4 kg per cylinder. Determine the primary and secondary forces if the engine runs at 2000 rpm.	**BTL-5**	Evaluating	**PO1, PO3, PO12**
5	A shaft has tree eccentrics, each 75 mm diameter and 25 mm thick, machined in one piece with the shaft. The central planes of the eccentric are 60 mm apart. The distance of the centers from the axis of rotation are 12 mm,18 mm and 12 mm and their angular positions are 120o apart. The density of metal is 700 kg/m3. Find the amount of out-of-balance force and couple at 600 rpm. If the shaft is balanced by adding two masses at a radius 75 mm and at distance of 100 mm from the central plane of the middle eccentric, find the amount of the masses and their angular positions.	**BTL-1**	Remembering	**PO1, PO3, PO12**
6	The cranks of a three-cylinder locomotive are set at 120o. The reciprocating masses are 450 kg for the inside cylinder and 390 kg for each outside cylinder. The pitch of the cylinder is 1.2 m and the stroke of each piston 500 mm. The planes of rotation of the balance masses are 960 mm from the inside cylinder. If 40% of the reciprocating masses are to be balanced, determine 1. The magnitude and the position of the balancing masses required at a radial distance of 500 mm; and 2. The hammer blow per wheel when the axle rotates at 350 rpm.	**BTL-5**	Evaluating	**PO1, PO3, PO12**

UNIT III SINGLE DEGREE FREE VIBRATION

Basic features of vibratory systems – Degrees of freedom – single degree of freedom – Free vibration – Equations of motion – Natural frequency – Types of Damping – Damped vibration– Torsional vibration of shaft – Critical speeds of shafts – Torsional vibration – Two and three rotor torsional systems.

PART-A

CO Mapping : C305.3

Q.No.	Questions	BT Level	Competence	PO
1	Define vibration.	**BTL-1**	Remembering	**PO1, PO12**
2	Vibration can have desirable effects – justify	**BTL-5**	Evaluating	**PO1, PO12**
3	How do you classify vibration? (or) What are the different types of vibrations?	**BTL-1**	Remembering	**PO1, PO12**
4	What is meant by free vibration?	**BTL-1**	Remembering	**PO1, PO12**
5	What do you meant by damping and damped vibration?	**BTL-1**	Remembering	**PO1, PO12**
6	Define followings.	**BTL-1**	Remembering	**PO1, PO12**
7	Define followings.	**BTL-1**	Remembering	**PO1, PO12**
8	What do you mean by a degree of freedom or movability?	**BTL-1**	Remembering	**PO1, PO12**
9	Define steady state and transient state vibrations.	**BTL-1**	Remembering	**PO1, PO12**
10	What do you mean by the term – Equivalent spring stiffness?	**BTL-1**	Remembering	**PO1, PO2, PO12**
11	List out the various methods of finding the natural frequency of free longitudinal vibrations.	**BTL-1**	Remembering	**PO1, PO3, PO12**
12	Distinguish between critical damping and large damping.	**BTL-4**	Analyzing	**PO1, PO12**
13	When do you say a vibrating system is under damped?	**BTL-1**	Remembering	**PO1, PO12**
14	Write the expression for the estimation of the natural frequency of free torsional vibration of a shaft.	**BTL-5**	Evaluating	**PO1, PO12**
15	Define Vibration Isolation.	**BTL-1**	Remembering	**PO1, PO12**
16	What is the principle of Rayleigh's method of finding naturalfrequencyofvibrations?	**BTL-1**	Remembering	**PO1, PO4, PO12**
17	Define critical or whirling or whipping speed of a shaft.	**BTL-1**	Remembering	**PO1, PO12**
18	What are the factors that affect the critical speed of a shaft?	**BTL-1**	Remembering	**PO1, PO12**
19	What are the causes of critical speed?	**BTL-1**	Remembering	**PO1, PO12**
20	Define Damping ratio.	**BTL-1**	Remembering	**PO1, PO12**
21	Define logarithmic decrement.	**BTL-1**	Remembering	**PO1, PO12**
22	What do you know about inertia effect of the mass of spring in longitudinal vibration?	**BTL-1**	Remembering	**PO1, PO12**
23	In a geared system, what assumptions to be made before replacing it with an equivalent system.	**BTL-4**	Analyzing	**PO1, PO12**
24	What is the condition of a system to vibrate?	**BTL-1**	Remembering	**PO1, PO12**
25	What is harmonic forcing?	**BTL-1**	Remembering	**PO1, PO12**
26	What is meant by *periodic forcing*?	**BTL-1**	Remembering	**PO1, PO12**

Q.No.	Questions	BT Level	Competence	PO
27	What is the response of the complete periodic forcing?	**BTL-1**	Remembering	**PO1, PO12**
28	What is Forced- Damped vibrations?	**BTL-1**	Remembering	**PO1, PO12**
29	What all are the factors upon which the magnification factor depends on?	**BTL-1**	Remembering	**PO1, PO12**
30	When will the maximum amplitude of vibration occur?	**BTL-1**	Remembering	**PO1, PO3, PO12**
31	In a system the dampers should not be used, When?	**BTL-1**	Remembering	**PO1, PO3, PO12**
	PART-B & PART-C			
Q.No.	**Questions**	**BT Level**	**Competence**	**PO**
1	Determine the equivalent spring stiffness and the natural frequency of the following vibrating systems when a) the mass is suspended to a spring b) the mass is suspended at the bottom of two springs in series c) the mass is fixed in between two springs d) the mass is fixed to the midpoint of a spring	**BTL-5**	Evaluating	**PO1, PO3, PO12**
2	A vibrating system consists of a mass of 50 kg, a spring of stiffness 30 kN/m and a damper. The damping provided is only 20 % of the critical value. Determine 1. the damping factor 2. the critical damping coefficient 3. the natural frequency of damped vibrations 4. the logarithmic decrement 5. the ratio of two consecutive amplitudes.	**BTL-5**	Evaluating	**PO1, PO3, PO12**
3	The machine mounted on springs and fitted with a dashpot has a mass of 60 kg. There are three springs, each of stiffness 12 N/mm. The amplitude of vibrations reduces from 45 to 8 mm in two complete oscillations. Assuming that the damping force varies as the velocity, determine i) the damping coefficient, ii) the ratio of frequencies of damped and undamped vibrations, and iii) the periodic time of damped vibrations.	**BTL-5**	Evaluating	**PO1, PO4, PO12**
4	Determine the (i) the critical damping co-efficient (ii) the damping factor, (iii) the natural frequency of damped vibrations (iv) the logarithmic decrement and (v) the ratio of two consecutive amplitudes of a vibrating system which consists of a mass of 25 kg, a spring of stiffness 15 kN/m and a damper. The damping provided is only 15 % of the critical value.	**BTL-5**	Evaluating	**PO1, PO3, PO12**
5	A shaft of length 1.25 m is 75 mm in diameter for the first 275 mm of its length, 125 mm in diameter for the next 500 mm length, 87.5 mm in diameter for the next 375 mm length and 175 mm in diameter for the remaining 100mm of its length. The shaft carries two rotors at two ends. The mass moment of inertia of the first rotor is 75 kg-m^2 whereas of the second rotor is 50 kg-m^2. Find the frequency of natural torsional vibrations of the system. The modulus of rigidity of the shaft material may be taken as 80 Gpa.	**BTL-1**	Remembering	**PO1, PO3, PO12**
6	(i) A machine weighs 18 kg and is supported on spring and dashpots. The total of the spring is 12 N/mm and damping is 0.2	**BTL-5**	Evaluating	**PO1, PO3, PO12**

	N/mm/s. the system is initially at rest and a velocity of 120 mm/s is imported to the mass. Determine (i) the displacement and velocity of mass as a function of time, and the displacement velocity after 0.4 sec (ii) Describe the types of vibrations with simple sketch.			

UNIT IV FORCED VIBRATION

Response of one degree freedom systems to periodic forcing – Harmonic disturbances –Disturbance caused by unbalance – Support motion –transmissibility – Vibration isolation vibration measurement.

PART-A

CO Mapping : C305.4

Q.No.	Questions	BT Level	Competence	PO
1	What is meant by Forced vibrations?	**BTL-1**	Remembering	**PO1, PO12**
2	Define Torsional vibration	**BTL-1**	Remembering	**PO1, PO12**
3	Differentiate between transverse and torsional vibration.	**BTL-4**	Analyzing	**PO1, PO12**
4	What is meant by dynamic magnifier or magnification factor?	**BTL-1**	Remembering	**PO1, PO12**
5	Define torsional equivalent shaft.	**BTL-1**	Remembering	**PO1, PO12**
6	Define transmissibility ratio or isolation factor.	**BTL-1**	Remembering	**PO1, PO12**
7	Briefly explain elastic suspension.	**BTL-2**	Understanding	**PO1, PO12**
8	What are the methods of isolating the vibration?	**BTL-1**	Remembering	**PO1, PO12**
9	Specify any two industrial application where the transmissibility effects of vibration are important.	**BTL-1**	Remembering	**PO1, PO12**
10	Define node in torsional vibration.	**BTL-1**	Remembering	**PO1, PO12**
11	What is free torsional vibration of a single rotor system?	**BTL-1**	Remembering	**PO1, PO12**
12	What do you know by multifilar systems?	**BTL-1**	Remembering	**PO1, PO12**
13	What is bifilar suspension?	**BTL-1**	Remembering	**PO1, PO12**
14	What is Trifilar suspension?	**BTL-1**	Remembering	**PO1, PO12**
15	Explain briefly about free torsional vibrations in a Two – Rotor system.	**BTL-2**	Understanding	**PO1, PO12**
16	Explain briefly about free torsional vibrations in a Three – Rotor system.	**BTL-2**	Understanding	**PO1, PO12**
17	What do you understand by two – node frequency?	**BTL-1**	Remembering	**PO1, PO12**
18	What do you understand by single – node frequency?	**BTL-1**	Remembering	**PO1, PO12**
19	How will you find the frequency of rotors are fixed to a shaft of various diameters at different sections?	**BTL-1**	Remembering	**PO1, PO12**
20	Write down the assumptions in the geared system to be replaced by an equivalent shaft system?	**BTL-1**	Remembering	**PO1, PO12**

Q.No.	Questions	BT Level	Competence	PO
21	What is meant by dynamic magnifier or magnification factor?	**BTL-1**	Remembering	**PO1, PO12**
22	What is meant by "Transmissibility?	**BTL-1**	Remembering	**PO1, PO12**
23	A vibrating system consist of a mass of 7Kg and a spring stiffness 50N/cm and damper of damping coefficient 0.36Ncm^{-1}sec. Find damping factor.	**BTL-1**	Remembering	**PO1, PO12**
24	Briefly explain elastic suspension.	**BTL-2**	Understanding	**PO1, PO12**
25	Specify the importance of vibration isolation?	**BTL-5**	Evaluating	**PO1, PO12**
26	What are the methods of isolating the vibration?	**BTL-1**	Remembering	**PO1, PO12**
27	Define frequency response curve.	**BTL-1**	Remembering	**PO1, PO12**
28	Define Damping ratio.	**BTL-1**	Remembering	**PO1, PO12**
29	Define Whirling speed.	**BTL-1**	Remembering	**PO1, PO12**
30	Differentiate between transverse and torsional vibration.	**BTL-4**	Analyzing	**PO1, PO12**
31	What are the conditions to be satisfied for an equivalent system to that of geared system in torsional vibrations?	**BTL-1**	Remembering	**PO1, PO12**
PART-B& PART-C				
1	A single cylinder vertical petrol engine has a mass of 200 kg and is mounted upon a steel chassis frame. The vertical static deflection of the frame is 2.4 mm due to the weight of the engine. The reciprocating part of the engine has a mass of 9 kg and move through a vertical stroke of 160 mm with simple harmonic motion. A dashpot with a damping co efficient of 1N/mm/s is also used to dampen the vibrations considering that the steady state of vibration is reached, determine (i) Amplitude of the forced vibration if the driving shaft rotates at 500 rpm (ii) The speed of the driving shaft at which resonance will occur	**BTL-5**	Evaluating	**PO1, PO3, PO12**
2	(i)Derive the relation for the displacement of mass from the equilibrium position of a damped vibration system with harmonic forcing (ii)Define the term vibrating isolation.	**BTL-6** **BTL-1**	Creating Remembering	**PO1, PO3, PO12**
3	(i) Discuss the forcing due to support motion. (ii) What is mean by magnification factor in case of forced vibrations?	**BTL-6** **BTL-1**	Creating Remembering	**PO1, PO3, PO12**
4	A shaft supported freely at the ends has a mass of 120 kg placed 250 mm from one end. Determine the frequency of the natural transverse vibrations if the length of the shaft is 700 mm, E = 200 GN/m2 and shaft diameter is 40 mm.	**BTL-5**	Evaluating	**PO1, PO3, PO12**
5	A shaft 40 mm diameter and 2.5 m long has a mass of 15 kg per meter length. It is simply supported at the ends and carries three masses 90 kg, 140 kg and 60 kg at 0.8 m, 1.5 m and 2 m respectively from the left support. Taking E = 200 GN/m2, find the frequency of the transverse vibrations.	**BTL-1**	Remembering	**PO1, PO3, PO12**
6	The following data relate to a shaft held in long	**BTL-5**	Evaluating	**PO1, PO3, PO12**

	bearings. Length of shaft = 1.2 m Diameter of shaft = 14, Mass of a rotor at midpoint = 16 kg, Eccentricity of center of mass of rotor from center of rotor = 0.4 mm Modulus of elasticity of shaft material = 200 GN/m2 Permissible stress in shaft material = 70 X 106 N/m2 Determine the critical speed of the shaft and the range of speed over which it is unsafe to run the shaft. Assume the shaft to be mass less.			

UNIT V MECHANISM FOR CONTROL

Governors – Types – Centrifugal governors – Gravity controlled and spring controlled centrifugal governors – Characteristics – Effect of friction – Controlling force curves. Gyroscopes –Gyroscopic forces and torques – Gyroscopic stabilization – Gyroscopic effects in Automobiles, ships and airplanes.

PART-A

CO Mapping : C305.5

Q.No.	Questions	BT Level	Competence	PO
1	Explain the function of governor.	**BTL-2**	Understanding	**PO1, PO12**
2	What is the principle of working of centrifugal governor?	**BTL-1**	Remembering	**PO1, PO12**
3	Differentiate between governor and flywheel?	**BTL-4**	Analyzing	**PO1, PO12**
4	What is the principle of inertia governors?	**BTL-1**	Remembering	**PO1, PO12**
5	What is equilibrium speed?	**BTL-1**	Remembering	**PO1, PO12**
6	What is governor?	**BTL-1**	Remembering	**PO1, PO12**
7	Explain controlling force?	**BTL-2**	Understanding	**PO1, PO12**
8	Explain the governor effort	**BTL-2**	Understanding	**PO1, PO12**
9	Define power of a governor	**BTL-1**	Remembering	**PO1, PO12**
10	Define coefficient of sensitiveness.	**BTL-1**	Remembering	**PO1, PO12**
11	What is meant by hunting?	**BTL-1**	Remembering	**PO1, PO12**
12	Explain the term stability of the governor?	**BTL-2**	Understanding	**PO1, PO12**
13	Explain Isochronism.	**BTL-2**	Understanding	**PO1, PO12**
14	Explain sensitiveness of governors.	**BTL-2**	Understanding	**PO1, PO12**
15	Give the applications of gyroscopic principle.	**BTL-1**	Remembering	**PO1, PO12**
16	Define steering, pitching and rolling.	**BTL-1**	Remembering	**PO1, PO12**
17	What is gyroscopic Torque or couple?	**BTL-1**	Remembering	**PO1, PO12**
18	Explain gyroscopic couple.	**BTL-2**	Understanding	**PO1, PO12**
19	What is meant by lag in response?	**BTL-1**	Remembering	**PO1, PO12**
20	What is controlling force diagram?	**BTL-1**	Remembering	**PO1, PO12**
21	Why there is no effect of the gyroscopic couple acting on the body of a ship during rolling?	**BTL-1**	Remembering	**PO1, PO12**
22	What is meant by lag in response?	**BTL-1**	Remembering	**PO1, PO12**
23	What is sleeve lift?	**BTL-1**	Remembering	**PO1, PO12**
24	High sensitiveness is undesirable for a governor. Validate this statement.	**BTL-5**	Evaluating	**PO1, PO12**
25	Stability and sensitiveness are two opposite	**BTL-1**	Remembering	**PO1, PO12**

	characteristics. Justify.			
26	Mention any two advantages of using spring loaded governors in the place of gravity controlled governors.	**BTL-1**	Remembering	**PO1, PO12**
27	When the engine is the above case rotates in clockwise then what is the effect of reactive gyroscopic couple?	**BTL-1**	Remembering	**PO1, PO12**
28	Explain the principle of gyroscope.	**BTL-2**	Understanding	**PO1, PO12**
29	When the aeroplane in the above case runs right, with other conditions kept same then what is the effect of reactive gyroscopic couple?	**BTL-1**	Remembering	**PO1, PO12**
30	What is the effect of gyroscope on rolling of ship?	**BTL-1**	Remembering	**PO1, PO12**
31	Write short notes on stability of an automobile.	**BTL-1**	Remembering	**PO1, PO12**
32	State the conditions for stability of a two wheeler.	**BTL-1**	Remembering	**PO1, PO12**
33	What are the types of Automatic control of systems?	**BTL-1**	Remembering	**PO1, PO12**
34	What are the terminologies used in Automatic control of systems?	**BTL-1**	Remembering	**PO1, PO12**
35	What is the effect of friction on the governors?	**BTL-1**	Remembering	**PO1, PO12**
PART-B& PART-C				
1	Calculate the minimum speed, maximum speed and range of the speed of a porter governor, which has equal arms each 200 mm long and pivoted on the axis of rotation. The mass of each ball is 4 kg and the central mass of the sleeve is 20 kg. the radius of the rotation of the ball is 100 mm when the governor begins to lift and 130 mm when the governor is at maximum speed**.**	**BTL-5**	Evaluating	**PO1, PO3, PO12**
2	The turbine rotor of a ship has a mass of 3500 kg. it has a radius of gyration of 0.45 m and a speed of 3000 rpm clockwise when looking from stern. Determine the gyroscopic couple and its effect upon the ship: (i) When the ship is steering to the left on a curve of 100m radius at a speed of 36kmph (ii) When the ship is pitching in a simple harmonic motion the bow falling with its maximum velocity the period of pitching is 40 sec and the total angular displacement between the two extreme positions of pitching is 12º	**BTL-5**	Evaluating	**PO1, PO3, PO12**
3	(i) Explain the functions of a proell governor with the help of a neat sketch. Derive the relationship among the various forces acting on the ling (ii) What are the centrifugal governors? How do they differ from inertia governors?	**BTL-2** **BTL-1**	Understanding Remembering	**PO1, PO3, PO12**
Q.No.	**Questions**	**BT Level**	**Competence**	**PO**
4	Each arm of a Porter governor is 250 mm long. The upper and lower arms are pivoted to links of 40 mm and 50 mm respectively from the axis of rotation. Each ball has a mass of 5 kg and the sleeve mass is 50 kg. The force of friction on the sleeve of the mechanism is 40 N. Determine the range of speed of the governor for extreme radii of rotation of 125 mm and 150 mm.	**BTL-5**	Evaluating	**PO1, PO3, PO12**

5	The mass of each ball of a Proell governor is 7.5 kg and the load on the sleeve is 80 kg. Each of the arms is 300 mm long. The upper arms are pivoted on the axis of rotation whereas the lower arms are pivoted to links of 40 mm from the axis of rotation. The extensions of the lower arms to which the balls are attached are 100 mm long and are parallel to the governor axis at the minimum radius. Determine the equilibrium speeds corresponding to extreme radii of 180 mm and 240 mm.	**BTL-5**	Evaluating	**PO1, PO3, PO12**
6	In a spring loaded Hartnell type of governor, the mass of each ball is 4 kg and the lift of the sleeve is 40 mm. The governor begins to float at 200 rpm when the radius of the ball path is 90 mm. The mean working speed of the governor is 16 times the range of speed when friction is neglected. The lengths of the ball and roller arms of the bell-crank lever are 100 mm and 80 mm respectively. The pivot centre and the axis of governor are 115 mm apart. Determine the initial compression of the spring, taking into account the obliquity of arms. Assuming the friction at the sleeve to be equivalent to a force of 15 N, determine the total alteration in speed before the sleeve begins to move from the mid- position	**BTL-5**	Evaluating	**PO1, PO3, PO12**

UNIT I FORCE ANALYSIS

Dynamic force analysis – Inertia force and Inertia torque– D Alembert's principle –Dynamic Analysis in reciprocating engines – Gas forces – Inertia effect of connecting rod– Bearing loads – Crank shaft torque – Turning moment diagrams –Fly Wheels – Flywheels of punching presses- Dynamics of Cam follower mechanism.

PART-A

1. Define free body diagram (AU Jun 2009, May 2005)

A free body diagram is a sketch of the isolated or free body which shows all the pertinent weight forces, the externally applied loads, and the reaction from its supports and connections acting upon it by the removed elements.

2.What are the conditions for a body to be in static and dynamic equilibrium? (AU Jun 2006)

Necessary conditions for static and dynamic equilibrium are

i) Vector sum of all forces acting on a body is zero.

ii) The vector sum of the moments of all forces acting about any arbitrary point or axis is zero.

3.Define static force analysis. (AU May 2012, 2013)

If components of a machine accelerate, inertia is produced due to their masses. However, the magnitudes of these forces are small compared to the externally applied loads. Hence inertia effects due to masses are neglected. Such an analysis is known as static force analysis.

4.Define Dynamic force analysis. (AU May 2012)

If components of a machine accelerate by the applied forces (F), inertia force (-ma) is produced due to their masses. Even though the magnitudes of these forces are small as compared to the externally applied loads, if we do force analysis of machine considering the inertia forces in addition to all applied forces, then the force analysis is called Dynamic force analysis.

5.When will the two force member is in equilibrium? (AU May 2014)

The member under the action of two force will be in equilibrium if

i) The two forces are of same magnitude.

ii) The forces act along the same line.

iii) The forces are in opposite direction.

6.Give any three advantages of free body diagrams.

i. Free body diagram assist in seeing and understanding all aspects of problem.
ii. They help in planning the approach to the problem.
iii. They make mathematical relations easier to the problem.

7.When will the three force member is in equilibrium?

i)A body or member will be in equilibrium under the action of three forces if the resultant of the forces is zero, and ii) the line of action of the forces intersect at a point

8.State D'Alembert's principle. (AU Dec 2006, 2011, 2015, May 2016)

i) It states that the inertia forces and torques, and the external forces and torques acting on a body together result in static equilibrium.
ii) In other words, the vector sum of all external forces and inertia forces acting upon a system of rigid bodies is also separately zero.

9.What is meant by turning moment diagram or crank effort diagram?

a. It is the graphical representation of the turning moment or crank effort for various position of the crank.
b. In turning moment diagram, the turning moment is taken as the ordinate (y-axis) and crank angle as abscissa(x-axis).

10.Differentiate between static force analysis and dynamic force analysis.

Static force analysis:

If components of a machine accelerate, inertia is produced due to their masses. However, the magnitudes of these forces are small compared to the externally applied loads. Hence inertia effects due to masses are neglected. Such an analysis is known as static force analysis.

Dynamic force analysis:

If the inertia effect due to the mass of the component is also considered, it is called dynamic force analysis.

11.What are the forces acting on the connecting rod?

a.Inertia force of the reciprocating parts acting along the line of stroke
b.The side thrust between the cross head and the guide bars acting at P and right angles to line of stroke
c.Weight of the connecting rod
d.Inertia force of the connecting rod
e.The radial force parallel to crank, and
f.The tangential force acting perpendicular to crank.

12.State the principle of virtual work. (AU May 2015)

It states that if a system is in equilibrium and undergoes an infinitesimal displacement from its equilibrium position without any lapse of time then the net work done is equal to zero.

13.State the principle of superposition. (AU May 2013)

It states that in linear systems, if a number of forces act on a member, the net effect is equal to the superposition of the effects of the individual forces taken one at a time.

14.Define Inertia forces. (AU Dec 2004, Apr 2015)

The inertia force is an imaginary force, which when acts upon a rigid body, brings it in an equilibrium position.

i. Inertia force = -Accelerating force = m.a.

15.Define constraint force

It is a pull or push, which acts on a body changes or tends to change, the state of rest or of uniform motion of the body. A force is completely characterized by its point of application, its magnitude and direction.

16.What is meant by correction couple?

If the two masses are placed orbitrarily in a rigid body, an error in torque is introduced. To make the

system dynamically equivalent a couple should be applied. This couple is called correction couple. The value of correction couple is always positive and its direction will be the same as that of angular acceleration 'α'.

17.Explain the term Maximum Fluctuation of Energy. (AU Dec 2003)

The difference between the maximum and minimum energies is known as the maximum fluctuation of energy.

18.Define 'Inertia Torque'.

The inertia torque is an imaginary torque, which when applied upon the rigid body, brings it in an equilibrium position. It is equal to the accelerating couple in magnitude but opposite in direction.

19.Define 'Coefficient of Fluctuation of Energy'. (AU Dec 2015, May 2014)

It is defined as the ratio between the maximum fluctuation of energy (ΔE) and the work done per cycle.

C_E = ΔE / Work done per cycle

20.Define 'Coefficient of Fluctuation of Speed'. (AU May 2014)

It is defined as the ratio of maximum fluctuation speed to the mean speed.

$$C_S = (N_1 - N_2) / N$$

where,

N_1& N_2 - Maximum & Minimum speed in rpm

N - Mean Speed in rpm - $(N_1 + N_2)/2$

21.Define Coefficient of Steadiness.

The reciprocal of the coefficient of fluctuation of speed is known as Coefficient of steadiness. $m = 1 / C_S$

22.How you will reduce a dynamic analysis problem into an equivalent problem of static equilibrium?

By applying D'Alembert's principle ($\Sigma F + (-ma) = 0, \Sigma T + (-I\alpha) = 0$) to a dynamic analysis problem, we can reduce into an equivalent problem of static equilibrium.

23.What do you mean by Equivalent offset inertia force?

Equivalent offset inertia force is the force which can replace both inertia force and inertia torque.

24.What do you mean by crank effort or turning moment on the crank shaft?

It is the product of the crank-pin effort (F_T) and crank pin radius (r). $T = F_T * r$

25.What do you understand by the fluctuation of energy in Fly wheel?

The difference between the maximum and the minimum energies in Turning moment diagram is known as ***Fluctuation of energy.***

26.Define shaking force. (AU Nov 2013)

A net unbalanced force acting on the frame of machine or mechanism is know as shaking force

27.Differentiate the function of flywheel and governor. (AU Dec 2012,2011)

S.No	Flywheel	Governor
1	Flywheel used is to reduce the fluctuation of speed during a cycle above and below the mean value for constant load from prime mover	Governor is used to control the mean speed over a period for output load variations
2	Flywheel works continuously from cycle to cycle	Governor works intermittently, i.e. only when there is change in the load.
3	Flywheel has no influence on mean speed of the prime move	Governor has no influence over cycle speed fluctuations.

28.What is meant by piston efforts and crank efforts.(AU Dec 2012,2013, May 2016)

Piston effort: it is the net force applied on the piston along the line of stroke.

Crank effort: it is the net force applied on the crank pin perpendicular to the crank which gives the required turning moment on the crank shafts.

29.List out the few machines in which flywheel are used.

1.Punching machines 2.Shearing machines

3.Riveting machines 4.Crushing machines.

30.What does 'float' or jump of a follower?

The stored energy in a camshaft due to windup phenomenon which occurs because of variations in torque gets released at the end of follower rise. This results in undue variation of velocity and acceleration of the follower. This phenomenon is called 'Jump' or 'Float'

31.Why smaller fly wheels are used in multi cylinder engines?

In multi cylinder engine more than one power stroke is produced per second. So the need to store energy in flywheel is lesser than single cylinder engines. This leads to smaller flywheel for multi cylinder engines.

32.Why negative loops are formed in turning moment diagrams?

During strokes other than power stroke, flywheel losses energy, negative loops are formed in turning moment diagram. This indicates more energy than produced is being taken from flywheel to do work absorbing processes.

33.What is the function of a fly wheel in engines? (AU Dec 2011, 2012, 2014)

Fly wheel acts as a reservoir. It absorbs some portion of energy while power stroke and delivers it in all other strokes in an Engine.

PART-B

1. A petrol engine has a stroke of 120 mm and connecting rod is 3 times the crank length. The crank rotates at 1500 rpm clockwise direction. Determine 1. Velocity and acceleration of the piston and 2. Angular velocity and angular acceleration of the connecting rod, when the piston has traveled one-fourth of its stroke from I.D.C. (Dec 2003)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:528*

2The ratio of the connecting rod length to crank length for a vertical petrol engine is 4:1. The bore/stroke is 80/100 mm and mass of the reciprocating part is 1 kg. The gas pressure on the piston is 0.7 N/mm2 when it has moved 10 mm from TDC on its power stroke. Determine the net load on the gudgeon pin. The engine runs at 1800 rpm at what engine speed will this load be zero. (Nov 2007)*Refer:* "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No: 537*

3The turning moment diagram for a four stroke gas engine may be assumed for simplicity to be represented by four triangles, the areas of which from the line of zero pressure are as follows: Expansion stroke = 3550 mm2; Exhaust stroke = 500 mm2; Suction stroke = 350 mm2; and compression stroke = 1400 mm2. each mm2 represents 3 N-m. Assuming the resisting moment to be uniform, find the mass of the rim of a fly wheel required to keep the mean speed 200 rpm within ±2%. The mean radius of the rim may be taken as 0.75 m. Also determine the crank positions for the maximum and minimum speeds. (Dec 2010)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No: 584*

4. During a trail on steam engine it is found that the acceleration of the piston is 36m/s^2 when the crank has moved 30^o from the inner dead center position. The net effective steam pressure on the piston is 0.5MPa and the frictional resistance is equivalent to force of 600 N, the diameter of the piston is 300 mm and the mass of the reciprocating parts is 180 kg. If the length of the crank is 300 mm and the ratio of the connecting rod length is 4.5 find (i) reaction on the guide bars (ii) thrust on the crank shafts bearings (iii) turning moment on the crank shaft. (Nov 2015)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No: 536*

5. A single cylinder double acting steam engine develops 150 kW at mean speed of 80 rpm. The co efficient of fluctuations of energy is 0.1 and the fluctuations of speed are ± 2% of mean speed. If the mean diameter of the flywheel rim is 2m and the hub and spokes provide 5% of the rotational inertia of the flywheel. Find the mass and cross sectional area of the flywheel rim. Assume density of the flywheel material (cast iron) as 7200 kg/ m^3. (Nov 2015)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No: 594*

6. (i) Derive the equation of force on the reciprocating parts of an engine, neglecting the weight of the connecting rod

(ii) What is turning moment diagram and draw it four stroke IC engine? (Nov-2013)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:529,567*

UNIT II BALANCING

Static and dynamic balancing – Balancing of rotating masses – Balancing a single cylinder engine – Balancing of Multi-cylinder inline, V-engines – Partial balancing in engines – Balancing of linkages – Balancing machines-Field balancing of discs and rotors.

PART-A

1. What is meant by balancing? (AU Nov 2013)

Balancing is the process of designing or modifying machinery so that unbalance is reduced to an acceptable level and if possible is eliminated entirely.

2.Write the importance of balancing.

If the moving part of a machine are not balanced completely then the inertia forces are set up which may cause excessive noise, vibration, wear and tear of the system. So, balancing of machine is necessary.

3.Mention any two practical examples of balancing.

The practical examples for balancing are

1. Automobile wheels 2. Watch needles

4.Write different types of balancing.

i) Balancing of rotating masses

(a) Static balancing (b) Dynamic balancing

ii) Balancing of reciprocating masses.

5.What is static balancing? (AU Dec 2015, May 2016)

A system of rotating masses is said to be in static balance if the combined mass centre of the system lies on the axis rotation.

6.State the condition for static balancing. (AU Nov 2011, May 2016)

The net dynamic force acting on the shaft is equal to zero or the centre of the masses of the system must lie on the axis of rotation.

7.What is dynamic balancing? (AU Jun 2009)

A system of rotating masses is said to be in dynamic balance if there does not exist any resultant centrifugal force as well as resultant couple.

8.Write the conditions for complete balancing. (AU May 2014)

a. The resultant centrifugal force must be zero
b. The resultant couple must be zero.

9.State the condition for dynamic balancing. (AU Nov 2011, 2012)

Condition for dynamic balancing

a.The net dynamic force acting on the shaft is equal to zero or the centre of the masses of the system must lie on the axis of rotation.

b.The net couple due to the dynamic force acting on the shaft is equal to zero or the algebraic sum of the moments about any point in the plane must be zero.

10.What do you understand by the term *partial balancing?* (AU Dec 2003)

In a reciprocating engine, the provision of a rotating counter mass results in only a partial balance, as onevertical component of rotating mass remains unchecked. This is called partial balancing.

11.What is the effect of unbalanced primary force in a twin cylinder locomotive?

The unbalanced primary force along the line of storke results in

a. Variation of tractive force b. Swaying couple.

The unbalanced primary force perpendicular to the line of stroke results in pressure variations leading to *hammer blow*

12.Define Tractive force. (AU May 2014) In a twin cylinder locomotive, the resultant unbalanced primary force due to both the cylinders, acting along the line of stroke is known as Tractive force.

13.Whether grinding wheels are balanced or not? If so why?

Yes, the grinding wheels are properly balanced by inserting some low density materials. If not, the required surface finish won't be attained and the vibration will cause much noise.

14.Whether grinding wheels are balanced or not? If so why?

Yes, the grinding wheels are properly balanced by inserting some low density materials. If not, the required surface finish won't be attained and the vibration will cause much noise.

15.Why complete balancing is not possible in reciprocating engine? (AU May 2012 2013)

Balancing of reciprocating masses is done by introducing the balancing mass opposite to the crank. The vertical component of the dynamic force of this balancing mass gives rise to "Hammer blow". In order to reduce the Hammer blow, a part of the reciprocating mass is balanced. Hence complete balancing is not possible in reciprocating engines.

16.Differentiate between the unbalanced force due to a reciprocating mass and that due to a revolving masses.

i.Complete balancing of revolving mass can be possible. But fraction of reciprocating mass only balanced.

ii.The unbalanced force due to reciprocating mass varies in magnitude but constant in direction. But in the case of revolving masses, the unbalanced force is constant in magnitude but varies in direction.

17.What are the conditions required for complete balancing of reciprocating parts? (AU Nov 2014)

i. Primary and secondary force polygon must be closed
ii. Primary and secondary couple polygon must be closed

18.What are the effects of an unbalanced primary force along the line of stroke of two cylinder locomotive?

i)Variation in Tractive force along the line of stroke, and ii. Swaying couple.
iii) Hammer Blow

19.What is swaying couple? (AU Nov 2014)

The unbalanced force acting at a distance between the line of stroke of two cylinders, constitute a couple in the horizontal direction. This couple is known as swaying couple

20.What are in-line engines?

Multi-cylinder engines with the cylinder centre lines in the same plane and on the same side of the centre line of the crank shaft, are known as in-line engine.

21.What are the condition to be satisfied for complete balance of in-line engine?

i. The algebraic sum of the primary and secondary forces must be zero, and
ii. The algebraic sum of the couples due to primary and secondary forces must be zero.

22.What are balancing machines? (AU May 2003)

Balancing machines are the "The machines which is used to determine whether the rotating parts of a machine is completely balanced or not, to check the static and dynamic balancing of rotating parts and to determine the extent to which balancing is done.

23.How the different masses rotating in different planes are balanced? (AU Nov 2014)

The resultant centrifugal force must be equal to zero and the resultant couple must be zero.

24.State the reason for positioning the cranks of a locomotive at right angles.

The reason for positioning the cranks of a locomotive at right angles it will even out the turning moment.

25.Give the different types of balancing machines used in practice.

The types of balancing machines are

i. Static balancing machines
ii. Dynamic balancing machines
iii. Universal balancing machines

26.Why the cranks of a locomotive are generally at right angles to one another?

In order to facilitate the starting of locomotive in any position (i.e., in order to have uniformity in turning moment) the cranks of a locomotive are generally at 90˚ to one another.

27.What is the effect of hammer blow and what is the cause of it?(AU Nov 2012, 2013, May 2004, 2013, 2016)

The effect of hammer blow is to cause the variation in pressure between the wheel and the rail, such that vehicle vibrates vigorously. Hammer blow is caused due to the effect of unbalanced primary force acting perpendicular to the line of stroke.

28.Write short notes on balancing of linkages.

Linkages are balanced by balancing the shaking force and shaking moment. In force balancing, the total mass centre is to be made stationary.

29.Why radial engines are preferred?

In radial engines the connecting rods are connected to a common crank and hence the plane of rotation of the various cranks is same, therefore there are no unbalanced primary or Secondary couples. Hence radial engines are preferred.

30.What are the effects of an unbalanced primary force along the line of stroke of two cylinder locomotive?

a. Variation in tractive force along the line of stroke, and (b) Swaying couple.

31.Can a single cylinder engine be fully balanced? Why? (AU Jun 2006)

No, A single cylinder engine cannot be fully balanced. It is considered as a reciprocating mass. Balancing of reciprocating masses is done by introducing the balancing mass opposite to the crank. The vertical component of the dynamic force of this balancing mass gives rise to "Hammer blow". In order to reduce the Hammer blow, a part of the reciprocating mass is balanced. Hence complete balancing is not possible in reciprocating engines.

32.Differentiate coupled and uncoupled locomotives.

If two or more pairs of wheels are coupled together, the locomotives are of coupled type. Whereas, if there is

only one pair of driving wheel, the locomotives are uncoupled type.

33.Write any two advantages of coupling the wheels of a coupled locomotive.

a) The wheel resistance against slipping on the rails is increased.
b) The hammer blow effect is minimized.

34.What is the difference between balancing of rotating &reciprocating masses.

S.No.	Balancing of Rotating Masses.	Balancing of Reciprocating Masses.
1.	Unbalanced force remains constant in magnitude, but varies in direction.	Unbalanced force remains constant in direction, but varies in magnitude.
2.	Complete balancing is possible.	Only partial balancing is possible.

35.What do you mean by the term 'shaking force' and 'shaking moment'?(AU May 2013)

Shaking forces are the forces transmitted to the foundation or frame of a machine owing to the inertia of the moving parts. The variation of these forces tends to shake or vibrate the machine causing shaking forces and shaking moments.

PART-B& PART-C

1.Three masses are attached to a shaft as follows: 10 kg at 90 mm radius, 15 kg at 120 mm radius and 9 kg at 150 mm radius. The masses are to be arranged so that the shaft is in complete balance. Determine the angular position of masses relative to 10 kg mass. All the masses are in the same (June 2014)*Refer:* "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:839*

2.A.B, C and D are four masses carried by a rotating shaft at radii 100, 125, 200 and 150mm respectively. The planes in which the masses revolve are spaced 600mm apart and the mass of B, C and D are 10kg, 5kg and 4kg respectively. Find the required mass a and the relative angular setting of the four masses so that the shaft shall be in complete balance. (Dec2015)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:845*

3.A 90^0-V engine has two cylinders which are placed symmetrically. The two connecting rods operate a common crank. The length of connecting rods is 320mm each and crank radius of 80mm. the reciprocating mass per cylinder is 12kg. If the engine speed is 600 rpm, then find the resultant primary and resultant secondary forces. Also find the maximum resultant secondary force. (Dec2015)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:903*

4.The axes of the three cylinder air compressor are 120 º to one another and their connecting rod are coupled to a single crank. The length of each connecting rod is 240mm and the stroke is 160 mm. the reciprocating parts have a mass of 2.4 kg per cylinder. Determine the primary and secondary forces if the engine runs at 2000 rpm. (Dec 2013)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:896*

5.A shaft has tree eccentrics, each 75 mm diameter and 25 mm thick, machined in one piece with the shaft. The central planes of the eccentric are 60 mm apart. The distance of the centers from the axis of

rotation are 12 mm,18 mm and 12 mm and their angular positions are 120^o apart. The density of metal is 700 kg/m3. Find the amount of out-of-balance force and couple at 600 rpm. If the shaft is balanced by adding two masses at a radius 75 mm and at distance of 100 mm from the central plane of the middle eccentric, find the amount of the masses and their angular positions. (May 2012)*Refer:* "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:850*

6.The cranks of a three-cylinder locomotive are set at 120^o. The reciprocating masses are 450 kg for the inside cylinder and 390 kg for each outside cylinder. The pitch of the cylinder is 1.2 m and the stroke of each piston 500 mm. The planes of rotation of the balance masses are 960 mm from the inside cylinder. If 40% of the reciprocating masses are to be balanced, determine

1. The magnitude and the position of the balancing masses required at a radial distance of 500 mm; and

2. The hammer blow per wheel when the axle rotates at 350 rpm. (May 2012)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:867*

UNIT III SINGLE DEGREE FREE VIBRATION

Basic features of vibratory systems – Degrees of freedom – single degree of freedom – Free vibration – Equations of motion – Natural frequency – Types of Damping – Damped vibration– Torsional vibration of shaft – Critical speeds of shafts – Torsional vibration – Two and three rotor torsional systems.

PART-A

1.Define vibration.

Any motion that exactly repeats itself after an interval, of time is a periodic motion and is called a vibration. Generally mechanical system must have elasticity in order to support vibration

2.Vibration can have desirable effects – justify. (AU Nov 2014)

Though vibration is mainly known for its undesirable effects like, unwanted noise and wear, sometimes it is used to design a machine with a specific application. Vibratory conveyor and cell phones are example in support of the statement.

3.How do you classify vibration? (or) What are the different types of vibrations? (AU May 2003, 2016)

a. According to the actuating force:
   i. Free vibrations
   ii. Forced vibrations
b. According to energy dissipation:
   i. Undamped vibration
   ii. Damped vibration
c. According to behaviour of vibrating system:
   i. Linear vibration
   ii. Non - linear vibration
d. According to motion of system w.r.t. axis:
   i. Longitudinal vibration
   ii. Transverse vibration
   iii. Torsional vibration

4.What is meant by free vibration? (AU May 2013)

When no external force acts on the body, after giving it an initial displacement, then thebody is said to be

under free or natural vibrations.

5.What do you meant by damping and damped vibration? (AU May 2013)

Damping:

The resistance against the vibration is called damping.

Damped vibration:

When there is a reduction in amplitude over every cycle of vibration, then the motion is said to be damped vibration.

6.Define followings. (AU May 2003)

a. Period b. Cycle c. Frequency

Period -It is the time taken by a motion to repeat itself, and is measured in seconds.

Cycle - It is the motion completed during one time period.

Frequency - It is the number of cycles described in one second

7.Define followings. (AU May 2003, 2015)

a. Frequency b. Resonance c. Amplitude

Frequency

Frequency is the number of cycles of motion completed in one second. It is expressed in Hertz (Hz) and is equal to none cycle per second.

Resonance

When the frequency of the external force is the same as that of the natural frequency of the system, a state of resonance is said to have been reached. Resonance results in large amplitudes of vibrations and this may be dangerous.

Amplitude – The maximum displacement of a vibrating body from the mean position

8.What do you mean by a degree of freedom or movability? (AU May 2003)

The number of independent coordinates required to completely define the motion of a system is known as degree of freedom of the system.

9.Define steady state and transient state vibrations.

In ideal systems, the free vibration continues indefinitely as there is no damping. Such vibration is termed as Steady state vibrations.

In real systems, the amplitude of vibration decays continuously because of natural damping and vanishes finally. Such vibration in real system is called Transient vibration.

10.What do you mean by the term – Equivalent spring stiffness?

Equivalent spring stiffness is a measure of overall spring stiffness of a mechanical system having two or more springs connected in series or parallel.

11.List out the various methods of finding the natural frequency of free longitudinalvibrations.

1. Energy method 2. Equilibrium method and 3. Rayleigh's method.

12.Distinguish between critical damping and large damping. (AU May 2008)

If system is critically damped, the mass moves back very quickly to its equilibrium position within no time. Whereas in large damping, the mass moves slowly to the equilibrium position.

13.When do you say a vibrating system is under damped? (AU Nov 2015)

The equation of motion of a free damped vibration is given by

$$\frac{d^2x}{dt^2} + \frac{c}{m}\frac{dx}{dt} + \frac{s}{m} \times x = 0$$

If $(s/m) > (c/2m)2$, then radical becomes negative. The two roots k1 and k2 are known as complex conjugate. Then the vibrating system is known as under damping.

14.Write the expression for the estimation of the natural frequency of free torsional vibration of a shaft. (AU Nov 2015)

$f_n = 1/t_p = 1/ 2\pi\sqrt{q/I}$

15.Define Vibration Isolation. (AU May 2013)

The process of reducing the vibrations of machines using vibration isolating materials is called vibration isolation.

16.What is the principle of Rayleigh's method of finding natural frequency of vibrations? (AU May 2014)

The principle of Rayleigh's method is "the maximum kinetic energy at the mean position is equal to the maximum potential energy at the extreme position".

17.Define critical or whirling or whipping speed of a shaft.

The speed at which resonance occurs is called critical speed of the shaft. In other words, the speed at which the shaft runs so that the additional deflection of the shaft from the axis of rotation becomes infinite is known as critical speed.

18.What are the factors that affect the critical speed of a shaft? (AU Jun 2007)

The critical speed essentially depends on

i) The eccentricity of the C.G of the rotating masses from the axis of rotation of the shaft.
ii) Type of supports connections at its ends.
iii) Diameter of the disc
iv) Span of the shaft

19.What are the causes of critical speed?

a. Eccentric mountings,
b. Bending due to self weight, and
c. Non-uniform distribution of rotor material

20.Define Damping ratio. (AU May 2014, Nov 2013)

It is defined as the ratio of actual damping coefficient(c) to the critical damping coefficient(c_c). Mathematically, Damping ratio, $\zeta = C/C_c = C/(2m\omega_n)$.

21.Define logarithmic decrement. (AU May 2003, 2014, 2016, Nov 2012, 2014)

Logarithmic decrement is defined as the natural logarithm of the amplitude reduction factor. The amplitude reduction factor is the ratio of any two successive amplitudes on the same side of the mean position.

$$\delta = \log_e (x_1/x_2) = \log_e (x_n/x_{n+1})$$

22.What do you know about inertia effect of the mass of spring in longitudinal vibratio (AU May 2016)

If the effect of inertia due to mass of the spring is taken into account, The inertia effect of the sprig is equal to that of a mass one third of the mass of the spring, concentrated at its free end.

23.In a geared system, what assumptions to be made before replacing it with an equivalentsystem.

i. Inertia of the gear and shafts are negligible.
ii. Loading is within the elastic limits.
iii. No backlash or slip occurs in the gear drive.

24.What is the condition of a system to vibrate?

For a system to vibrate, it must possess inertial and restoring elements, whereas it may possess some damping element responsible for dissipating the energy.

25.What is *harmonic forcing*?

In spring mass system, if the resultant motion is the sum of two harmonics, then it is said to be Harmonic forcing.

26.What is meant by *periodic forcing*?

A periodic force is one in which the motion repeats itself in all details after a certain interval of time.

27.What is the response of the complete periodic forcing?

The response of the complete periodic forcing is the vector sum of the responses to the complimentary functions and particular solutions of the individual forcing functions as on the right hand side of the equation.

28.What is Forced- Damped vibrations?

If in a spring mass system, Damping is also provided with a dashpot means, the system is called as forced-damped vibration system.

29.What all are the factors upon which the magnification factor depends on?

Magnification factor depends on the following factor,

1. The ratio of frequencies, ω/ω_n 2. The damping factor.

30.When will the maximum amplitude of vibration occur?

Irrespective of the amount of damping, the maximum amplitude of vibration occurs before the ratio ω/ω_nreaches unity or when the frequency of the forced vibration is less than that of the un damped vibration.

31.In a system the dampers should not be used, When?

In a system where ω/ω_ncan vary from zero to higher values, dampers should not be used. Instead stops may be provided to limit the resonance amplitude.

PART-B& PART-C

1.Determine the equivalent spring stiffness and the natural frequency of the following vibrating systems when

a) the mass is suspended to a spring

b) the mass is suspended at the bottom of two springs in series

c) the mass is fixed in between two springs

d) the mass is fixed to the midpoint of a spring (Dec 2012)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:911*

2. A vibrating system consists of a mass of 50 kg, a spring of stiffness 30 kN/m and a damper. The damping provided is only 20 % of the critical value. Determine

1. the damping factor

2. the critical damping coefficient

3. the natural frequency of damped vibrations

4. the logarithmic decrement

5. the ratio of two consecutive amplitudes. (Nov 2014)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:937*

3. The machine mounted on springs and fitted with a dashpot has a mass of 60 kg. There are three springs, each of stiffness 12 N/mm. The amplitude of vibrations reduces from 45 to 8 mm in two complete oscillations. Assuming that the damping force varies as the velocity, determine

i) the damping coefficient,

ii) the ratio of frequencies of damped and undamped vibrations, and

iii) the periodic time of damped vibrations. (May 2013)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:947*

4.Determine the (i) the critical damping co-efficient (ii) the damping factor, (iii) the natural frequency of damped vibrations (iv) the logarithmic decrement and (v) the ratio of two consecutive amplitudes of a vibrating system which consists of a mass of 25 kg, a spring of stiffness 15 kN/m and a damper. The damping provided is only 15 % of the critical value. (Nov 2015)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:948*

5.A shaft of length 1.25 m is 75 mm in diameter for the first 275 mm of its length, 125 mm in diameter for the next 500 mm length, 87.5 mm in diameter for the next 375 mm length and 175 mm in diameter for the remaining 100mm of its length. The shaft carries two rotors at two ends. The mass moment of inertia of the first rotor is 75 kg-m^2 whereas of the second rotor is 50 kg-m^2. Find the frequency of natural torsional vibrations of the system. The modulus of rigidity of the shaft material may be taken as 80 Gpa. (Nov 2015)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:983*

6. (i) A machine weighs 18 kg and is supported on spring and dashpots. The total of the spring is 12 N/mm and damping is 0.2 N/mm/s. the system is initially at rest and a velocity of 120 mm/s is imported to the mass. Determine (i) the displacement and velocity of mass as a function of time, and the displacement velocity after 0.4 sec

(ii) Describe the types of vibrations with simple sketch. (Nov 2013)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:949*

UNIT IV FORCED VIBRATION

Response of one degree freedom systems to periodic forcing – Harmonic disturbances –Disturbance caused by unbalance – Support motion –transmissibility – Vibration isolation vibration measurement.

PART-A

1.What is meant by Forced vibrations? (AU Nov 2011)

When the body vibrates under the influence of external force, then the body is said to be under forced vibrations.

2.Define Torsional vibration.

Torsional vibration of a shaft or a disc is the alternate twisting and untwisting of the rotating material. In this kind the particles move in a circle about the axis.

3. Differentiate between transverse and torsional vibration.

i. In transverse vibrations, the particles of the shaft move approximately perpendicular to the axis of the shaft. But in torsional vibrations, the particles of the shaft move in a circle about the axis of the shaft.
ii. Due to transverse vibrations, tensile and compressive stresses are induced.
iii. Due to torsional vibrations, torsional shear stresses are induced in the shaft.

4.What is meant by dynamic magnifier or magnification factor? (AU Dec 2004)

It is the ratio of maximum displacement of the forced vibration to the deflection dueto the static force.

5. Define torsional equivalent shaft.

A shaft having variable diameter for different lengths can be theoretically replaced by an equivalent shaft of uniform diameter such that they have the same total angle of twist when equal opposing torques are applied at their ends. Such a theoretically replaced shaft is known as torsionally equivalent shaft.

6 Define transmissibility ratio or isolation factor. (AU May 2008)

The ratio of force transmitted to the force applied is known as transmissibility ratio.

7. Briefly explain elastic suspension.

When machine components are suspended from elastic members, the vibrational force produced by the machine components will not be transmitted to the foundation. This is called as elastic suspension.

8. What are the methods of isolating the vibration? (AU June 2006)

i. High speed engines/machines mounted on foundation and supports cause vibrations of excessive amplitude because of the unbalanced forces. It can be minimized providing spring-damper, etc.

ii. The materials used for vibration isolation are rubber, felt cork, etc. These are placed between the foundation and vibrating body

9. Specify any two industrial application where the transmissibility effects of vibration are important.

i. All machine tools, and ii. All turbo machines.

10. Define node in torsional vibration. (AU Dec2013)

Node is the point or the section of the shaft at which amplitude of the torsional vibration is zero. At nodes, the shaft remains unaffected by the vibration.

11. What is free torsional vibration of a single rotor system?

In single rotor system the shaft is assumed to be massless. If the disc is given a twist about its vertical axisandthenreleased, it will start oscillating about the axis and will perform torsional vibrations.

12. What do you know by multifilar systems?

Multifilar systems are used to determine the moment of inertia of irregular bodies such as unsymmetrical castings, connecting rods, ect. For which it is quite difficult to find their moment of inertia from their dimensions.

13 What is bifilar suspension?

If a disc of mass is suspended from a rigid support with the help of two cords, that system is said to be a *bifilar suspension.*

If the disc turned through a small angle, on release, the disc will oscillate about the vertical axis and execute a torsional vibration.

14. What is Trifilar suspension?

If a disc of mass is suspended from a rigid support with the help of three vertical cords, that system is saidto be a *Triifilar suspension* system.

15. Explain briefly about free torsional vibrations in a Two – Rotor system.

If a shaft held in bearings carries a rotor at each end, it can vibrate torsionally such that the two rotors move in the opposite directions.Thus, some length of the shaft is twisted in the other.

16.Explain briefly about free torsional vibrations in a Three – Rotor system.

In a three – rotor system, two rotors A and B are fixed to the ends of the shaft, and the rotor C is in between those.

17 What do you understand by *two – node frequency?*

One set of values given by the quadradic equation gives the position of two nodes and the frequency thus obtained is known as *two – node frequency.*

18.What do you understand by *single – node frequency?*

In the other set of values, one gives the position of a single node and the other is beyond the physical limitsof the equation. The frequency so obtained is known as *single – node frequency.*

19. How will you find the frequency of rotors are fixed to a shaft of various diameters at different sections?

The most convenient manner of finding frequency of rotors are fixed to a shaft of various diameters at different sections is by replacing the shaft with a tortionally equivalent shaft having a suitable diameter.

20. Write down the assumptions in the geared system to be replaced by an equivalent shaftsystem?

The assumptions are

i. The inertia of the gears and shafts are negligible
ii. The load is within elastic limits of gear teeth
iii. No backlash or slip occurs in the gear drive.

21. What is meant by dynamic magnifier or magnification factor? (AU Nov 2014, May 2014, 2016)

It is the ratio of maximum displacement of the forced vibration(x_{max}) to the deflection due to the static force F (x_o).

$D= x_{max}/ x_o$

22.What is meant by "Transmissibility?(AU May 2005, 2012, 2014, Nov 2013, 2014)

When a machine is supported by a spring, the spring transmits the force applied on the machine to the fixed support or foundation. This is called as transmissibility.

23.Avibrating system consist of a mass of 7Kg and a spring stiffness 50N/cm and damper of damping coefficient 0.36Ncm^{-1}sec. Find damping factor.

Given data:
m=7Kg
s=50N/cm=5000N/m
c=0.36N/cm/sec=36N/m/sec
Sol:
$\omega_n=\sqrt{s/m}= \sqrt{(5000/7)}=26.72$ rad/sec
$c_c=2m\ \omega_n=2*7*26.72=374.16$ N/m/s
Damping factor= $c/ c_c=0.0962$

24. Briefly explain elastic suspension.

When machine components are suspended from elastic members, the vibrational force produced by the machine components will not be transmitted to the foundation. This is called as elastic suspension.

25. Specify the importance of vibration isolation?

When an unbalanced machine is installed on the foundation, it produces vibration in the foundation. So, in order to prevent these vibrations or to minimize the transmission of forces to the foundation, vibration isolation is important.

26.What are the methods of isolating the vibration?

a. High speed engines / machines mounted on foundation and supports cause vibrations of excessive amplitude because of the unbalanced forces.
b. The materials used for vibration isolation are rubber, felt cork, etc. These are placed between the foundation and vibrating body.

27 Define frequency response curve.

Frequency response curve is a curve drawn between magnification factor and frequency ratio (ω/ω_n) for various values of damping factor.

28.Define Damping ratio. (AU Dec2013)

It is defined as the ratio of actual damping coefficient(c) to the critical damping coefficient(c_c).
Mathematically,
Damping ratio, $\zeta=C/ C_c= C/(2m\omega_n)$.

29.Define Whirling speed. (AUMay 2013, Nov 2011, 2012)

It is the speed at which a rotating shaft tends to vibrate violently in the transverse direction.

30 Differentiate between transverse and torsional vibration.

i. In transverse vibrations, the particles of the shaft move approximately perpendicular to the axis of the shaft. But in torsional vibrations, the particles of the shaft move in a circle about the axis of the shaft.
ii. Due to transverse vibrations, tensile and compressive stresses are induced. Due to torsional vibrations, torsional shear stresses are induced in the shaft.

31.What are the conditions to be satisfied for an equivalent system to that of geared system in torsional vibrations? (AU May 2014)

a. The kinetic energy of the equivalent system must be equal to the kinetic energy of the original system.
b. The strain energy of the equivalent system must be equal to the strain energy of the original system.

PART-B& PART-C

1. A single cylinder vertical petrol engine has a mass of 200 kg and is mounted upon a steel chassis frame. The vertical static deflection of the frame is 2.4 mm due to the weight of the engine. The reciprocating part of the engine has a mass of 9 kg and move through a vertical stroke of 160 mm with simple harmonic motion. A dashpot with a damping co efficient of 1N/mm/s is also used to dampen the vibrations considering that the steady state of vibration is reached, determine

(i) Amplitude of the forced vibration if the driving shaft rotates at 500 rpm

(ii) The speed of the driving shaft at which resonance will occur (Dec 2015)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No: 985*

2. (i)Derive the relation for the displacement of mass from the equilibrium position of a damped vibration system with harmonic forcing

(ii)Define the term vibrating isolation. (Dec 2013)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No: 972*

3.(i) Discuss the forcing due to support motion.

(ii) What is mean by magnification factor in case of forced vibrations? (Dec 2013)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No: 955.*

4.A shaft supported freely at the ends has a mass of 120 kg placed 250 mm from one end. Determine the frequency of the natural transverse vibrations if the length of the shaft is 700 mm, E = 200 GN/m2 and shaft diameter is 40 mm. (June 2014)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:920*

5.A shaft 40 mm diameter and 2.5 m long has a mass of 15 kg per meter length. It is simply supported at the ends and carries three masses 90 kg, 140 kg and 60 kg at 0.8 m, 1.5 m and 2 m respectively from the left support. Taking E = 200 GN/m2, find the frequency of the transverse vibrations. (Dec 2010)*Refer:* "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No: 929.*

6.The following data relate to a shaft held in long bearings.

Length of shaft = 1.2 m

Diameter of shaft = 14,

Mass of a rotor at midpoint = 16 kg,

Eccentricity of centre of mass of rotor from centre of rotor = 0.4 mm

Modulus of elasticity of shaft material = 200 GN/m2

Permissible stress in shaft material = 70 X 106 N/m2

Determine the critical speed of the shaft and the range of speed over which it is unsafe to run the shaft. Assume the shaft to be mass less. (Nov 2012)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No: 959*

UNIT V MECHANISM FOR CONTROL

Governors – Types – Centrifugal governors – Gravity controlled and spring controlled centrifugal governors – Characteristics – Effect of friction – Controlling force curves. Gyroscopes –Gyroscopic forces and torques – Gyroscopic stabilization – Gyroscopic effects in Automobiles, ships and airplanes.

PART-A

1.Explain the function of governor. (AU May 2005, Nov 2012)

The function of a governor is to maintain the speed of an engine within specified limits whenever there is a variation of load. Governors control the throttle valve and hence the fuels supply to cater the load variation on engines.

2.What is the principle of working of centrifugal governor? (AU Jun 2009)

The centrifugal governors are based on balancing of centrifugal force on the rotating balls by an equal and opposite radial force.

3.Differentiate between governor and flywheel? (AU May 2003, 2015)

S.No	GOVERNOR	FLYWHEEL
1	The function of a governor is to regulate the mean speed of an engine, when there are variations in the load.	The function of a flywheel is to reduce the fluctuations of speed caused by the fluctuation of the engine turning moment during each cycle of operation.
2	It is provided on prime movers such as engines and turbines.	It is provided on engine and fabricating machines viz., rolling mills, punching machines, shear machines, presses,etc.
3	It works intermittently, i.e., only when there is change in load.	It works continuously from cycle to cycle.
4	It has no influence over cyclic speed fluctuation	It has no influence on mean speed of the prime mover.

4.What is the principle of inertia governors?

In inertia governors, the ball are so arranged that the inertia forces caused by an angular acceleration or retardation of the shaft tend to alter their positions.

5.What is equilibrium speed?

The speed at which the governor balls arms, sleeve, etc., are in complete equilibrium and there is no upward or downward movement of the sleeve on the spindle is known as equilibrium speed.

6.What is governor?

Governor is a component to regulate the mean speed of an engine, when there are variations in the load. This is done by regulating the fuel supply to the engine.

7.Explain controlling force?

An equal and opposite force to the centrifugal force acting radially inwards (i.e. centripetal force) is termed as controlling force of a governor.

8.Explain the governor effort

The mean force acting on the sleeve for a given percentage change of speed for lift of the sleeve is known as the governor effort

9.Define power of a governor

The power of a governor is the work done at the sleeve for a given percentage change of speed. It is the product of the mean value of the effort and the distance through which the sleeve moves.

Power= Mean effort* Lift of sleeve.

10.Define coefficient of sensitiveness. (AU May 2008)

It is the ratio between range of speed and mean speed.

$$\text{Coefficient of sensitiveness} = \frac{\text{Range of speed}}{\text{Mean speed}} = \frac{N_1 - N_2}{N}$$

11.What is meant by hunting? (AU Nov 2012, 2015, May 2012, 2016)

The phenomenon of continuous fluctuation of the engine speed above and below the mean speed is termed as hunting. This occurs in over-sensitive governors

12.Explain the term stability of the governor?

A governor is said to be stable if there is only one radius of rotation for all equilibrium speeds of the balls within the working range. If the equilibrium speed increases the radius of governor ball must also increase.

13.Explain Isochronism. (AU May 2014)

A governor with zero range of speed is known as an isochronous governor. Actually the isochronism is the stage of infinite sensitivity. i.e., when the equilibrium speed is constant for all radii of rotation of the balls within the working range, the governor is said to in isochronism.

This means that the range of speed (N_1-N_2) = 0.

$$\text{Sensitiveness} = \frac{\text{Mean speed}}{\text{Range of speed}} = \alpha$$

14.Explain sensitiveness of governors. (AU May, Nov 2013, 2014)

The sensitiveness is defined as the ratio of the mean speed to the difference between the maximum and minimum speeds.

$$\text{Sensitiveness} = \frac{\text{Mean speed}}{\text{Range of speed}} = \frac{N}{N_1 - N_2} = \frac{N_1 + N_2}{2(N_1 - N_2)}$$

15.Give the applications of gyroscopic principle.

i) In instrument or toy known as gyroscope,

ii) In ships in order to minimize the rolling and pitching effects of waves, and

iii) In aero planes, monorail cars, gyrocompasses, etc.

16.Define steering, pitching and rolling.

Steering: It is the turning of a complete ship in a curve towards left or right, while it moves forward.

Pitching: It is the turning of a complete ship up and down in a vertical plane about transverse axis.

Rolling: It is the movement of a ship in a linear fashion.

17.What is gyroscopic Torque or couple?

Whenever a rotating body changes its axis of rotation, a torque or couple is applied on the rotating body. This torque or couple is known as gyroscopic torque or couple.

18.Explain gyroscopic couple. (AU Nov 2005, 2011, May 2014)

If a body having moment of inertia I and rotating about its own axis at ω rad/sec is also caused to turn at ω_p rad/sec about an axis perpendicular to axis of spin, then it experiences a gyroscopic couple of magnitude ($I\ \omega\ \omega_p$) in an axis which is perpendicular to both the axis of spin and axis of precession.

19.What is meant by lag in response?

In any control system, there is a delay in response due to some inherent cause and it becomes difficult to measure the input and output simultaneously. This delay in response is termed as lag in response.

20.What is controlling force diagram?

When the graph is drawn between the controlling force as ordinate and radius of rotation of the balls as, the graph so obtained is called controlling force diagram.

21.Why there is no effect of the gyroscopic couple acting on the body of a ship during rolling?

We know that, for the effect of gyroscopic couple to occur ,the axis of precession should always be perpendicular to the axis of spin . In case of rolling of a ship, the axis of precession is always parallel to the axis of spin for all positions. Hence there is no effect of the gyroscopic couple acting on the body of the ship during rolling.

22.What is meant by lag in response?

In any control system, there is a delay in response due to some inherent cause and it becomes difficult to measure the input and output simultaneously. This delay in response is termed as lag in response.

23.What is sleeve lift?

The sleeve lift is the vertical distance through which the sleeve is displaced due to change in equilibrium speed.

24.High sensitiveness is undesirable for a governor. Validate this statement.

If a governor is too sensitive, when the load on engine falls, the sleeve rises rapidly to a maximum position. This triggers the closure of throttle valve leading sudden fall in speed. Now the sleeve moves rapidly downwards to a minimum position. Thus the governor fluctuates continuously, which is undesirable.

25.Stability and sensitiveness are two opposite characteristics. Justify.

The balls of a stable governor should occupy the same position for each speed of the engine within the working range. This in possible only when the speed fluctuations are kept at minimum, while means when sensitiveness is lesser, thus stability and sensitiveness are opposite characteristics.

26.Mention any two advantages of using spring loaded governors in the place of gravity-controlled governors.

i. Spring loaded governors can operate at higher speeds.

ii. It is capable of being fixed at any inclination.

27.When the engine is the above case rotates in clockwise then what is the effect of reactivegyroscopic couple?

To raise the tail and dip the nose of the aero plane.

28.Explain the principle of gyroscope. (AU Nov 2013)

A gyroscope is a spinning body which is free to move in other directions under the sections of external forces.

Let us consider a disc rotating with uniform angular velocity in counter clockwise about its own axis called axis of spin. If it turns in a horizontal plane by rotating about a vertical axis in counter clockwise direction, then a clockwise couple will be automatically induced about the axis perpendicular to X-Y plane.

This results a reactive couple due to the reaction in the bearings. The active and reactive couple constitute active and reactive gyroscopic torques.

29.When the aeroplane in the above case runs right, with other conditions kept same thenwhat is the effect of reactive gyroscopic couple?

To raise the tail and dip the nose.

30.What is the effect of gyroscope on rolling of ship?

As the axis of rolling of the ship and the rotor are parallel, there is no effect of the gyroscopic couple.

31.Write short notes on stability of an automobile.

In case of four wheeler, stability while in motion is based on two effects.

- effect due to gyroscopic couple
- effect due to centrifugal couple.

32.State the conditions for stability of a two-wheeler.

The overturning couple due to centrifugal force should be balance by the couple due to the weight of the vehicle.

33.What are the types of Automatic control of systems?

a. Open-loop (or) unmonitored control system
b. Closed-loop (or) Monitored control system
c. Continuous control system
d. Discontinuous control system

34.What are the terminologies used in Automatic control of systems?

1. Command, 2. Response, 3. Process control, 4. Process controller, 5. Regulator, 6. Kinetic control, 7. Feedback, 8. Deviation sensor

35.What is the effect of friction on the governors?

Generally, we have assumed the governor to be frictionless. In actual practice there is always friction in the joints and operating mechanism of the governor. Since the frictional force always acts in the opposite direction to that of motion, therefore when the speed of rotation decreases, the friction prevents the downward movement of the sleeve and the radial inward movement of the balls.

PART-B& PART-C

1. Calculate the minimum speed, maximum speed and range of the speed of a porter governor, which has equal arms each 200 mm long and pivoted on the axis of rotation. The mass of each ball is 4 kg and the central mass of the sleeve is 20 kg. the radius of the rotation of the ball is 100 mm when the governor begins to lift and 130 mm when the governor is at maximum speed. (Dec 2015)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:657*

2. The turbine rotor of a ship has a mass of 3500 kg. it has a radius of gyration of 0.45 m and a speed of 3000 rpm clockwise when looking from stern. Determine the gyroscopic couple and its effect upon the ship:

(i) When the ship is steering to the left on a curve of 100m radius at a speed of 36kmph

(ii) When the ship is pitching in a simple harmonic motion the bow falling with its maximum velocity the period of pitching is 40 sec and the total angular displacement between the two extreme positions of pitching is 12º (Dec 2015)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:492.*

3.(i) Explain the functions of a proellgoverner with the help of a neat sketch. Derive the relationship among the various forces acting on the ling

(ii) What are the centrifugal governors? How do they differ from inertia governors?(Dec 2013)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:670,654*

4.Each arm of a Porter governor is 250 mm long. The upper and lower arms are pivoted to links of 40 mm and 50 mm respectively from the axis of rotation. Each ball has a mass of 5 kg and the sleeve mass is 50 kg. The force of friction on the sleeve of the mechanism is 40 N. Determine the range of speed of the governor for extreme radii of rotation of 125 mm and 150 mm. (June 2011)*Refer:* "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:657*

5.The mass of each ball of a Proell governor is 7.5 kg and the load on the sleeve is 80 kg. Each of the arms is 300 mm long. The upper arms are pivoted on the axis of rotation whereas the lower arms are pivoted to links of 40 mm from the axis of rotation. The extensions of the lower arms to which the balls are attached are 100 mm long and are parallel to the governor axis at the minimum radius. Determine the equilibrium speeds corresponding to extreme radii of 180 mm and 240 mm. (May 2012)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:670*

6. In a spring loaded Hartnell type of governor, the mass of each ball is 4 kg and the lift of the sleeve is 40 mm. The governor begins to float at 200 rpm when the radius of the ball path is 90 mm. The mean working speed of the governor is 16 times the range of speed when friction is neglected. The lengths of the ball and roller arms of the bell-crank lever are 100 mm and 80 mm respectively. The pivot center and the axis of governor are 115 mm apart. Determine the initial compression of the spring, taking into account the obliquity of arms. Assuming the friction at the sleeve to be equivalent to a force of 15 N, determine the total alteration in speed before the sleeve begins to move from the mid- position (Dec 2012)

Refer: "Khurmi, R.S.,"Theory of Machines", 14th Edition, S Chand Publications, 2005. *Page No:678*