INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Name	:	**DYNAMICS OF MACHINERY**
Course Code	:	**A50317**
Class	:	III B. Tech I Semester
Branch	:	ME
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Course Coordinator	:	Prof. V. V. S. H. Prasad, Professor
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OBJECTIVES

I. To understand the basic principles of dynamics and to determine the forces acting on machines considering friction.
II. Formulate the concept of synthesis and analysis of different machines.
III. Design the machines based on force analysis, proper balancing & minimizing vibrations.
IV. To understand the working of various dynamometers, brakes, clutches and governors.

S No	QUESTION	Blooms taxonomy level	Course Outcomes
	UNIT - I		
Part - A (Short Answer Questions)			
1	Define dynamic force analysis.	Understand Remember	3,6
2	What is a gyroscope?	Understand Remember	3,6
3	What is gyroscopic effect?	Understand Remember	3,6
4	Define preceesional angular velocity.	Understand Remember	3,6
5	Give the expression for gyroscopic couple for a spinning disc.	Understand Remember	3,6
6	Define Dynamics.	Understand Remember	3,6
7	Define static force analysis.	Understand Remember	3,6
8	Define active force.	Understand Remember	3,6
9	Define reactive force.	Understand Remember	3,6
10	Define plane of precession	Understand Remember	3,6
11	Define axis of precession.	Understand Remember	3,6

12	Define plane of spinning.	Understand Remember	3,6
13	Define axis of spinning.	Understand Remember	3,6
14	Define plane of active gyroscopic couple.	Understand Remember	3,6
15	Define plane of reactive gyroscopic couple.	Understand Remember	3,6
16	Define gyroscopic acceleration.	Understand Remember	3,6
17	Give the expression for gyroscopic acceleration.	Understand Remember	3,6
18	Define angle of heel.	Understand Remember	3,6
19	Explain the effect of gyroscopic couple on an automobile taking left turn.	Understand Remember	3,6
20	Explain the effect of gyroscopic couple on a ship pitching upward.	Understand Remember	3,6
Part - B (Long Answer Questions)			
1	Derive the relation for the magnitude of gyroscopic couple.	apply Understand	3,2
2	Explain what is meant by applied torque and reaction torque.	apply Understand	3,2
3	Discuss the gyroscopic effect on sea vessels.	apply Understand	3,2
4	Explain the gyroscopic effect on four wheelers.	apply Understand	3,2
5	Derive the relation for limiting speed of a two wheeler.	apply Understand	3,2
6	Explain the gyroscopic effects on the motion of an air craft while taking a turn.	apply Understand	3,2
7	How do the effects of gyroscopic couple and centrifugal force make the rider of a two wheeler to tilt to one side?	apply Understand	3,2
8	Explain plane of spinning, plane of precession and plane of gyroscopic couple.	apply Understand	3,2
9	Explain axis of spinning, axis of precession and axis of gyroscopic couple.	apply Understand	3,2
10	Explain the gyroscopic effect on a ship during pitching.	apply Understand	3,2
11	What are applied and constraint forces?	apply Understand	3,2
12	What are the conditions for a body to be in equilibrium under the action of two forces?	apply Understand	3,2
13	What are the conditions for a body to be in equilibrium under the action of three forces?	apply Understand	3,2
14	What are the conditions for a body to be in equilibrium under the action of two forces and a torque?	apply Understand	3,2
15	How are free body diagrams helpful in finding the various forces acting on Different members of the mechanism?	apply Understand	3,2
16	Explain the principle of superposition as applicable to a system of forces in a Mechanism.	apply Understand	3,2
17	Explain the principle of virtual work.	apply Understand	3,2
18	What are the conditions for a body to be in equilibrium under the action of four forces?	apply Understand	3,2
19	Explain static equilibrium.	apply Understand	3,2
20	Explain dynamic equilibrium.	apply Understand	3,2
Part - C (Problem Solving and Critical Thinking Questions)			

1	The mass of turbine rotor of a ship is 8 tonnes and has a radius of gyration of 0.6 meters. It rotates at 1800 rpm clockwise when looking from the front. Determine the gyroscopic effect if i) The ship is travelling at 100 km/h and steers to the right in a curve of 70 meters radius. ii) The ship is pitching and the bow descends with maximum velocity. The pitching is simple harmonic and the total angular movement between the extreme positions is 10 degrees. iii) The ship is rolling and at a certain instant has an angular velocity of 0.03 radians/ second clockwise when looking from bow.	Evaluate analyse	1,3,9
2	The mass of the motor cycle along with the rider is 180 kg. The height of the centre of gravity of total mass is 600mm above the ground when it moves straight. Each wheel has a diameter of 700mm and mass moment of inertia of 2 kgm^2. The engine rotates at a speed of 5 times the road wheel and engine rotating parts have mass moment of inertia of 0.2 kgm^2.	Evaluate analyse	1,3,9
3	A racing car weighs 20kN.It has a wheel base of 2m, track width of 1m and height of C.G 300mm above ground level and lies midway between the front and rear axles. The engine flywheel rotates at 3000 rpm clockwise when viewed from the front. The moment of inertia of the flywheel is 4kgm^2 and the moment of inertia of each wheel is 3kgm^2 Find the reactions between the wheels and the ground when the car takes a curve of 15m towards right at 30 km/hr, taking into consideration the gyroscopic and centrifugal effects. Each wheel radius is 400mm.	Evaluate analyse	1,3,9
4	An aero-plane makes a complete half circle of 50 m radius towards left in a time of 20 seconds when flying at 200kmph. The rotary engine and the propeller of the plane has a mass of 400kg and a radius of gyration of 0.3 m. The engine rotor rotates at 2400 rpm clockwise when seen from the rear. Find the gyroscopic couple on the air craft and state its effect on the aero-plane.	Evaluate analyse	1,3,9
5	A uniform disc having a mass of 8 kg and radius of gyration 150 mm is mounted on one end of a horizontal arm of length 200 mm. The other end rotates freely in a bearing. The disc is given a clockwise spin of 240 rpm. Determine the motion of the disc if its arm remains horizontal.	Evaluate analyse	1,3,9
6	Determine the required input torque on the crank of a slider crank mechanism for static equilibrium when the applied piston load is 1500N. The length of the crank and connecting rod are 40 mm and 100 mm respectively and the crank has turned through 45^0 from the inner dead center.	Evaluate analyse	1,3,9
7	In a four link mechanism ABCD, the link AB revolves with an angular velocity of 10 radians/second and angular acceleration of 20 radians/sec2 at the instant when it makes an angle of 45^0 with AD the fixed link. The lengths of the links are AB=CD=800mm, BC=1000mm and AD=1500mm. The mass of the links is 4kg/m length. Determine the torque required to overcome the inertia forces, neglecting the gravitational effects. Assume the links to be of uniform cross-section.	Evaluate analyse	1,3,9
8	In a four bar mechanism, the link 3 and 4 are subjected to forces of 100N at an angle of 60^0 and 50N at an angle of 45^0. The dimensions of the links are O2O4= 800 mm, O2B=500 mm, BC=450 mm, O4C= 300mm, BD=200 mm and O4E=150mm. Calculate the shaft torque on link2 for static equilibrium of the mechanism along with the constraint forces.	Evaluate analyse	1,3,9
9	A vertical petrol engine 150 mm diameter and 200 mm stroke has a connecting rod 350 mm long. The mass of the piston is 1.6 kg and the engine speed is 1800 rpm. On the expansion stroke with crank angle 30^U from top dead center, the gas pressure is 750 kN/m^2. Determine the net thrust on the piston.	Evaluate analyse	1,3,9
10	For the static equilibrium of a quick return mechanism of crank and slotted lever, determine the required input torque for a force of 5000N acting from left to right on the slider. The dimensions of various links are crank AB=120mm, fixed link AC =175 mm, connecting link DE=250mm and slotted link CD= 300 mm. The crank makes 60^U with the vertical.	Evaluate analyse	1,3,9

UNIT - II

Part – A (Short Answer Questions)

1	Define limiting angle of friction.	Understand Remember	3,6
2	What is friction axis?	Understand Remember	3,6
3	What is friction couple?	Understand Remember	3,6
4	Explain friction circle.	Understand Remember	3,6
5	Define angle of repose.	Understand Remember	3,6
6	Define angle of friction.	Understand Remember	3,6
7	Define limiting friction.	Understand Remember	3,6
8	Define pivot friction.	Understand Remember	3,6
9	Define collar friction.	Understand Remember	3,6
10	Define boundary friction.	Understand Remember	3,6
11	Define lubricated surfaces.	Understand Remember	3,6
12	Define film lubrication.	Understand Remember	3,6
13	Define clutch.	Understand Remember	3,6
14	Define brakes.	Understand Remember	3,6
15	Define Dynamometers.	Understand Remember	3,6
16	Define absorption type dynamometer.	Understand Remember	3,6
17	Define transmission type dynamometer.	Understand Remember	3,6
18	Define centrifugal clutch.	Understand Remember	3,6
19	Define cone clutch.	Understand Remember	3,6
20	Define internal expanding brake.	Understand Remember	3,6

Part - B (Long Answer Questions)

1	Describe the various types of friction.	Understand Apply	3,6
2	Define the terms coefficient of friction and limiting angle of friction.	Understand Apply	3,6
3	Derive the expression for the efficiency of an inclined plane when a body moves up the plane.	Understand Apply	3,6
4	Derive the expression for the efficiency of an inclined plane when a body moves down the plane	Understand Apply	3,6
5	Derive the expression for the efficiency of a square thread.	Understand Apply	3,6
6	Deduce expression for the friction torque for a flat collar considering uniform wear.	Understand Apply	3,6
7	Deduce expression for the friction torque for a flat collar considering uniform pressure.	Understand Apply	3,6

8	Deduce expression for the friction torque for a conical collar considering uniform wear.	Understand Apply	3,6
9	Deduce expression for the friction torque for a conical collar considering uniform pressure.	Understand Apply	3,6
10	Describe the working of a single plate clutch.	Understand Apply	3,6
11	Explain the working of a multi plate clutch with a neat sketch.	Understand Apply	3,6
12	Deduce expression for the friction torque for a centrifugal clutch.	Understand Apply	3,6
13	What are the laws of film friction?	Understand Apply	3,6
14	What is the difference between brake and clutch?	Understand Apply	3,6
15	Describe briefly the various types of brakes.	Understand Apply	3,6
16	What is self locking and self energized brake?	Understand Apply	3,6
17	Deduce the relation for ratio of tensions in a band brake.	Understand Apply	3,6
18	Derive the relation for friction torque in an internal expanding shoe brake.	Understand Apply	3,6
19	Explain any one type of absorption dynamometer.	Understand Apply	3,6
20	Explain any one type of transmission dynamometer	Understand Apply	3,6
Part - C (Problem Solving and Critical Thinking Questions)			
1	The mean diameter of Whitworth bolt having V-Threads is 25 mm. The pitch of the thread is 5 mm and the angle of V is 550. The bolt is tightened by a nut whose mean radius of bearing surface is 25 mm. If the coefficient of friction between nut and bolt is 0.1 and nut with bearing surface is 0.16, find the force required at the end of the spanner 0.5 m long when the load on the bolt is10kN.	Evaluate analyse	1,3,9
2	An effort of 3000N is required to just move a certain body up an inclined plane of angle 120, force acting parallel to the plane. If the angle of inclination is increased to 150, then the effort required is 3500N. Find the weight of the body and the coefficient of friction.	Evaluate analyse	1,3,9
3	The mean diameter of a screw jack having pitch of 10mm is 50mm. A load of 20kN is lifted through a distance of 170 mm. Find the work done in lifting the load and η of the screw jack when i) the load rotates with the screw and ii) load rests on loose end which does not rotate with the screw.	Evaluate analyse	1,3,9
4	Determine the axial force required to engage a cone clutch transmitting 20kW of power at 750 rpm. Average friction diameter of the cone is 400mm and average pressure intensity 60 kN/m2. Semi cone angle is 100 and coefficient of friction is 0.25.Also find the width of the friction cone.	Evaluate analyse	1,3,9
5	A band brake acts on 3/4 th of a circumference of a brake drum of 450 mm diameter which is keyed to a shaft. The band brake provides a braking torque of 225 Nm. One end of the lever is attached to a fulcrum pin of the lever and the other end is attached to a pin 100 mm from the fulcrum. If the operating force is applied at 500 mm from the fulcrum and coefficient of friction is 0.25, find the operating force when the drum rotates in i) Clock-wise direction, ii) anti- clockwise direction.	Evaluate analyse	1,3,9
6	In a vertical belt transmission dynamometer, the diameter of the driving pulley rotating at 1500 rpm is 80 mm. The centre distance of the intermediate pulley from the fulcrum is also 80 mm each. The weighing pan on the lever is at a distance of 250 mm. find the power transmitted when a mass of 20kg is required on the pan including its own mass.	Evaluate analyse	1,3,9

7	The following data refer to a rope brake dynamometer in a laboratory experiment. Diameter of the flywheel=1m Diameter of the rope=10 mm. Dead weight on the brake=50 kg Speed of the engine =180 rpm Spring balance reading=120 N. Find the power of the engine?	Evaluate analyse	1,3,9
8	A conical pivot supports a load of 20kN, cone angle is 120^0 and intensity of pressure normal to the cone is $0.3N/mm^2$. The outer diameter is twice the inner diameter. Find the outer and inner radii of bearing surface if the shaft rotates at 200 rpm and μ= 0.1. Find the power absorbed in friction assuming uniform wear.	Evaluate analyse	1,3,9
9	An effort of 1500N is required to just move a body up an inclined plane of angle 12^0, force acting parallel to the plane. If the angle of inclination is increased to15^0, the effort required is 1720n. Determine the weight of the body and coefficient of friction.	Evaluate analyse	1,3,9
10	The thrust of a propeller shaft in a marine engine is taken up by a number of collars integral with the shaft which is 300 mm diameter. The thrust on the shaft is 200kN and the speed is 75 rpm. Taking coefficient of friction equal to 0.05 and intensity of pressure equal to 0.3 N/m^2, find the external diameter of the collars and the number of collars required. The power lost in friction is 16kW.	Evaluate analyse	1,3,9
	UNIT-III		
Part - A (Short Answer Questions)			
1	Define turning moment.	Understand Remember	3,6
2	What is a governor?	Understand Remember	3,6
3	What are the types of governors?	Understand Remember	3,6
4	Define fluctuation of energy.	Understand Remember	3,6
5	Define fluctuation of speed.	Understand Remember	3,6
6	What is a fly wheel?	Understand Remember	3,6
7	What is the function of fly wheel?	Understand Remember	3,6
8	What is the function of a governor?	Understand Remember	3,6
9	How does a governor differ from that of flywheel.	Understand Remember	3,6
10	Explain the term sensitiveness	Understand Remember	3,6
11	Explain the term stability	Understand Remember	3,6
12	Explain the term hunting	Understand Remember	3,6
13	What is the equilibrium speed of a governor?	Understand Remember	3,6
14	What is a Proell governor?	Understand Remember	3,6
15	What is a Porter governor?	Understand Remember	3,6
16	What is Hartung governor?	Understand Remember	3,6
17	What is Hartnell governor?	Understand Remember	3,6

18	What is Watt governor?	Understand	3,6
19	Define isochronism of a governor.	Understand Remember	3,6
20	Define effort and power of a governor.	Understand Remember	3,6
Part – B (Long Answer Questions)			
1	State and explain D'Alembert principle.	Understand Remember	3,6
2	What is meant by piston effort and crank effort?	Understand Remember	3,6
3	What are turning moment diagrams?	Understand Remember	3,6
4	Define the terms coefficient of fluctuation of energy and coefficient of fluctuation of speed.	Understand Remember	3,6
5	What is the function of a flywheel?	Understand Remember	3,6
6	Derive the relation for the coefficient of fluctuation of speed in terms of maximum fluctuation of energy and the kinetic energy of the flywheel at mean speed.	Understand Remember	3,6
7	Describe the graphical method of determining the inertia of the connecting rod of a reciprocating engine.	Understand Remember	3,6
8	What is meant by dynamically equivalent system?	Understand Remember	3,6
9	Derive an expression for the angular acceleration of the connecting rod of a reciprocating engine.	Understand Remember	3,6
10	What is meant by equivalent offset inertia force?	Understand Remember	3,6
11	Differentiate between the functions of a governor and flywheel.	Understand Remember	3,6
12	What are centrifugal governors? How do they differ from inertia governors?	Understand Remember	3,6
13	Describe the function of a Watt governor.	Understand Remember	3,6
14	How does a Porter governor differ from Watt governor?	Understand Remember	3,6
15	What is the effect of friction in a Porter governor?	Understand Remember	3,6
16	Describe the function of a Proell governor with a neat sketch.	Understand Remember	3,6
17	What are spring controlled governors?	Understand Remember	3,6
18	Describe the function of a Hartnell governor.	Understand Remember	3,6
19	Explain the function of a Hartung governor with a neat sketch	Understand Remember	3,6
20	Derive the expressions for the effort and power of a Porter governor.	Understand Remember	3,6
Part - C (Problem Solving and Critical Thinking Questions)			
1	A machine shaft running at 200 rpm requires a torque increasing uniformly from 1200 Nm to 3600 Nm during1800 of rotation. It is steady at 3600 Nm for subsequent one revolution and decreases uniformly to its original value of 1200 Nm in subsequent one revolution and is again steady at 1200 Nm for the next two revolutions. This completes the cycle. The motor has a constant torque which has a rotor of mass 450 kg and 250mm radius of gyration. In addition, if it has a flywheel of mass 2000kg and 600 mm radius of gyration fitted to the shaft. Determine the power required to drive the motor and percentage fluctuation in speed.	Understand Application Evaluate Analyze.	1,2

2	The effective turning moment exerted by a two stroke engine at crank shaft is T= 8000+ 1000sin2θ- 2000cos2θ where θ is the inclination of the crank to inner dead center. The mass of the flywheel is 500kg and radius of gyration is 750 mm. The engine speed is 300 rpm. Determine the power developed, the total percentage fluctuation of speed and maximum angular retardation.	Understand Application Evaluate Analyze.	1,2
3	The turning moment diagram for a multi cylinder engine has been drawn to a scale of 1mm to 500 Nm of torque and 1mm to 60 of crank displacement. The intercepted areas between the output torque curve and the mean resistance line taken in order from one end of the engine are -30, +410, -280, +320, -330, +250, -360, +280, -260 mm2 when the engine runs at 800 rpm. The engine has a stroke of 300mm and the fluctuation of speed is not to exceed 2% of mean speed. Determine suitable diameter and cross section of the flywheel rim for a limiting value of safe centrifugal stress of 7 Mega Pascal. The material density is 720kg / m3. Width of the rim is 5 times the thickness.	Evaluate Analyse	1,3,9
4	The turning moment diagram for a multi cylinder engine has been drawn to a scale of 1cm= 5000Nm torque and 1cm= 600 respectively. The intercepted areas between output torque curve and mean resistance taken in order from one end are -0.3, +4.1, -2.8, +3.2, -3.3, +2.5, -3.6, +2.8, -2.6 square cm when the engine is running at 800rpm. The engine has a stroke of 300 mm and the fluctuation of speed is not to exceed 2% of mean speed. Determine a suitable diameter of cross section of the flywheel rim for limiting value of the shaft centrifugal stress of 280 X 103 N/ m2. The material density may be assumed as 7.2 g/cm3. Assume the thickness of the rim to be ¼ th of the width.	Evaluate Analyse	1,3,9
5	A single cylinder single acting four stroke gas engine develops 20kW at 300 rpm. The work done by the gases during the expansion stroke is three times the work done on the gases during the compression stroke, the work done during the suction and exhaust strokes is negligible. If the total fluctuation of speed is not to exceed ± 2 percent of the mean speed and the turning moment diagram during compression and expansion is assumed to be triangular in shape, find the moment of inertia of the flywheel.	Evaluate Analyse	1,3,9
6	Each arm of a porter governor is 300 mm long and is pivoted on the axis of rotation. Each ball has a mass of 6 kg and the sleeve weighs 18kg. The radius of rotation of the ball is 200 mm when the governor begins to lift and 250 mm when the speed is maximum. Determine the maximum and minimum speeds and the range of speed of the governor.	Evaluate Analyse	1,3,9
7	The weight of each ball of a Proell governor is 90N. The central load is 1500N and the arms are 250mm long. The arms are open and pivoted at a distance of 50 mm from the axis of rotation. The extension of the lower arms to which each ball is attached is 125 mm long and the radius of rotation of the balls is 250mm. When the arms are inclined at 400 to the axis of rotation, find i) the equilibrium speed for the above configuration and the coefficient of insensitiveness if friction is equivalent to a force of 20N at the sleeve.	Evaluate Analyse	1,3,9
8	A Hartnell governor having a central sleeve spring and two right angle bell crank levers moves between 290 rpm and 310 rpm for a sleeve lift of 15 mm. The sleeve arms and the ball arms are 80 mm and 120 mm respectively. The levers are pivoted at 120 mm from the governor axis and the mass of each ball is 2.5 kg. Determine the loads on the spring at the lowest and highest equilibrium speeds and the stiffness of the spring.	Evaluate Analyse	1,3,9
9	Calculate the minimum speed of a Porter governor , which has equal arms each 200mm long and are pivoted on the axis of rotation. The mass of each ball is 5 kg and the minimum radius of rotation for the ball is 100mm.	Evaluate Analyse	1,3,9
10	In a spring controlled governor of the Hartung type, the length of the ball and sleeve arms are 80mm and 120mm respectively. The total travel of the sleeve is 25 mm. In the mid position, each spring is compressed by 50mm and the radius of rotation of the mass center is 140mm. Each ball has a mass of 4 kg and the spring has a stiffness of 10kN/m. The equivalent mass at the sleeve is 16kg. Neglecting the moment due to the revolving masses, when the arms are inclined, determine the ratio of range of speed to the mean speed of the governor. Also find the speed in mid position.	Evaluate Analyse	1,3,9
	UNIT-IV		

Part – A (Short Answer Questions)			
1	What is balancing?	Understand Remember	3,6
2	What is static balancing?	Understand Remember	3,6
3	What is dynamic balancing?	Understand Remember	3,6
4	What is balancing of rotating masses?	Understand Remember	3,6
5	What is balancing of reciprocating masses?	Understand Remember	3,6
6	What is locomotive balancing?	Understand Remember	3,6
7	Define tractive force.	Understand Remember	3,6
8	Define swaying couple.	Understand Remember	3,6
9	Define hammer blow.	Understand Remember	3,6
10	What is multi cylinder engine?	Understand Remember	3,6
11	What is a V engine?	Understand Remember	3,6
12	What is primary balancing?	Understand Remember	3,6
13	What is secondary balancing?	Understand Remember	3,6
14	What are unbalanced forces?	Understand Remember	3,6
15	What are unbalanced couples?	Understand Remember	3,6
16	What is radial engine?	Understand Remember	3,6
17	What are in-line engines?	Understand Remember	3,6
18	State the conditions for static balancing.	Understand Remember	3,6
19	State the conditions for dynamic balancing.	Understand Remember	3,6
20	What are coupled locomotives?	Understand Remember	3,6
Part – B (Long Answer Questions)			
1	What is meant by static and dynamic unbalance in machinery?	Understand apply	3,6
2	Why is balancing necessary in rotors of high speed engines?	Understand apply	3,6
3	How are rotating masses balanced?	Understand apply	3,6
4	What is balancing of reciprocating masses?	Understand apply	3,6
5	Derive the expression for variation in tractive force in locomotive balancing.	Understand apply	3,6
6	Derive the expression for swaying couple in locomotive balancing.	Understand apply	3,6
7	Derive the expression for hammer blow in locomotive balancing.	Understand apply	3,6
8	What is meant by primary balancing in reciprocating engines?	Understand apply	3,6
9	What is meant by secondary balancing in reciprocating engines?	Understand apply	3,6

10	Determine the unbalanced forces and couples in case of two cylinder engines.	Understand apply	3,6
11	Determine the magnitudes of unbalanced forces in V- Engines.	Understand apply	3,6
12	Determine the magnitudes of unbalanced forces in Radial Engines.	Understand apply	3,6
13	Determine the magnitudes of unbalanced forces in In-line Engines	Understand apply	3,6
14	Determine the magnitudes of unbalanced forces in Multicylinder Engines	Understand apply	3,6
15	Explain the method of direct and reverse cranks to determine the unbalance in radial engines.	Understand apply	3,6
16	How is the effect of hammer blow reduced in coupled locomotives?	Understand apply	3,6
17	Explain the method of balancing different masses revolving in the same plane.	Understand apply	3,6
18	How are different masses rotating in different planes balanced?	Understand apply	3,6
19	Explain how a single revolving mass is balanced by two masses revolving in different planes.	Understand apply	3,6
20	What are the conditions for balancing several masses revolving in the same plane?	Understand apply	3,6
Part - C (Problem Solving and Critical Thinking Questions)			
1	The cranks of a three cylinder locomotive are set at 1200. The stroke is 120 mm, the length of the connecting rod is 240 mm, the mass of the reciprocating parts per cylinder is 1 kg and the speed of the crank shaft is2400 rpm. Determine the magnitude of primary and secondary balancing.	Understand apply	3,6
2	A rigid rotor has all its unbalance in one plane and can be considered to consist of three masses m1 = 5 kg, m2 = 3 kg at an angle of 1650 counter clockwise from m1 and m3 = 8 kg at angle 850 clockwise from m1. The radii r1 = 200mm, r2 = 80mm and r3 = 140 mm. Determine the balancing mass required at a radius of 100 mm. Specify the location of this mass with respect to m1.	Understand apply	3,6
3	An air compressor has four vertical cylinders 1,2,3 and 4 inline and the driving cranks at 900 intervals reach their uppermost positions in this order. The cranks are of 150 mm radius, the connecting rods 500 mm long and the cylinder centre lines 400 mm apart. The mass of the reciprocating parts of each cylinder is 22.5 kg and the speed of rotation is400 rpm. Show that there are no out of balance primary and secondary forces. Determine the corresponding couples indicating their positions for maximum values. The central plane of the machine may be taken as reference plane.	Understand apply	3,6
4	The pistons of 600 twin V-Engine have strokes of 120 mm. The connecting rods driving a common crank are of length 200 mm. The mass of the reciprocating parts per cylinder is 1.5 kg and the sped of the crankshaft is 2500 rpm. Determine the magnitude of primary and secondary unbalanced forces.	Understand apply	3,6
5	A single cylinder horizontal engine runs at 120 rpm. The length of stroke is 400mm. The mass of the revolving parts assumed concentrated at the crank pin, is 100kg and mass of reciprocating parts is 150kg. Determine the magnitude of the balancing mass required to be placed opposite to the crank at a radius of 150mm which is equivalent to all the revolving and 2/3 of the reciprocating masses. If the crank turns 300 from the inner dead center, find the magnitude of the unbalanced force due to the balancing mass.	Understand apply	3,6
6	An inside cylinder locomotive has its cylinder center lines 0.7 m apart and has a stroke of 0.6 m. The rotating masses per cylinder are equivalent to 150kg at the crank pin and the reciprocating masses per cylinder are 180kg. The wheel center lines are 1.5m apart. The cranks are at right angles. The whole of rotating parts and 2/3 of reciprocating masses are to be balanced by masses placed at a radius of 0.6m. Find the magnitude and direction of the balancing masses.	Understand apply	3,6

7	Four masses P, Q, R and S are completely balanced. Masses R and S make angles of 900 and 2100 respectively with Q in the same sense. The planes containing Q and R are 300 mm apart. Masses P, Q, R and S are supposed to be concentrated at radii of 360mm, 480mm, 240mm and 300mm respectively. The masses Q,R and S are 15kg, 25kg and 20kg respectively. Determine i) The mass P and its angular position. ii) The planes in which the masses P and S are placed.	Understand apply	3,6
8	The three cylinders of an air compressor have their axes1200 to one another and their connecting rods are coupled to a single crank. The stroke is 100mm and the length of each connecting rod is 150mm. The mass of the reciprocating parts per cylinder is 1.5 kg. Find the maximum primary and secondary forces acting on the frame of the compressor when running at 3000 rpm.	Understand apply	3,6
9	A V- twin engine has the cylinder axes at right angles and the connecting rods operate a common crank. The reciprocating masses per cylinder are 11.5kg and the crank radius is 75mm. The length of connecting rod is 0.3m. Show that the engine may be balanced for primary forces. If the engine speed is 500rpm, what is the maximum secondary unbalanced force?	Understand apply	3,6
	UNIT-V		
Part - A (Short Answer Questions)			
1	What is vibration?	Understand Remember	3,6
2	What are the causes of vibration?	Understand Remember	3,6
3	What are the effects of vibration?	Understand Remember	3,6
4	Define free vibration.	Understand Remember	3,6
5	Define forced vibration	Understand Remember	3,6
6	Define damped vibration	Understand Remember	3,6
7	Define longitudinal vibration.	Understand Remember	3,6
8	Define transverse vibration	Understand Remember	3,6
9	Define torsional vibration	Understand Remember	3,6
10	Define critical Speed of shaft	Understand Remember	3,6
11	Explain the term under damping.	Understand Remember	3,6
12	Explain the term critical damping.	Understand Remember	3,6
13	Explain the term over damping.	Understand Remember	3,6
14	What is transmissibility?	Understand Remember	3,6
15	Define Damping Factor.	Understand Remember	3,6
16	Define logarithmic decrement.	Understand Remember	3,6
17	What is a torsionally equivalent shaft.	Understand Remember	3,6
18	What is meant by magnification factor?	Understand Remember	3,6
19	What is Dunkerley's method.	Understand Remember	3,6

20	What is Raleigh's method	Understand Remember	3,6
Part - B (Long Answer Questions)			
1	What are the causes of vibrations?	Understand Remember	3,6
2	What are the effects of vibrations?	Understand Remember	3,6
3	Define free, forced and damped vibrations.	Understand Remember	3,6
4	Describe with neat sketch the longitudinal free vibrations.	Understand Remember	3,6
5	Describe with neat sketch the transverse free vibrations.	Understand Remember	3,6
6	Describe with neat sketch the torsional free vibrations.	Understand Remember	3,6
7	Derive an expression for the natural frequency of free longitudinal vibrations.	Understand Remember	3,6
8	Derive an expression for the natural frequency of free transverse vibrations	Understand Remember	3,6
9	Derive an expression for the natural frequency of free transverse vibrations for a simply supported shaft carrying uniformly distributed mass of m kg per meter length.	Understand Remember	3,6
10	Deduce an expression for the natural frequency of free transverse vibrations for a beam fixed at both ends and carrying uniformly distributed mass of m kg per meter length.	Understand Remember	3,6
11	Establish an expression for the natural frequency of free transverse vibration for a simply supported beam carrying a number of point loads by energy method.	Understand Remember	3,6
12	Establish an expression for the natural frequency of free transverse vibration for a simply supported beam carrying a number of point loads by Dunkerley's method.	Understand Remember	3,6
13	Explain the term whirling speed or critical speed of shaft.	Understand Remember	3,6
14	Prove that the whirling speed of a rotating shaft is the same as the frequency of natural transverse vibration.	Understand Remember	3,6
15	Explain the terms under damping, critical damping and over damping.	Understand Remember	3,6
16	Explain the term logarithmic decrement as applied to damped vibrations.	Understand Remember	3,6
17	Establish an expression for the amplitude of forced vibrations.	Understand Remember	3,6
18	What is transmissibility?	Understand Remember	3,6
19	Derive the differential equation for the motion of an oscillating system subjected to viscous damping without a periodic excitation force.	Understand Remember	3,6
20	Derive the equation for natural frequency of free torsional vibration of three rotor system	Understand Remember	3,6
Part - C (Problem Solving and Critical Thinking Questions)			
1	A shaft 50 mm diameter and 3 m long is simply supported at its ends and carries three loads of 1000 N, 1500N and 750N at 1m, 2m and 2.5m from the left support. Modulus of elasticity is 200 GN/m2. Find the frequency of transverse vibrations.	Evaluate Analyse	1,3,9
2	A cantilever shaft of 50 mm diameter and 300 mm long has a disc of mass 100 kg at its free end. The Young's modulus of the shaft material is 200 GN / m2. Determine the frequency of longitudinal and transverse vibrations of the shaft.	Evaluate Analyse	1,3,9
3	A vibrating system consists of a mass of 50 kg, a spring of stiffness 30kN/m and a damper. The damping provided is only 20% of the critical value. Determine the damping factor, critical damping coefficient and logarithmic decrement.	Evaluate Analyse	1,3,9

4	Calculate the whirling speed of a shaft 20 mm diameter and 0.6 m long, carrying a mass of 1 kg at its mid point. Density of the shaft material is 40 Mg/m3 and E = 200 GN/m2. Assume freely supported shaft.	Evaluate Analyse	1,3,9
5	A 1.5 m long shaft AB has flywheels at its ends A and B. The mass of the flywheel at the end A is 600kg and its radius of gyration is 400mm. The corresponding values for the flywheel at the end B are 300kg and 300 mm. The diameter of the shaft for the first 400mm starting from the end A is 50mm, 60 mm diameter for the next portion of 500 mm length and the remaining portion of 600mm length is unknown. Determine the diameter of the shaft for the portion B so that the node of the torsional vibration of the system will be at the center of 500 mm long segment. Also determine the frequency of vibration.	Evaluate Analyse	1,3,9
6	A stepped shaft of 0.05 m in diameter for the first 0.6 m length, 0.08 m diameter for the next 1.8 m and 0.03 m diameter for the remaining 0.25 m length. While the 0.05 m diameter end is fixed, the 0.03 m diameter end of the shaft carries a rotor of mass moment of inertia 14.7 kg-m2. If the modulus of elasticity of the shaft material is 0.83 x 1011 N/m2, find the natural frequency of torsional oscillations, neglecting theinertia effect of the shaft.	Evaluate Analyse	1,3,9
7	A shaft 100 mm diameter and 1000 mm long is fixed at one end and the other end carries a flywheel of mass 90 kg. The radius of gyration of the flywheel is 500mm. Find the frequency of torsional vibration, if the modulus of rigidity for the shaft material is 80GN/m2.	Evaluate Analyse	1,3,9
8	A single cylinder engine of total mass 200kg is to be mounted on an elastic support which permits vibratory movement in vertical direction only. The mass of the piston is 3.5 kg and has a vertical simple harmonic motion with a stroke of 150mm. It is desired that the maximum vibratory force transmitted through the elastic support to the foundation shall be 600N when the engine speed is 800 rpm. Find the necessary stiffness of the elastic support and the amplitude of vibration at 800 rpm.	Evaluate Analyse	1,3,9
9	An instrument vibrates with a natural frequency of 1 Hz. When there is no damping. When the damping is provided, the frequency of damped vibration was observed to be 0.9 Hz. Find the damping factor and logarithmic decrement.	Evaluate Analyse	1,3,9
10	A body of mass 20kg is suspended from a spring which deflects 15mm under this load. Calculate the frequency of free vibrations and verify that a viscous damping force of 1000N at a speed of 1 m/s is just sufficient to make the motion aperiodic.	Evaluate Analyze	1,3,9

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